HARTFORD HOSPITAL

80 Seymour Street
P.O. Box 5037
Hartford, CT 06102-5037
860/545-5000

March 22, 2010

Cristine A. Vogel, Deputy Commissioner
Department of Public Health, Office of Health Care Access
MS#13HCA
410 Capitol Avenue
P.O. Box 340308
Hartford, CT 06134-0308

Dear Commissioner Vogel:

Enclosed please find for your review and consideration completed form 2030, a letter of intent for the purchase of a CT Simulator to be located in Hartford Hospital's Helen and Harry Gray Cancer Center. As you may recall from your previous meeting with Dr. Andrew Salner and Kevin Kinsella, the proposed machine will replace an antiquated unit installed in 1992 for an amount below the CON threshold in place at the time. Therefore, a CON was neither required nor obtained.

Please feel free to contact me directly at 860 545-1532 if you or your staff has any questions. Thank you in advance for your consideration of this matter.

Sincerely,

Karen T. Goyette
Vice President, Strategic Planning and Business Development

Encl.

000001

State of Connecticut
Office of Health Care Access
Letter of Intent Form
Form 2030

All Applicants involved with the proposal must be listed for identification purposes. A proposal's Letter of Intent (LOI) form must be submitted prior to a Certificate of Need application submission to OHCA by the Applicant(s), pursuant to Sections 19a-638 and 19a-639 of the Connecticut General Statutes and Section 19a-643-79 of OHCA's Regulations. Please complete and submit Form 2030 to the Commissioner of the Office of Health Care Access, 410 Capitol Avenue, MS# 13HCA, P.O. Box 340308, Hartford, Connecticut 06134-0308.

SECTION I. APPLICANT INFORMATION

If this proposal has more than two Applicants, please attach a separate sheet, supplying the same information for each additional Applicant in the format presented in the following table.

	Applicant One	Applicant Two
Full legal name	**Hartford Hospital**	
Doing Business As	**Hartford Hospital**	
Name of Parent Corporation	**Hartford Healthcare Corporation**	
Applicant's Mailing Address, if Post Office (PO) Box, include a street mailing address for Certified Mail (Zip Code Required)	**80 Seymouor Street P.O. Box 5037 Hartford, CT 06102-5037**	
Identify Applicant Status: P for Profit or NP for Nonprofit	**NP**	
Does the Applicant have Tax Exempt Status?	**Yes**	Yes No
Contact Person, including Title/Position: This Individual will be the Applicant Designee to receive all correspondence in this matter.	**Karen T. Goyette Vice President, Strategic Planning and Business Development**	
Contact Person's Mailing Address, if PO Box, include a street mailing address for Certified Mail (Zip Code Required)	**80 Seymouor Street P.O. Box 5037 Hartford, CT 06102-5037**	
Contact Person Telephone Number	**860-545-1532**	
Contact Person Fax Number	**860-545-2127**	
Contact Person e-mail Address	kgoyette@harthosp.org	

SECTION II. GENERAL APPLICATION INFORMATION

a. Project Title: **CT Simulator Replacement for Radiation Oncology**

b. Project Proposal: **Replacement of a CT Simulator for Radiation Oncology**

c. Type of Project/Proposal, please check all that apply:

Inpatient Service(s):

☒ Medical/Surgical ☐ Cardiac ☐ Pediatric ☐ Maternity
☐ Trauma Center ☐ Transplantation Programs
☐ Rehabilitation *(specify type)* _____
☐ Behavioral Health (Psychiatric and/or Substance Abuse Services)
☐ Other Inpatient *(specify)* _____

Outpatient Service(s):

☐ Ambulatory Surgery Center ☐ Primary Care ☒ Oncology
☐ New Hospital Satellite Facility ☐ Emergency ☐ Urgent Care
☐ Rehabilitation *(specify type)* _____ ☐ Central Services Facility
☐ Behavioral Health (Psychiatric and/or Substance Abuse Services)
☐ Other Outpatient *(specify)* _____

Imaging:

☐ MRI ☐ CT Scanner ☐ PET Scanner
☒ CT Simulator ☐ PET/CT Scanner ☐ Linear Accelerator
☐ Cineangiography Equipment ☐ New Technology: _____

Non-Clinical:

☐ Facility Development ☐ Non-Medical Equipment ☒ Renovations
☐ Change in Ownership or Control ☐ Land and/or Building Acquisitions
☐ Organizational Structure (Mergers, Acquisitions, & Affiliations)
☐ Other Non-Clinical: _____

d. Does the proposal include a Change in Facility (F), Service (S)/Function (Fnc) pursuant to Section 19a-638, C.G.S.?

☒ Yes ☐ No

If you checked "Yes" above, please check the appropriate box below:

☐ New (F, S, Fnc) ☐ Additional (F, S, Fnc) ☒ Replacement
☐ Expansion (F, S, Fnc) ☐ Relocation ☐ Termination of Service
☐ Reduction ☐ Change in Ownership/Control

e. Will the Capital Expenditure/Cost of the proposal exceed $3,000,000, pursuant to Section 19a-639, C.G.S.?

☐ Yes ☒ No

If you checked "Yes" above, please check the boxes below, as appropriate:

☐ New equipment acquisition and operation

☐ Replacement equipment with disposal of existing equipment

☐ Major medical equipment

☐ Change in ownership or control

f. Location of proposal, identifying Street Address, Town and Zip Code:

80 Seymour Street, Hartford, CT, 06102-5037

g. List each town this project is intended to serve:

Primary Service Area

Avon	Hartford	Simsbury
Bloomfield	Manchester	South Windsor
Bolton	New Britain	West Hartford
East Hartford	Newington	Wethersfield
Farmington	Rocky Hill	Windsor
Glastonbury		

Secondary Service Area

Andover	Enfield	Portland
Barkhamsted	Franklin	Preston
Berlin	Granby	Salem
Bozrah	Haddam	Somers
Bristol	Hartland	Southington
Burlington	Harwinton	Stafford
Canton	Hebron	Suffield
Colchester	Lebanon	Tolland
Columbia	Mansfield	Torrington
Coventry	Marlborough	Union
Cromwell	Meriden	Vernon
East Granby	Middlefield	Wallingford
East Haddam	Middletown	Winchester
East Hampton	New Hartford	Windham
East Windsor	Norwich	Windsor Locks
Ellington	Plainville	

h. Estimated starting date for the project: **September 1, 2010**

i. If the proposal includes change in the number of beds provide the following information:

Not applicable. This proposal does not result in any change in number of beds

Type	Existing Staffed	Existing Licensed	Proposed Increase or (Decrease)	Proposed Total Licensed

SECTION III. ESTIMATED CAPITAL EXPENDITURE/COST INFORMATION

a. Estimated Total Project Expenditure/Cost: $ 999,414

b. Please provide the following tentative capital expenditure/costs related to the proposal:

Major Medical Equipment Purchases*	$ 599,262
Medical Equipment Purchases*	178,819
Non-Medical Equipment Purchases*	9,333
Land/Building Purchases	0
Construction/Renovation	185,000
Other (Non-Construction) Specify: **Contingency**	27,000
Total Capital Expenditure	**$ 999,414**
Major Medical Equipment – Fair Market Value of Leases Medical	
Equipment – Fair Market Value of Leases	
Non-Medical Equipment – Fair Market Value of Leases*	
Fair Market Value of Space – Capital Leases Only	
Total Capital Cost	**$ 999,414**
Total Project Cost	**$ 999,414**
Capitalized Financing Costs (Informational Purpose Only)	

* Provide an itemized list of all medical and non-medical equipment to be purchased and leased. **(See Attachment 1)**

c. If the proposal has a total capital expenditure/cost exceeding $20,000,000 or if the proposal is for major medical equipment exceeding $3,000,000, you may request a Waiver of Public Hearing pursuant to Section 19a-643-45 of OHCA's Regulations? Please check your preference.

☐ Yes ☒ No

1. If you checked "Yes" above: please check the appropriate box below indicating the basis of the projects eligibility for a waiver of hearing

   ☐ Energy Conservation ☐ Health, Fire, Building and Life Safety Code

   ☐ Non Substantive

2. Provide supporting documentation from elected town officials (i.e. letter from Mayor's Office).

d. Major Medical and/or Imaging Equipment Acquisition:

Equipment Type	Name	Model	Number of Units	Cost per unit
Large Bore CT Simulator	Toshiba	Aquillion	1	$ 599,262

Note: Provide a copy of the vendor contract or quotation for each major medical/imaging equipment. **See Attachment 2**

e. Type of financing or funding source (more than one can be checked):

☐ Applicant's Equity	☐ Capital Lease	☐ Conventional Loan
☐ Charitable Contributions	☐ Operating Lease	☐ CHEFA Financing
☒ Funded Depreciation	☐ Grant Funding	
☐ Other *(specify)* _____		

SECTION IV. PROJECT DESCRIPTION

In paragraph format, please provide a description of the proposed project, highlighting each of its important aspects, on at least one, but not more than two separate 8.5" X 11" sheets of paper. At a minimum each of the following items need to be addressed, if applicable.

1. List the types of services are currently being provided. If applicable, provide a copy of each Department of Public Health (DPH) license held by the Applicant.

2. List the types of services being proposed and what DPH licensure categories will be sought, if applicable.

3. Identify the current population served and the target population to be served.

4. Identify any unmet need and describe how this project will fulfill that need.

5. Are there any similar existing service providers in the proposed geographic area?

6. Describe the anticipated effect of this proposal on the health care delivery system in the State of Connecticut.

7. Who will be responsible for providing the service?

8. Who are the current payers of this service and identify any anticipated payer changes when the proposed project becomes operational?

AFFIDAVIT

To be completed by each Applicant

Applicant: **Hartford Hospital**

Project Title: **Replacement of a CT Simulator for Radiation Oncology**

I, Thomas Marchozzi, Chief Financial Officer of Hartford Hospital
(Name) (Position) (Facility Name)

being duly sworn, depose and state that the information provided in this CON Letter of Intent (Form 2030) is true and accurate to the best of my knowledge, and that Hartford Hospital (Facility Name) complies with the appropriate and applicable criteria as set forth in the Sections 19a-630, 19a-637, 19a-638, 19a-639, 19a-486 and/or 4-181 of the Connecticut General Statutes.

Signature 3/23/10 Date

Subscribed and sworn to before me on March 23, 2010

Rebecca Scibelli
Notary Public/Commissioner of Superior Court

My commission expires: 02/28/2010

Rebecca Scibelli
Notary Public, Connecticut
My Commission Expires Feb. 28, 2012

RECEIVED
2010 MAR 25 P 2:11
CONNECTICUT OFFICE OF HEALTH CARE ACCESS

Form 2030
Revised 10/2007

Project Description

This is a proposal for the replacement of a Philips SLS 9 simulator with a Toshiba Aquillion 16 slice Large Bore CT Simulator, as well as for the relocation of an existing Varian Acuity simulator within the department of Radiation Oncology at Hartford Hospital's Helen and Harry Gray Cancer Center. The existing Philips conventional simulator was installed in 1992 at a cost of $400,000. Since this amount did not exceed the Certificate of Need threshold in place at the time, no CON was required nor obtained. The Philips simulator no longer provides the standard of care associated with modern radiation oncology departments. The large bore of the proposed CT will allow simulation of more patients in the treatment position with various treatment devices. Many larger patient cannot be treated in conventional (smaller bore) CT Scanners. The acquisition of this scanner will also reduce the Cancer Center's dependence on other CT Scanners located in the Department of Radiology and the Emergency Department, thus freeing up those scanners for routine and emergent studies. The addition of this scanner will allow the provision of limited diagnostic services to bariatric patients. The Cancer Center will also be able to provide service to a limited number of Oncology patients who may require urgent scanning when not available elsewhere. The Acuity simulator will be relocated into the HDR suite, where it will be used for brachytherapy applications and some conventional external beam simulation. This will free up the current Acuity space for the CT Simulator.

1. **List the types of services are currently being provided. If applicable, provide a copy of each Department of Public Health (DPH) license held by the Applicant.**

Response: Hartford Hospital Department of Radiation Oncology delivers Radiation treatments in the form of Image Guided Radiation Oncology, Intensity Modulated Radiation Therapy, stereotactic radiation therapy, and convention radiation oncology treatments. The hospital also provides HDR and LDR brachytherapy services as well as Simulation and Treatment Planning services. Similar external radiation therapy services are provided at the hospital's Avon facility, utilizing a CT simulator very similar to the proposed CT simulator. All services would be provided under Hartford Hospital's license.

2. **List the types of services being proposed and what DPH licensure categories will be sought, if applicable?**

Response: The services associated with this application are currently being provided. CT based treatment planning is considered to be the standard in Radiation Oncology treatment. Patients currently receive CT scans in the hospital's Radiology and Emergency Departments. These facilities are used heavily and do not always permit as timely a service for cancer patients as would be indicated. The location of these units are not in proximity to the Cancer Center and therefore mandates the transportation of the patient, treatment record and treatment devices. This is inconvenient for the patient and inefficient for the staff. The current bore size of existing HH Scanners limits the scanning of patients in the treatment position due to the size of the devices required. The Large Bore of the proposed scanner will alleviate this issue as well as enable the provision of this service within the Cancer Center, thus reducing the stress and enhancing access for our patients and staff. No additional licenses will be sought.

3. **Identify the current population served and the target population to be served.**

Response: The new CT scanner will continue to serve the current population of patients receiving care in Radiation Oncology. Also, the addition of this CT scanner will make available to Hartford Hospital limited diagnostic scanning capability for the bariatric and cancer patient population.

4. Identify any unmet need and describe how this project will fulfill that need.

Response: As noted above, this service is currently being provided by Hartford Hospital, however. the existing Philips simulator no longer provides the standard of care associated with modern radiation oncology departments. The large bore of the proposed CT will allow simulation of more patients in the treatment position with various treatment devices. Many larger patients cannot be simulated in conventional (smaller bore) CT Scanners. The acquisition of this scanner will also reduce dependence on existing CT Scanners located in the Department of Radiology and the Emergency Department, thus freeing up those scanners for routine and emergent studies. The addition of this scanner will also allow the provision of limited diagnostic services to bariatric patients. Finally, we will also be able to provide service to a limited number of Oncology patients that are in the Cancer Center that may require urgent scanning when not available elsewhere.

5. Are there any similar existing service providers in the proposed geographic area?

Response: Hartford Hospital's Helen and Harry Gray Cancer Center is the primary provider of this service in the area. Approval of this proposal will make it possible for the hospital to continue to provide high quality radiation oncology services. Other providers of radiation oncology in the immediate area are St, Francis Hospital and Medical Center and the University of Connecticut Health Center.

6. Describe the anticipated effect of this proposal on the health care delivery system in the State of Connecticut.

Response: This proposal will not have a significant effect upon the health care delivery system in the State of Connecticut, since the services it will enable are, in large part, already being provided at Hartford Hospital. It will, however, have a significant impact upon the quality and efficiency of the care provided to patients receiving radiation oncology services at Hartford Hospital.

7. Who will be responsible for providing this service?

Response: Hartford Hospital will provide this service.

8. Who are the current payers of this service and identify any anticipated payer changes when the proposed project becomes operational?

Response: The current payers of this service include Medicare, Medicaid, Anthem Blue Cross, Aetna, and ConnectiCare. No change is anticipated.

Project Description

This is a proposal for the replacement of a Philips SLS 9 simulator with a Toshiba Aquillion 16 slice Large Bore CT Simulator, as well as for the relocation of an existing Varian Acuity simulator within the department of Radiation Oncology at Hartford Hospital's Helen and Harry Gray Cancer Center. The existing Philips conventional simulator was installed in 1992 at a cost of $400,000. Since this amount did not exceed the Certificate of Need threshold in place at the time, no CON was required nor obtained. The Philips simulator no longer provides the standard of care associated with modern radiation oncology departments. The large bore of the proposed CT will allow simulation of more patients in the treatment position with various treatment devices. Many larger patient cannot be treated in conventional (smaller bore) CT Scanners. The acquisition of this scanner will also reduce the Cancer Center's dependence on other CT Scanners located in the Department of Radiology and the Emergency Department, thus freeing up those scanners for routine and emergent studies. The addition of this scanner will allow the provision of limited diagnostic services to bariatric patients. The Cancer Center will also be able to provide service to a limited number of Oncology patients who may require urgent scanning when not available elsewhere. The Acuity simulator will be relocated into the HDR suite, where it will be used for brachytherapy applications and some conventional external beam simulation. This will free up the current Acuity space for the CT Simulator.

1. **List the types of services are currently being provided. If applicable, provide a copy of each Department of Public Health (DPH) license held by the Applicant.**

Response: Hartford Hospital Department of Radiation Oncology delivers Radiation treatments in the form of Image Guided Radiation Oncology, Intensity Modulated Radiation Therapy, stereotactic radiation therapy, and convention radiation oncology treatments. The hospital also provides HDR and LDR brachytherapy services as well as Simulation and Treatment Planning services. Similar external radiation therapy services are provided at the hospital's Avon facility, utilizing a CT simulator very similar to the proposed CT simulator. All services would be provided under Hartford Hospital's license.

2. **List the types of services being proposed and what DPH licensure categories will be sought, if applicable?**

Response: The services associated with this application are currently being provided. CT based treatment planning is considered to be the standard in Radiation Oncology treatment. Patients currently receive CT scans in the hospital's Radiology and Emergency Departments. These facilities are used heavily and do not always permit as timely a service for cancer patients as would be indicated. The location of these units are not in proximity to the Cancer Center and therefore mandates the transportation of the patient, treatment record and treatment devices. This is inconvenient for the patient and inefficient for the staff. The current bore size of existing HH Scanners limits the scanning of patients in the treatment position due to the size of the devices required. The Large Bore of the proposed scanner will alleviate this issue as well as enable the provision of this service within the Cancer Center, thus reducing the stress and enhancing access for our patients and staff. No additional licenses will be sought.

3. **Identify the current population served and the target population to be served.**

Response: The new CT scanner will continue to serve the current population of patients receiving care in Radiation Oncology. Also, the addition of this CT scanner will make available to Hartford Hospital limited diagnostic scanning capability for the bariatric and cancer patient population.

4. Identify any unmet need and describe how this project will fulfill that need.

Response: As noted above, this service is currently being provided by Hartford Hospital, however. the existing Philips simulator no longer provides the standard of care associated with modern radiation oncology departments. The large bore of the proposed CT will allow simulation of more patients in the treatment position with various treatment devices. Many larger patients cannot be simulated in conventional (smaller bore) CT Scanners. The acquisition of this scanner will also reduce dependence on existing CT Scanners located in the Department of Radiology and the Emergency Department, thus freeing up those scanners for routine and emergent studies. The addition of this scanner will also allow the provision of limited diagnostic services to bariatric patients. Finally, we will also be able to provide service to a limited number of Oncology patients that are in the Cancer Center that may require urgent scanning when not available elsewhere.

5. Are there any similar existing service providers in the proposed geographic area?

Response: Hartford Hospital's Helen and Harry Gray Cancer Center is the primary provider of this service in the area. Approval of this proposal will make it possible for the hospital to continue to provide high quality radiation oncology services. Other providers of radiation oncology in the immediate area are St, Francis Hospital and Medical Center and the University of Connecticut Health Center.

6. Describe the anticipated effect of this proposal on the health care delivery system in the State of Connecticut.

Response: This proposal will not have a significant effect upon the health care delivery system in the State of Connecticut, since the services it will enable are, in large part, already being provided at Hartford Hospital. It will, however, have a significant impact upon the quality and efficiency of the care provided to patients receiving radiation oncology services at Hartford Hospital.

7. Who will be responsible for providing this service?

Response: Hartford Hospital will provide this service.

8. Who are the current payers of this service and identify any anticipated payer changes when the proposed project becomes operational?

Response: The current payers of this service include Medicare, Medicaid, Anthem Blue Cross, Aetna, and ConnectiCare. No change is anticipated.

ATTACHMENT 1

Itemized List of Medical and Non-Medical Equipment

Hartford Hospital - CT Simulator Replacement

Equipment Vendor	Item	Category	Cost
Toshiba	Aquillion LB	Major Medical	**$599,262.00**
LifeLine Software	RadCalc Brachytherapy Module	Medical	6,375.00
Standard Imaging	Lucy 3D Phantom w/ Acc plus PIPSPro QA Software	Medical	54,090.00
Bionix	2 prone breast boards	Medical	9,702.00
Varian	Chart QA site licenses	Medical	28,000.00
	Injector	Medical	30,000.00
Nucletron	CT Compatible HDR Cylinder Applicators	Medical	26,800.00
Nucletron	HDR "baseplate"	Medical	7,000.00
Civco	Timo Headrests - MTTIMO	Medical	255.00
Civco	Wing Board - MTWB09	Medical	335.00
Civco	Kneefit 2 Cushion - MTSIN301047	Medical	556.00
Civco	Multi Purpose Support Sponge Set - MTSIN400006	Medical	508.00
Civco	Carbon Fiber Breastboard MT-350-N X2	Medical	10,000.00
Civco	Transfer Board - MTVIP40	Medical	450.00
PTW	Parallel Plate Chamber HH	Medical	4,000.00
Market Lab	Table Pad - HR3270	Medical	440.00
Market Lab	Triple Glove Dispenser - HR3615	Medical	83.00
Market Lab	7 Gallon Bio Hazard Waste Bin - HR10043+HR1029	Medical	225.00
Subtotal - Medical			**$178,819.00**
COI	Bariatric chair	Non-Medical	897.75
COI	3 Tall stool chairs	Non-Medical	1,151.04
AOS	PC X 5	Non-Medical	6,800.00
AOS	CCTV Monitor	Non-Medical	275.00
AOS	Wall mount	Non-Medical	40.00
Market Lab	Sundry jars - ML0238	Non-Medical	85.00
Market Lab	Foot Stool w/ handle - HR4043	Non-Medical	84.00
Subtotal - Non-Medical			**$9,332.79**
Total Purchases			**$787,413.79**

Renovations		
Varian	Relocation of Acuity	48,500.00
Donati Construction	Room modifications	94,500.00
Donati Construction	Additional work	2,000.00
HH	2New network drops	1,000.00
	New door opener & veneer	5,000.00
JOBuilt	Millwork	29,000.00
	Art	5,000.00
	Contingency	27,000.00
SubTotal Renovations		**$212,000.00**

Total Project **$999,413.79**

ATTACHMENT 2

Vendor Quote for Medical/Imaging Equipment

TOSHIBA
Leading Innovation >>>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER SUMMARY

OMT NO: 374952
DATE: 3/15/2010 QUOTE NO: 96123

PRESENTED TO: (COMPLETE LEGAL NAME)

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

DELIVER TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

EQUIPMENT SUMMARY:

#AQLB **AQUILION LARGE BORE CT SCANNER**

CT SCANNER AQ LB WITH EXTENDED COUCH

CT ACCESSORY KIT - EXTENDED COUCH 1800 MM

MED-TEC IPPS™ CT INSERT TABLETOP FOR EXTENDED 1800 MM COUCH

CT PHANTOM

CONSOLE DESK 65" X 36" X 30"

(2) CHAIR WITH ADJUSTABLE ARMS AND BACK

(5) MEDIA FOR DVD-RAM DRIVE (9.4 GB)

CABLE CATEGORY 5E/RJ45 5M

This quotation shall remain valid for 30 days (not to exceed 60 days) from date of submission.
All prices are F.O.B. destination.
Payment terms are: Cash - 10% down payment, 70% upon shipment, 20% net 30 days after shipment or upon availability for first use by purchaser, whichever comes first.

Additional terms and conditions appear at the end of this quotation. McKesson Agreement Required _____Yes __X____No
Vital Software License Agreement Required _____Yes __X____No
Please return signed quotation to: Toshiba America Medical Systems, 2441 Michelle Drive, Tustin, CA 92780.

ACCEPTED AGREED AND ORDERED:

CUSTOMER REQUESTED DELIVERY DATE: _____ _____ _____
TOSHIBA REP/CONTACT DATE

_____ _____ _____ _____
PURCHASER'S SIGNATURE/TITLE DATE ZONE SALES MANAGER DATE

TOSHIBA
Leading Innovation >>>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER SUMMARY

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO: (COMPLETE LEGAL NAME)

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

EQUIPMENT SUMMARY: (continued)

CABLE CATEGORY 5E/RJ45 35M

(2) SERVICE MODEM CABLE

FLOOR LEVELING EPOXY KIT

DICOM MODALITY WORKLIST MANAGEMENT (MWM) SERVICE CLASS USER (SCU) SYSTEM

VARIAN RPM RESPIRATORY GATING

RESPIRATORY GATING SYSTEM

RESPIRATORY GATING JAN06~

POWER CONDITIONER/DISTRIBUTOR 125 KVA UNIVERSAL

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

TOSHIBA
Leading Innovation >>>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

#AQLB

AQUILION LARGE BORE CT SCANNER

Aquilion LB is a large bore Computed Tomography (CT) scanner that provides uncompromised patient positioning with outstanding image quality and clinical performance.

The system was designed for uncompromised patient positioning and image quality necessary for CT simulation and oncology treatment planning. This includes:

- Widest bore opening in the industry (90 cm) for easy patient positioning and maximum flexibility for treatment planning, and
- Largest true (non-extrapolated) field-of-view (70 cm), which covers more anatomy with greater accuracy then ever before by using Toshiba's Quantum^{PLUS} Detector

The Aquilion LB solves one of the biggest problems faced in oncology – the positioning of a large patient on a breast board with both arms up and the board tilted to its maximum (25%).

Aquilion's Quantum^{PLUS} detector introduces true isotropic resolution to oncology. This enables the user to scan in one plane and reconstruct information in another plane with the same image quality, allowing clinicians to use 3-D volumetric information when needed. Aquilion's Quantum^{PLUS} detector is the only detector to provide three slice-width combinations – 16x0.5, 16x1 and 16x2 mm – and it achieves an industry-leading, low-contrast resolution without using additional dose.

The combination of a high-speed scanner and a powerful, high-voltage generator meets every diagnostic requirement. Solid-state, multi-row detectors and optimal reconstruction techniques ensure high-quality images. A high-performance CPU, large color monitors, hybrid keyboard and refined Graphic User Interface (GUI) make the operating environment highly efficient.

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

TOSHIBA
Leading Innovation >>>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

COMPONENTS

- Large-aperture, 90 cm, slip-ring gantry and extra-wide couch (47 cm)
- MEDTEC CT table insert/overlay
- High-frequency X-ray generator and high-heat-capacity X-ray tube
- Ergonomic operator console
- Volumetric image processor
- High-capacity hard disk
- CD-R / DVD-RAM Drive – 9.4 GBytes (double sided DVD RAM)
- Image data transfer link
- Patient comfort accessories
- Operator manuals and quality assurance phantoms

KEY FEATURES

Uncompromised Patient Positioning: The industry's largest aperture of 90 cm and the 70 cm true reconstruction field-of-view provides extreme flexibility during CT simulation and uncompromised treatment planning.

Routine Fast Scanning: Using slip-ring technology, Aquilion LB is able to perform 0.32-second partial scans and 0.5-second routine scans to meet the demands of dynamic and helical examinations.

High Image Quality: The Aquilion LB features 994 channels in 40 rows of solid-state detectors; specialized, user-selectable, image-reconstruction algorithms; and a wide selection of slice thicknesses. The system provides outstanding low-contrast resolution of 2 mm at 0.3% and high-contrast resolution of 0.35 mm.

High-Power Generator: Robust, high-voltage circuits generate 60 kW of power and 500 mA, providing support for the 7.5 MHU X-ray tube that makes possible helical scans up to 100 seconds and scans with metal-free scan range of up to 1,800 mm.

Multiple kV Selections: 80, 100, 120 and 135 kV.

TOSHIBA
Leading Innovation >>>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

Fast Image Reconstruction Time: Up to 10 images per second.

SURE**Technology:** Provides maximum productivity and best image quality at the lowest possible dose. Real-time helical display, which provides instantaneous visualization of acquired images, allows the operator to rapidly assess if additional images are needed. SUREStart bolus tracking software, which is included in the standard configuration, provides the ability to monitor contrast media in real-time.

Easy Operation: Perform easy operations using the 18-inch LCD monitor, mouse and hybrid keyboard. Scan automatically by programming procedures with eXam Plan and vocal instructions through VoiceLink™.

Optimal Space Utilization: The Aquilion LB has only three components – gantry, couch and console – with a footprint of only 27 square meters.

DOSE REDUCTION FEATURES

The Aquilion CT systems from its dual-supported anode grounded x-ray tube, to the ultra-efficient Quantum Detector system and low noise data acquisition system (DAS), to the dose-saving SUREExposure3D (x, y ,z mA modulation software), to advanced adaptive reconstruction (QDS) and noise reduction algorithms (Boost3D), have been designed to deliver the best image quality at the lowest possible dose.

Quantum Denoising Software - QDS (Adaptive Noise Reduction) : Toshiba's Quantum Denoising Software is an adaptive noise reduction algorithm that works in the image data space by preferentially smoothing areas of uniform density while preserving the edge information of the image. QDS works in both two and three dimensions and can drastically reduce image noise, allowing a corresponding savings in patient dose of up to 50%. Most importantly, QDS works in conjunction with the SUREExposure3D software to adjust the mAs based on the expected noise reduction from QDS. In this way, patient dose reduction is totally integrated in the Aquilion console software prior to turning on the x-ray beam.

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

TOSHIBA
Leading Innovation >>>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

SUREExposure3D (x, y, z automated mA modulation software) : Toshiba's SUREExposure3D software automatically adjusts the mAs rapidly during the scan to adapt to and compensate for changes in attenuation level produced by the non-uniformity of the anatomy being imaged. Therefore, as the scan moves from the shoulders to the lung, the mAs goes down, and as the tube rotates around the patient, less mAs is used anterior-posterior than laterally. For the same image quality level, compared to non-modulated scanning, SUREExposure3D can reduce the dose by up to 40%.

Boost3D : Boost3D is an adaptive, three-dimensional algorithm that virtually eliminates degradation of image quality due to highly attenuating anatomical structures, such as the pelvis or shoulders. Without dose reduction algorithms, like Boost3D, these highly attenuating areas require increased mAs and kVp to overcome the low photon count. Instead, Boost3D seeks out portions of the raw-projection data where there is a disproportionate loss in x-ray signal and applies a three-dimensional algorithm locally to reduce the image noise and streak artifacts.

EQUIPMENT DESCRIPTION

Aquilion LB Gantry
The Aquilion LB gantry uses a direct-drive design to provide accurate alignment between beam and detector, and to reduce rotational noise for higher-quality images.

A low-voltage slip ring assures reliable, continuous power transfer.

- Digital signal transmission facilitated by innovative optical-coupling technology moves information to the volumetric image processor
- Generator is inside the gantry to conserve space

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

TOSHIBA
Leading Innovation >>>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

Other features include:

- Industry's largest aperture: 90 cm
- Five scan fields of view: 24, 32, 40, 55 and 70 cm
- Gantry controls on both sides
- Patient positioning lights
- Wide range of scan times provides greater flexibility for optimal image quality (0.32 partial; 0.5, 0.75, 1, 1.5, 2 and 3 seconds full)
- Slice thickness selections of 16x0.5, 16x1 and 16x2 mm with the capability of stacking images to the desired slice thickness

Couch

- 47 cm wide, metal-free couch top
- Horizontal stroke of 2,190 mm and a scanning range of 1,800 mm for tall patients
- Couch top can be lowered to 30 cm (12 inches)
- Manual control of table movement from both the gantry and console or programmed by an exam protocol
- Couch top supports up to 450 lbs. while maintaining accuracy of ±0.25 mm

Couch Insert/Overlay

- Toshiba IPPS™ table overlay uses MEDTEC's patented indexing feature for rapid, accurate and repeatable patient set-up
- 53 cm wide, 200 cm long, 10 cm thick and 14 kg weight
- Constructed of foam core covered with carbon fiber

Dual CT Consoles

- Consists of hybrid keyboards, mouse, monitors and Navibox
- Controls the entire system, including power
- Image display
- Scanoscope control
- Remote control of couch-top movement
- Window level and width adjustment
- Three preset windows can be stored in the eXam Plans
- Other mouse-operated, image-processing functions

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

TOSHIBA
Leading Innovation >>>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

- High line-rate, 18-inch LCD monitors
- Displays images in 512x512 or 1024x1024
- CT number display ranges from -1,536 to +8,191
- 32 programmable voice commands

X-ray Tube
The Aquilion LB is equipped with the MegaCool™ X-ray tube. This compact, high-performance tube was designed specifically to minimize tube-cooling delays in heavy patient-load conditions using 0.5-second scan time.

Other features include:
- Dual focal spots
- Anode capacity of 7.5 MHU
- Dissipation rate of 1,386 kHU per minute maximum

Detectors
The Quantum^{PLUS} detector design allows Toshiba to generate a 70 cm true field-of-view – the largest in the industry – for uncompromised positioning.

Other features include:
- Solid-state detector array
- Low-contrast resolution of 2 mm at 0.3%
- 994 detector channels and 40 rows of detector elements
- 1,800 views per second to produce high-resolution images

Computer
- Two 32-bit processors
- Capable of simultaneous scanning, retrieving, reconstructing, archiving and filming without interruption – true multi-tasking system
- Ultra-fast, 217 GB hard disk
- 100,000 images on both scan and display console
- 3,600 rotations of raw data maximum
- CD-R / DVD-RAM Drive – 9.4 GBytes (double sided DVD RAM)
- DICOM CD writer *(option)* – Archive up to 1000 images

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

TOSHIBA
Leading Innovation >>>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

PATIENT AND IMAGE MANAGEMENT

Patient Demographics Management

- Enter individual patient information at the time of examination manually or imported from Modality Worklist Management query.
- On-line patient appointment file management

Image Management

Aquilion LB images can be stored on hard disk, magneto-optical disk or transferred via gigabit Ethernet connection using DICOM 3.0 standards.

DICOM 3.0 (Storage SCU)

- Allows the CT scanner to export images to CT simulation, 3-D workstations or any other device on the network
- Consists of software only and utilizes pre-existing Ethernet ports on the CT scanner to connect to a coax-Ethernet-based network running TCP-IP communication protocols
- The system can be set to automatically transfer images to the network after an exam is complete

DICOM 3.0 (Print SCU)

- Allows the CT scanner to send image data that has been acquired and reconstructed to a film imager for printing via Ethernet in conformance with DICOM 3.0 standards

Image Display

- Display in multiple formats ranging from 1 to 16
- Overlay an inset scanogram for quick reference marking
- Add, subtract, rotate or filter images
- Adjust window width and level non-linearly, accommodating up to six built-in curves and six user-defined curves

TOSHIBA
Leading Innovation >>>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

IMAGE QUALITY ENHANCEMENTS

Automatic, 2-Pass, Beam-Hardening Correction (BHC): Compensates for the non-uniform, beam-hardening effect of bone for more accurate reconstruction. Reduction of streak artifacts in the posterior fossa and elimination of cupping artifact in the mid-brain.

Raster Artifact Suppression Protocol (RASP): Reduces artifacts caused by non-uniform attenuation such as in the shoulders and pelvis, and may be applied prospectively or retrospectively.

Reconstruction Algorithms: Grouped by anatomical application, more than 20 algorithms are provided for customized image reconstruction according to the diagnostic information needed or physician preference.

HELICAL SCAN & FUNCTIONALITY

MultiView: Built into protocol for fast, multi-planar reconstruction in batch mode specifically for multislice data sets. Coronal, sagittal and axial images are created from isotropic volume data.

3-D Imaging: Provides excellent image quality with surface shaded-renderings and volume-rendered 3-D images. Provides zooming and panning over the 3-D surface and performs distance measurements. Other features include:

- 3-D surface display
- 3-D shaded volume display
- Maximum intensity projection (Max - IP)
- Minimum intensity projection (Min - IP)
- Intensity volume rendering

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

TOSHIBA
Leading Innovation >>>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

Quantitative Analysis
- Profile display of CT numbers along a selected line in the axial plane
- Distance measurement and display
- CT number display
- Histogram display
- Circulatory function analysis fits a curve to CT number changes over time for a selected region of interest (ROI)
- Functional images based on peak height, peak time, appearance time, area under curve, mean transit time, second moment and transit time
- ROIs can be rectangular, circular or irregular

Image Manipulation
- Vari-area allows pre-selection of ROI for accurate display field of view (DFOV) using raw data for immediate viewing
- User-defined, post-processing filters for edge enhancement and smoothing

Annotation
- Four lines of comments and arrow display
- 36 exam information fields that can be selectively masked or shown depending on site requirements

eXam Plan Protocols
- 684 eXam Plan protocols that can be adjusted while scanning
- Four preset reconstructions
- eXam Plan sets can be stored on optical disks and copied to other Toshiba scanners

Archiving
- Can be automated with each eXam Plan
- Data can be stored on and retrieved from MOD
- Raw data and image data can be protected to prevent deletion

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

TOSHIBA
Leading Innovation >>>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

Filming
- Auto filming can be set as part of the eXam Plan
- Images are displayed in 512x512 or 1024x1024

CUSTOMER CARE SERVICES

InnerVision
Remote diagnostics proactively monitor the system to minimize downtime

Image Maker Express
The Image Maker Express is a marketing support online resource designed exclusively for Toshiba customers that helps you create outreach programs to generate awareness about your imaging services.
- Includes positioning and messaging guides to help you strategize your communications efforts and tactics
- Contains product information, ready-to-use collaterals, and ideas for creating custom materials to promote your new imaging capabilities

Image Maker Express gives you access to:
- Product images
- Clinical images
- PowerPoint presentations
- Sample brochures
- Sample press releases
- Marketing strategy tutorials
- Updates at www.imagemaker.toshiba.com/express

**Offerings may vary per product*

Build demand by:
- Sending a press release
- Developing a strategic plan
- Creating brochures
- Finding tips on effective presentations

TOSHIBA
Leading Innovation >>>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

Application Training
Each system includes three phases of training.

Phase I: A one-week intensive course on the operation of the scanner
- Conducted at the Toshiba Training Academy in Irvine, California
- Accredited for continuing education by the ASRT Education Foundation
- Two attendance vouchers good for course and travel expenses provided with each system
- One technologist must attend prior to system installation
- The second voucher is valid for six months following installation
- Additional vouchers available for $3,500

Phase II: 32 hours of training that builds on the Phase I academy training
- On-site at client facility
- Training for up to four technologists
- Technologist who attends the academy course must attend Phase II

Phase III: 32 hours of follow-up training
- On-site at client facility
- Approximately 8-10 weeks after Phase II training

Additional On-Site Training:
Additional On-site training available for purchase.

Applications support is available by phone on the toll-free ASSIST line.

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

TOSHIBA
Leading Innovation >>>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

COMPONENT SUMMARY:

#CA-3110P	**AQUILION LB EXTENDED COUCH**
TSX-201A/1L	**CT SCANNER AQ LB WITH EXTENDED COUCH**
CT-9058	**CT ACCESSORY KIT - EXTENDED COUCH 1800 MM**

Accessory Kit for Extended Couch -Includes each of the following items:

- "The Shield" Table Pad
- Rolled Edge Foot Extension Pad
- Protective Table Cover
- Chin Strap
- Forehead Strap with Adult Pad
- Adult Head Rests
- Tilt Wedge
- Knee Wedge
- Coronal Head Positioner
- Pediatric Lift Pad

CAFT-016A/1B — **MED-TEC IPPS™ CT INSERT TABLETOP FOR EXTENDED 1800 MM COUCH**

The IPPS™ CT Couch Overlay is designed to provide rapid, accurate, and repeatable patient setup and localization. The MED-TEC indexing system provides convenient and consistent orthogonal alignment.

- Optimum patient comfort
- Treatment flexibility
- Quick set-up and ease-of-use
- Highly repeatable patient positioning

Note: Applies to Aquilion 64, 32, 16, 8 and Super 4 ***extended 1800 mm couches.***

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

TOSHIBA
Leading Innovation >>>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

DCHIS-CT-PHANTM	**CT PHANTOM**
	Measures image quality to ensure compliance to Toshiba standards for: • High-contrast resolution • Low-contrast resolution • Slice thickness • Noise • Contrast scale
SK-03050-1	**CONSOLE DESK 65" X 36" X 30"**
	Measures 65" x 36" x 30"
E31752-CHAIR (Qty 2)	**CHAIR WITH ADJUSTABLE ARMS AND BACK**
LM-HB94LU (Qty 5)	**MEDIA FOR DVD-RAM DRIVE (9.4 GB)**
	9.4 GB Removable Cartridge Media for DVD-RAM Drive. • Type 4, Double-sided • 3x Speed
L88C5EGRY-05M	**CABLE CATEGORY 5E/RJ45 5M**
L88C5EGRY-35M	**CABLE CATEGORY 5E/RJ45 35M**
TNULL9F9M-75 (Qty 2)	**SERVICE MODEM CABLE**
1559	**FLOOR LEVELING EPOXY KIT**

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

TOSHIBA
Leading Innovation >>>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

COT-32D	**DICOM MODALITY WORKLIST MANAGEMENT (MWM) SERVICE CLASS USER (SCU) SYSTEM**

Allows the CT system to receive patient demographic data from an HIS/RIS system in conformance with the DICOM 3.0 standard.

Note: This option does not include a DICOM gateway for the HIS/RIS system.

#GATING-RESPLB	RESPIRATORY GATING PACKAGE

Toshiba's Respiratory Gating option provides a comprehensive package of hardware and software for the Aquilion LB to perform 4-D respiratory gating using the Varian RPM system. This provides tumor tracking during respiration. The system detects the patient's respiratory cycle prior to scanning and allows the user to define respiratory phase or phases for gated scanning or image reconstruction.

Toshiba's Prospective Respiratory Gating software will allow you to acquire multiple series of Axial scans that correspond to multiple phases of inspiration provided by Varian RPM system or you may choose to acquire only one series of axial scans at a pre selected phase, example inspiration, in order to reduce table time and exposure.

Toshiba's Retrospective Respiratory Gating software will allow you to acquire a single low pitched helical scan. During this scan the raw data is tagged with time information that is received from the Varian RPM system. After the scan is completed the images are reconstructed in the selected phases by the CT system. Up to 10 phases can selected for reconstruction.

TOSHIBA
Leading Innovation >>>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

Respiratory Gating 4D package includes:

- Toshiba Respiratory Gating Software (CKRS-003A/1B) for acquisition and reconstruction of Prospectively Gated Images.
- Toshiba Respiratory Gating Software (CKRS-003B/1B) for acquisition and reconstruction of Retrospectively Gated Images.
- Varian RPM PC Workstation running the system software. The monitor displays motion data, live video images from the tracking camera, and, in the standard simulation room.
- Varian Reflective Marker Block which you position on the patient to track respiration motion.
- Varian Tracking Camera. The (CCD) tracking camera acquires video images of the marker block.
- In-room viewfinder (monitor) that shows the image from the tracking camera to confirm visualization of the marker block position by the camera.

Important Note – This package only provides respiratory gating acquisition capability. It is recommended that the end user have a CT Sim workstation or Treatment planning system that supports 4-D analysis and image manipulation.

Note – Med-Tec IPPS™ CT Insert Tabletop is required for mounting of the Respiratory Gating camera. This item comes standard with the Aquilion Large Bore.

<RPM-VARIAN2	**VARIAN RPM RESPIRATORY GATING**
<CKRS-003B/1B	**RESPIRATORY GATING SYSTEM**
<CKRS-003A/1B	**RESPIRATORY GATING JAN06~**

PURCHASER		TOSHIBA REP/ CONTACT	
INITIALS	DATE	INITIALS	DATE

TOSHIBA
Leading Innovation >>>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER DETAIL

OMT NO: 374952
DATE: 3/15/2010 QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

PCDU-TW/U **POWER CONDITIONER/DISTRIBUTOR 125 KVA UNIVERSAL**

The PCDU-CT is engineered to address the vast majority of common power problems found in the hospital environment, thus providing clean power and good grounding for optimal reliability and performance of CT systems.

This device provides most of the electrical site preparation requirements of Toshiba CT systems, including:

Power Conditioning
The PCDU contains a combination of a shielded, ultra-low impedance isolation transformer with matched L-R-C low-pass filters and surge suppressors. The quality of power to the Toshiba system is improved in many ways:

- The isolation transformer re-references the power line to the local ground point (with connection to local building steel), isolating the system from upstream, ground-quality problems.
- The transformer shield helps protect against ground impulses and noise (*common mode* disturbances).
- The sine wave tracking filter protects against both high-frequency noise and fast-voltage impulses (*normal mode* disturbances), clamping spikes and filling-in notches.
- The surge suppressors protect against slower voltage impulses that have frequency below the filter cutoff.

Voltage Conversion
Wiring costs are significantly reduced since the PCDU accepts a single, 480V delta input with code minimum ground, supplying 120/208V wye to the generator and the various other parts of the system.

Distribution
The PCDU comes prepackaged with the distribution breakers needed for each system feed. Having all system breakers in one location also makes it easier for service personnel to remove power.

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

TOSHIBA
Leading Innovation >>>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

Control
The PCDU includes a circuit breaker on the input (primary) and a 24 VAC control signal for remote, emergency off control of the circuit breaker.

Impedance Control
The ultra-low impedance design of the isolation transformer helps ensure the power feed meets the low impedance requirement of today's CT labs as spelled out in the Toshiba Optimal Power Specifications (TOPS) manuals.

Planning
Planning is simplified by having all these components and functions delivered in a single box.

Installation
Installation is much faster, more predictable, and less expensive with a factory-assembled and tested system.

Approvals
UL listing will reduce time and uncertainties obtaining local electrical inspection approvals.

Reduced Site Preparation Costs
The PCDU comes equipped with an input-shunt, trip-circuit breaker, eliminating, in most cases, the need for a room breaker. Only an Emergency Power Off button for remote breaker control is required.

Note: Not for use with Aquilion ONE

TOTAL QUOTE PRICE **$599,266.00**
Applicable Sales Tax Additional

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

TOSHIBA
Leading Innovation >>>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

ADDENDUM

ALL INFORMATION CONTAINED IN THIS QUOTATION IS CONFIDENTIAL AND MAY NOT BE DISCLOSED TO ANY THIRD PARTY WITHOUT TOSHIBA'S PRIOR WRITTEN CONSENT.

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

TOSHIBA
Leading Innovation >>>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

PRODUCT WARRANTY AND SERVICES COVERAGE

SYSTEM WARRANTY TERMS
Toshiba America Medical Systems, Inc. (TAMS) warrants to Customer that the product(s) to be delivered hereunder will be free from defects in material, manufacturing workmanship, and title. Any product or part furnished to Customer during the warranty period (stated in the table below) to correct a warranty failure shall be warranted to the extent of the unexpired term of the warranty applicable to the repaired or replaced product or part.

The warranty period shall commence on the date the Product is delivered to Customer. However, if TAMS installs the product, the warranty period for such product shall commence on the date the installation of the product is complete. Notwithstanding the foregoing, in the event that the installation of the product is delayed for a total of thirty (30) days or more from the date of delivery for any reason or reasons for which TAMS is not responsible, the warranty period for such product may, at TAMS' option, commence on the thirtieth (30th) day from the date such product is delivered to Customer.

WARRANTY EXCLUSIONS
Warranty coverage does not include any defect which results, in whole or in part, from (1) negligent storage or handling of the product by Customer, its employees, agents, or contractors, (2) failure of Customer to prepare the site or provide power requirements or operating environmental conditions in compliance with any applicable instructions or recommendations of TAMS, (3) absence of any product, component, or accessory recommended by TAMS but omitted at Customer's direction, (4) any design, specification or instruction furnished by Customer, its employees, agents, or contractors, (5) any alteration of the product by persons other than TAMS, (6) combining TAMS' product with any product furnished by others, (7) combining incompatible products of TAMS, (8) improper use of the product, improper maintenance of the product by a party other than TAMS, or failure to comply with any applicable instructions or recommendations of TAMS, or (9) acts of God, acts of civil or military authority, fires, floods, strikes or other labor disturbances, war, riot, or other causes beyond the reasonable control of TAMS.

TAMS does not warrant any products not manufactured by Toshiba such as, without limitation, monitors, cameras, computer equipment, etc. Such items will be furnished subject only to the manufacturer's warranty, if any, and without any warranty whatsoever by Toshiba.

Warranty coverage also excludes consumables, including but not limited to cryogens, cassettes, magazines, imaging screens, disks, cartridges, etc.

GLASSWARE WARRANTY
Glassware, including X-ray tubes and Image Intensifiers, are provided separate warranties. Glassware included with the purchase of a new system is governed by the glassware warranty, described below, not the system warranty.

CT X-ray tubes carry a prorated warranty based on the number of rotations shown below or 12 months, whichever comes first.

Tube Type	Prorated Warranty
CXB-350	150,000 rotations*
CXB-400 (Helicool)	150,000 rotations*
CXB-650	150,000 rotations*
CXB-750/D/4A (Megacool™)	200,000 rotations*
CXB-750/E/2A (Megacool™ V) Aquilion Premium	100,000 rotations*
CXB-750/E/2A (Megacool™ V) Aquilion ONE	100,000 rotations*

*A rotation is any 360-degree or single rotation of the gantry with X-rays on.

The following time-based warranty terms apply to all other glassware:

Tube Type	Time-Based Warranty
Liquid Bearing Tubes (DSRX-TXXXX)	12 months, non-prorated
All Other X-ray tubes	12 months, non-prorated
Image Intensifiers	18 months, non-prorated

GLASSWARE PRORATION CALCULATION:
Credits for glassware that fails during the warranty periods stated above will be calculated as follows:

Tubes with Prorated Rotation Warranty:

$$\text{Credit} = 1 - \frac{\text{Number of Rotations Used}}{\text{Number of Rotations Warranted}}$$

Credit will be applied to the purchase of the replacement X-ray tube or Image Intensifier. Complete glassware coverage during warranty period may be purchased from the local services organization at an additional charge.

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

TOSHIBA
Leading Innovation >>>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

Tubes with Non-Prorated, Time-Based Warranty:

Tubes with a non-prorated warranty will be replaced during the initial warranty period at no charge to the customer. The replacement tube carries the remainder of the original warranty. For example, a tube with a 24-month non-prorated warranty fails at month thirteen (13), the tube is replaced at no charge and carries eleven (11) months of warranty.

REMEDIES
If TAMS determines that any product fails to meet any warranty during the applicable warranty period, TAMS shall correct any such failure by either, at its option, repairing, adjusting, or replacing without charge to Customer any defective or nonconforming parts of the product. TAMS shall have the option to furnish either new or remanufactured replacement parts or assemblies. During the warranty period, Toshiba will furnish free of charge any upgrades, including software required to correct any defect in the warranted products or as required under applicable laws.

WARRANTY SERVICE
Warranty service during the applicable warranty period will be performed without charge to Customer during TAMS' normal business hours, Monday through Friday, excluding holidays. Subject to the availability of personnel, after-hours service is available upon request at an additional charge.

The remedies set forth herein are conditional upon Customer promptly notifying TAMS within the applicable warranty period of any defect or nonconformance and making the product available for correction.

DISCLAIMERS AND LIMITATIONS ON LIABILITY
TAMS' obligation to repair or replace defective parts will be Customer's sole and exclusive remedy for a breach of the warranty set forth above. SUCH WARRANTY WILL BE IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION, THE WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

In no event shall TAMS be liable for special, incidental or consequential damages. Toshiba does not warrant that the operation of the warranted products will be uninterrupted.

WARRANTIES BY PRODUCT LINE

	COMPUTERIZED TOMOGRAPHY	MAGNETIC RESONANCE	PACS SYSTEMS	ULTRASOUND	X-RAY VASCULAR	X-RAY R/F & RAD
SYSTEMS AND MAJOR COMPONENTS	12 Months	12 Months	12 Months	12 Months	12 Months	12 Months
ACCESSORY OPTIONS	6 Months	6 Months	6 Months	6 Months	6 Months	6 Months
REPLACEMENT & OPTIONAL PARTS	90 Days	90 Days	90 Days	90 Days	90 Days	90 Days
UPGRADE COMPONENTS	90 Days	90 Days	N/A	12 Months	6 Months	6 Months
MISC. WARRANTY ITEMS	Detectors: Solid State 12 Months	N/A	N/A	Transducers: 12 Months	N/A	N/A

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

TOSHIBA
Leading Innovation >>>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

TERMS AND CONDITIONS OF SALE

1. GENERAL TERMS. Unless otherwise specified on the face of this document, this Quotation/Order ("Agreement") will remain valid only if accepted by Customer no later than 60 days from date of submission to Customer.

2. TITLE AND RISK OF LOSS. Title and risk of loss to the Equipment purchased under this Agreement will pass to Customer: (a) if Toshiba is to provide installation, upon Toshiba's completion of installation, or (b) if Toshiba will not provide installation, upon delivery by Toshiba to a common carrier at Toshiba's facility from which the Equipment is shipped.

3. TERMS OF PAYMENT. Unless otherwise specified on the face of this document, prices stated are F.O.B. Customer's facility. All taxes which are payable by Toshiba in connection with the sale, use, or possession of the Equipment (excluding income taxes), will be paid by Customer in addition to the quoted price. Terms of payment for, C.T., M.R.I, X-Ray, and the McKesson System will be cash-10% upon execution of this Agreement, 70% upon delivery, balance due upon completion of installation and/or availability for first use, whichever is earlier. Terms of payment for Ultrasound and Nuclear will be cash-10% upon execution of this Agreement, 90% NET upon completion of installation and/or availability for first use, whichever is earlier. All invoices paid after due date will be assessed a late payment charge of the lesser of 1 1/2% per month or the maximum rate permitted by law.

4. DELAYS. If Customer changes the scheduled delivery date specified on the face of this document ("Scheduled Delivery Date") during the period of 120 days preceding such date, Customer will nevertheless pay the installment of the purchase price which would have been payable upon delivery, on the Scheduled Delivery Date as if delivery had been made on such date. In addition, Customer will pay all extra costs incurred by Toshiba as a result of such delay, including, without limitation, storage and transportation. Storage fees will be charged at commercially comparable rates for storage on Toshiba's site. If delivery is delayed by 12 months or more from the Scheduled Delivery Date, except through the fault of Toshiba, the price set forth in this Agreement may be increased by Toshiba to a level equal to the prevailing price in effect at the time of the revised delivery date.

5. ACCEPTANCE BY TOSHIBA. This Quotation/Order will not be binding on Toshiba even if signed by a Toshiba employee, until Customer's order for the Equipment is booked by Toshiba's Headquarter office.

6. EQUIPMENT INSTALLATION. Toshiba will install all Equipment purchased under this Agreement and connect them to existing power and/or plumbing lines at no additional charge to Customer. Customer will be responsible for electrical wiring, plumbing, carpentry, plastering, painting, or all other site preparation required prior to installation and connection of the Equipment by Toshiba. Customer will provide space at the installation site for the safe storage of Toshiba's tools, test equipment and other materials used for installation at no charge to Toshiba. Customer shall, at its cost, obtain all permits and licenses required by governmental authorities in connection with the installation and operation of the Equipment. The Equipment may contain certain components, which may have been re-manufactured. However, such components will meet the manufacturer's specifications for new components as of the date of completion of installation. Customer acknowledges that the System and Software are designed to operate within certain power, temperature, airborne contamination, and humidity ranges. Customer will be responsible for, without limitation: (i) preparing and maintaining the Customer facility in conformance with the Site Preparation Guide; (ii) maintaining its network infrastructure; (iii) providing Toshiba, McKesson or its subcontractors access to a network connection in or near the area of the System being serviced by the equipment service staff; and (iv) supplying computer grade AC power. The Equipment relies upon a stable grounded connection to the main power grid in order to function effectively. Customer acknowledges that AC power supply quality may be a problem in old facilities or in those facilities receiving poor quality utility service and that power conditioning may be necessary in such cases.

7. EQUIPMENT OPERATION AND INDEMNITY. Customer agrees that all Equipment purchased under this Agreement will be operated exclusively by duly qualified technicians and/or medical doctors in a safe and reasonable manner in accordance with Toshiba's written instructions, applicable laws and regulations, and for the purposes for which such Equipment was intended.

8. LIMITED WARRANTY AND REMEDY. **A. For the Toshiba Equipment:** For the warranty period described below by product, Toshiba, as its only obligation, will replace or repair, without charge to Customer during Toshiba's normal working hours (if Customer requests warranty service outside such hours, Customer will pay overtime premium for labor), any component of the Equipment that is defective in materials or workmanship, provided such defect is reported to Toshiba within the warranty period. Toshiba's warranty

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

TOSHIBA
Leading Innovation >>>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER DETAIL

OMT NO: 374952
DATE: 3/15/2010 QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

period is as follows: (a) Systems and Major Components - one year from date of completion of installation; (b) Accessories/Options (except glassware) - six months from date of completion of installation. Components not manufactured by Toshiba will be furnished subject only to the manufacturer's warranty, if any, and without any warranty whatsoever by Toshiba. During the warranty period, Toshiba will furnish free of charge any upgrades, including software required to correct any defect in the Equipment or as required under applicable laws.

B. For the McKesson System: The McKesson System ("System") will be covered by a 12-month warranty beginning the date of completion of installation of the System (the "Warranty Period"). The warranty covers repair of any defects in materials or workmanship related to the computer equipment ("Equipment") that is included in the System purchased by Customer under this Agreement. The warranty also covers correction of any McKesson software ("Software") that does not conform with its functional specifications. In order to receive services during the Warranty Period, Customer must provide McKesson and Toshiba with remote access through a VPN. During the Warranty Period, Customer is entitled to (a) all Generally Available Software Updates except for Updates that are separately priced and marketed by Toshiba or McKesson, and (b) all Generally Available Software Upgrades, except for Upgrades that are separately priced and marketed by Toshiba or McKesson. ***"Software Updates"*** means Software modifications, enhancements, corrections, improvements, and patches to the existing functionality of Customer's licensed version of the McKesson Software (e.g., version 4.1 to 4.3 to 4.5). ***"Software Upgrades"*** means new versions and future releases of the McKesson Software (e.g. version 4.x, 5.x, 6.x). Software Updates or Upgrades that provide new features not originally purchased may be separately priced and marketed. Software Updates and Software Upgrades to the McKesson Software will be delivered remotely, on-line. The warranty does not include any non-McKesson Software, the labor and travel expenses associated with on-site installation of a Software, or any hardware addition or modification.

The warranty set forth in this Section will not apply:

a. if Customer operates the Software on equipment other than Equipment purchased from Toshiba or attaches other equipment to the System not approved by Toshiba;
b. if a person or entity other than McKesson or its authorized third party suppliers modifies the Software;
c. as a result of Customer's improper use, abuse, neglect of the Equipment, including failure to maintain environmental conditions within the operating range specified by the Equipment manufacturer or accident;
d. as a result of viruses or other corruption caused by external entities; or
e. for damages resulting from a Force Majeure condition described in Section 13 below.

C. The Following Applies to Both the Toshiba Equipment and the McKesson System: Toshiba does not warrant that the operation of the Equipment of the System will be uninterrupted. All defective parts replaced by Toshiba will become the property of Toshiba. Replacement parts may be re-manufactured. However, such parts will meet the manufacturer's specifications for new components as of the date of completion of installation. TOSHIBA'S OBLIGATION TO REPAIR OR REPLACE DEFECTIVE PARTS OR SOFTWARE WILL BE CUSTOMER'S SOLE AND EXCLUSIVE REMEDY FOR A BREACH OF THE WARRANTY SET FORTH IN THIS AGREEMENT. SUCH WARRANTY WILL BE IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION, THE WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. The warranty set forth in this Agreement will not apply to, and Toshiba will not be liable for any defects resulting from misuse, repairs performed by unauthorized third parties, accidents, acts of God, or neglect of anyone other than Toshiba.

9. **LIMITATION OF LIABILITY.** NEITHER TOSHIBA NOR CUSTOMER WILL UNDER ANY CIRCUMSTANCES BE LIABLE FOR CONSEQUENTIAL, SPECIAL, INCIDENTAL, OR EXEMPLARY DAMAGES OR ECONOMIC LOSS ARISING OUT OF OR RELATED TO THE TRANSACTIONS CONTEMPLATED IN THIS AGREEMENT, EVEN IF EITHER PARTY IS APPRISED OF THE LIKELIHOOD OF SUCH DAMAGES OCCURRING. IN NO EVENT WILL EITHER PARTY'S LIABILITY TO THE OTHER (WHETHER BASED ON AN ACTION OR CLAIM IN CONTRACT, TORT, INCLUDING NEGLIGENCE, STRICT LIABILITY, OR OTHERWISE) ARISING OUT OF OR RELATING TO THE TRANSACTIONS CONTEMPLATED IN THIS AGREEMENT EXCEED THE AGGREGATE AMOUNT ACTUALLY PAID BY CUSTOMER TO TOSHIBA UNDER THIS AGREEMENT. THE LIMITATION OF LIABILITY SET FORTH ABOVE WILL NOT APPLY TO CLAIMS FOR PERSONAL INJURY OR PROPERTY DAMAGE CAUSED BY EQUIPMENT DEFECTS, OR TO CLAIMS FOR PATENT INFRINGEMENT.

10. **SECURITY INTEREST.** Toshiba hereby reserves and Customer grants to Toshiba a security interest pursuant to the Uniform Commercial Code, in and to the Equipment (and all products and proceeds of it) until full payment of the purchase price is received.

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

TOSHIBA
Leading Innovation >>>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

11. REMOVAL OF EQUIPMENT. Until Toshiba has received full payment of the purchase price, Customer will not remove all or any part of the Equipment from Customer's premises, nor will Customer sell, lease, transfer or otherwise part with the possession of, or permit any lien or encumbrance to be placed on all or any part of the Equipment.

12. REMEDIES OF TOSHIBA. If Customer fails to make any payment when due under this Agreement or under any other agreement between Customer and Toshiba, or becomes insolvent or makes an assignment for the benefit of creditors, or if a petition in Bankruptcy is filed by or against Customer, or if the financial responsibility of Customer becomes impaired or unsatisfactory in Toshiba's reasonable judgment, or if Customer otherwise breaches any of the terms and conditions of this Agreement, then Toshiba may, without prior notice or demand, defer shipments, cancel the balance of the order, suspend performance of any obligation (including without limitation, all obligations set forth under Limited Warranty And Remedy above), and/or take immediate possession of the Equipment delivered, until the full purchase price of the Equipment is paid by Customer or, at Toshiba's discretion, until security satisfactory to Toshiba is given by Customer. Any costs incurred by Toshiba as a result of suspending performance or repossession or collection will be payable by Customer. Toshiba may sell repossessed Equipment with proceeds to be applied to unpaid balance and expenses incurred in sale, repossession and collection. Customer will pay any remaining deficiency. Toshiba may exercise any other rights available to it by law.

13. EXCUSED PERFORMANCES. Neither party will be liable to the other for non-performance or delay in performance resulting directly or indirectly from any occurrences beyond such party's control, including without limitation, strikes or other labor troubles, acts of God, war, accidents, fires, floods, other catastrophes, inclement weather, transportation, unavailability of materials and labor, delays caused by suppliers, or laws, regulations, or acts of any governmental agency.

14. SOFTWARE. All rights and interest in any software that may be furnished under this Agreement, and any updates and enhancements to it, will remain the property of Toshiba. Such software is being furnished to Customer under a non-exclusive license. Customer will not, or allow others to decompile, modify, copy, reproduce, or transcribe the software nor allow third parties to use the same without Toshiba's prior written consent. Upon Toshiba's request, Customer will execute an End-User Software License Contract, in a form to be mutually agreed between the parties.

15. CANCELLATION. Customer may not cancel the order subject to this Agreement except with Toshiba's prior written consent. In the event of such cancellation, Toshiba will be entitled to recover any and all damages suffered by it caused by the cancellation as allowed by law, but in no event less than an amount equal to twenty percent (20%) of the purchase price for a restocking charge.

16. ASSIGNMENT. Neither party may assign any of its obligations under this Agreement without the prior written consent of the other party However, some of the obligations stated in this Agreement, such as the ones relating to installation of the McKesson System and warranty may be performed by Toshiba's contractors or suppliers.

17. EXPORT REGULATIONS. This Agreement involves products, and/or technical data that may be controlled under the U.S. Export Administration Regulations and may be subject to the approval of the U.S. Department of Commerce prior to export. Any export or re-export by Customer, directly or indirectly, in contravention of such Regulations is prohibited.

18. ENTIRE AGREEMENT. This quotation as well as the attached McKesson Pass Through Terms and Conditions contains the entire agreement between the parties and supersedes all prior and contemporaneous agreements between the parties, whether oral or written, relating to its subject matter, including, without limitation, all different or additional terms and conditions which may be contained in Customer's bid documents, purchase order or any other documents furnished by Customer. The provisions of this Agreement may not be modified unless in writing and executed by both parties.

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

VARIAN
medical systems

Quotation

TYM20091020-001

Hartford Hospital, Hartford, CT

Item	Qty	Product Description	Offer Price
Section 1		**Acuity and Gating Move for H770168 / H780168**	
1.01	1	**Removal**	Included
1.02	1	**Equipment inspection and preparation for move.**	3,000.00
1.03	1	**Rig-out and Varian supervision**	5,500.00
1.04	1	**Installation**	Included
1.05	1	**New site coordination**	2,500.00
1.06	1	**Rig-in and Varian supervision**	5,500.00
1.07	1	**Installation of Lasers and Gating**	5,000.00
1.08	1	**Acuity Installation (7-10) days**	27,000.00
1.09	1	**Completion of move will be upon acceptance.** Acceptance will be SVS and CAP.	Included
		Section Total $	48,500.00
Section 2		**Customer Responsibility Section**	
2.01	1	**Customer will reuse base frame and cables.** Customer will extract baseframe and cables from current vault and reuse it in the new vault. All costs associated with this activity are the sole responsibility of the Hartford Hospital, Hartford, Ct. The condition of the base frame and cables post extraction must be in excellent condition for reuse in new vault. Any issue which causes delay or necessity for replacement of the cables for proper operation of the Acuity for control signals and power will be done on a T&M basis. Customer will grout the base frame using in-house facilities.	Included
		Section Total $	0.00
		Quotation Total $	48,500.00

VARIAN
medical systems

Quotation

TYM20091020-001

Hartford Hospital, Hartford, CT

Item	Qty	Product Description	Offer Price

Terms & Conditions of Sale

This offer is subject to credit approval and is exclusive of any applicable sales taxes or duties.

Early Termination Hardware Support Agreements:

Customer may, without charge, terminate this Hardware Support Agreement after thirty (30) days written notice and opportunity to cure in the event of material default by Varian. Customer may further, without charge, terminate this Hardware Support Agreement with respect to the Covered Product in the event the Covered Product is replaced by another product supplied by Varian. If this Hardware Support Agreement covers multiple Covered Products, and is terminated as to some, but not to all the covered products, Varian will adjust the Maintenance Fee in an appropriate manner to reflect removal of the replaced Covered Product, such adjustment to be determined by Varian in its sole and absolute discretion. Customer may terminate for any other reason upon ninety (90) days written notice to Varian and payment for the amount applicable to service performed, including parts supplied and labor, of period expired plus 25% of the remaining annual contract fee for the year in which terminated. Varian may terminate this Support Agreement without notice and without refund or other liability in the event of default by Customer. This Support Agreement will terminate automatically if Customer becomes insolvent.

Customers, who prematurely terminate this Hardware Support Agreement and have received under it, deferred payment terms for new hardware, additional software licenses or an Upgrade Release, will be liable for the cost of the hardware, licenses or Upgrade as defined in the non-contract quotation provided by the Varian Upgrades Department. The Cost includes all hardware, software, installation labor, and applications training provided to perform the Upgrade. Payment is due within thirty (30) days of termination.

Early Termination Software Support Agreements:

Customer may, without charge, terminate this Software Support Agreement after thirty (30) days written notice and opportunity to cure in the event of material default by Varian. Customer may further, without charge, terminate this Software Support Agreement with respect to the Covered Product in the event the Covered Product is replaced by another product supplied by Varian. If this Software Support Agreement covers multiple Covered Products, and is terminated as to some, but not to all the covered products, Varian will adjust the Maintenance Fee in an appropriate manner to reflect removal of the replaced Covered Product, such adjustment to be determined by Varian in its sole and absolute discretion. Customer may terminate for any other reason upon ninety (90) days written notice to Varian and payment for the amount applicable to service performed of period expired plus 25% of the remaining annual contract fee for the year in which terminated. Varian may terminate this Support Agreement without notice and without refund or other liability in the event of default by Customer. This Support Agreement will terminate automatically if Customer becomes insolvent.

Customers, who prematurely terminate this Software Support Agreement and have received under it, deferred payment terms for new hardware, additional software licenses or an Upgrade Release, will be liable for the cost of the license or Upgrade as defined in the non-contract quotation provided by the Varian Upgrades Department. The Cost includes all hardware, software, installation labor, and applications training provided to perform the Upgrade. Payment is due within thirty (30) days of termination.

FINANCING AVAILABLE: For lease and finance plans, call Tony Susen, Director - Varian Customer Finance, at (508) 668-4609.

000042

VARIAN
medical systems

Quotation

TYM20091020-001 Page: 1

Quotation For:

Bob Lindeyer
Hartford Hospital
80 Seymour Street
Hartford, CT 06101
(860) 545 - 4346 FAX: (860) 545 - 1500

Please address inquiries and replies to:

Timothy Macfarlane
Varian Medical Systems
11 Commerce Drive
Second Floor
Cranford, NJ 07016
(732) 499 - 2260 FAX: (732) 381 - 1060
timothy.macfarlane@oscs.varian.com

Your Reference:	*Quotation Firm Until:* **December 9, 2009**
FOB Point:	*Shipping Allocation:*
Payment Terms:	**Varian Terms and Conditions of Sale 1652T Attached**

Acuity and Gating Move for H770168 / H780168
Customer Responsibility Section

Hartford Hospital

Quotation Total of: USD $48,500 Accepted by:

Signature: _____

Name: _____

Title: _____

Date: _____

For this purchase, we designate **NOVATION** as our Institution's Primary Group Purchasing Organization affiliation. Any change will be Indicated below:

☐ **AmeriNet**	☐ **Aptium**	☐ **BJC**	☐ **Broadlane**
☐ **CHW**	☐ **Consorta/HPG**	☐ **KP Select**	☐ **Magnet**
☐ **Matrix**	☐ **MedAssets**	☐ **Novation**	☐ **Premier**
☐ **ROI**	☐ **USO**	☐ **VA Gov**	☐ **None**

Varian Medical Systems

Submitted by:

_____
(Signature)

Name: **Timothy Macfarlane**

Title: **District Manager**

Date: **October 20, 2009**

VARIAN
medical systems

Quotation

TYM20091020-001

Hartford Hospital, Hartford, CT

Item	Qty	Product Description	Offer Price

Terms & Conditions of Sale

This offer is subject to credit approval and is exclusive of any applicable sales taxes or duties.

Early Termination Hardware Support Agreements:

Customer may, without charge, terminate this Hardware Support Agreement after thirty (30) days written notice and opportunity to cure in the event of material default by Varian. Customer may further, without charge, terminate this Hardware Support Agreement with respect to the Covered Product in the event the Covered Product is replaced by another product supplied by Varian. If this Hardware Support Agreement covers multiple Covered Products, and is terminated as to some, but not to all the covered products, Varian will adjust the Maintenance Fee in an appropriate manner to reflect removal of the replaced Covered Product, such adjustment to be determined by Varian in its sole and absolute discretion. Customer may terminate for any other reason upon ninety (90) days written notice to Varian and payment for the amount applicable to service performed, including parts supplied and labor, of period expired plus 25% of the remaining annual contract fee for the year in which terminated. Varian may terminate this Support Agreement without notice and without refund or other liability in the event of default by Customer. This Support Agreement will terminate automatically if Customer becomes insolvent.

Customers, who prematurely terminate this Hardware Support Agreement and have received under it, deferred payment terms for new hardware, additional software licenses or an Upgrade Release, will be liable for the cost of the hardware, licenses or Upgrade as defined in the non-contract quotation provided by the Varian Upgrades Department. The Cost includes all hardware, software, installation labor, and applications training provided to perform the Upgrade. Payment is due within thirty (30) days of termination.

Early Termination Software Support Agreements:

Customer may, without charge, terminate this Software Support Agreement after thirty (30) days written notice and opportunity to cure in the event of material default by Varian. Customer may further, without charge, terminate this Software Support Agreement with respect to the Covered Product in the event the Covered Product is replaced by another product supplied by Varian. If this Software Support Agreement covers multiple Covered Products, and is terminated as to some, but not to all the covered products, Varian will adjust the Maintenance Fee in an appropriate manner to reflect removal of the replaced Covered Product, such adjustment to be determined by Varian in its sole and absolute discretion. Customer may terminate for any other reason upon ninety (90) days written notice to Varian and payment for the amount applicable to service performed of period expired plus 25% of the remaining annual contract fee for the year in which terminated. Varian may terminate this Support Agreement without notice and without refund or other liability in the event of default by Customer. This Support Agreement will terminate automatically if Customer becomes insolvent.

Customers, who prematurely terminate this Software Support Agreement and have received under it, deferred payment terms for new hardware, additional software licenses or an Upgrade Release, will be liable for the cost of the license or Upgrade as defined in the non-contract quotation provided by the Varian Upgrades Department. The Cost includes all hardware, software, installation labor, and applications training provided to perform the Upgrade. Payment is due within thirty (30) days of termination.

FINANCING AVAILABLE: For lease and finance plans, call Tony Susen, Director - Varian Customer Finance, at (508) 668-4609.

000044

October 23, 2009

Mr. Robert Lindeyer
Hartford Hospital Cancer Center
80 Seymour Street
Hartford, CT 06115

PROPOSAL to provide support services for the installation of a new Toshiba Aquilion-LB CT Scanner and relocate existing Varian Acuity Simulator.

DONATI PROPOSAL No. 361-09

Dear Bob:

DONATI CONTRACTING is pleased to submit this BUDGET proposal for the installation of your new Toshiba Aquilion-LB CT scanner and the relocation of your existing Varian Acuity Simulator. As we understand it, our effort is to include the following:

ROOM # 111
Remove existing base frame from room #111concrete floor and save for relocation in room # 107
Cut concrete floor to accommodate new Toshiba Aquilion LB CT scanner base frame and power trench.
Install base frame and grout in place
Patch and repair flooring finishes
Modify existing bi-fold door with new hardware
Modify existing power configuration for new equipment installation

ROOM # 107
Remove existing base frame and millwork closets
Cut concrete floor to accommodate Varian Acuity Simulator base frame and modify power trench.
Install base frame and grout in place.
Patch and repair flooring finishes
Run new conduits from control room to rear of equipment
Modify existing power configuration for equipment installation from existing power in hot lab room.

Our price for the work described above is $97,500.00 Tax Exempt.
(Ninety-Seven Thousand Five Hundred Dollars)

411 Summer Street • Plantsville, CT 06479
Phone (860) 621-3325 • Fax (860) 621-4067

Included in that fee is a one-year warranty on all labor provided by DONATI CONTRACTING, LLC. Parts and materials are covered by standard warranties provided by their manufacturers. Warranty periods begin when installation is completed. The owner has a one-week period following the completion of the installation to accept or reject work performed by DONATI CONTRACTING, LLC, after which time it will be assumed that the work has been accepted.

DONATI CONTRACTING, LLC assumes normal workday access to the job site and payment in full within 30 days after receipt of each invoice. DONATI CONTRACTING, LLC will not be held responsible for normal wear and tear. The removal and disposal of asbestos and toxic materials are the owner's responsibility. This proposal is valid for a period of 30 days from the date shown at the top of this proposal, after which time we will be happy to provide an adjusted quote if necessary.

We look forward to performing this work for you. Please contact us at 860-621-3325 if you have any questions.

Thank you for your consideration,

DONATI CONTRACTING, LLC

Louis C. Donati Jr.
President

ACKNOWLEDGED AND ACCEPTED

BY: _____

DATE: _____

P.O. NO.: _____

000046

VARIAN
medical systems

Quotation

TYM20091020-001 Page: 1

Quotation For:

Bob Lindeyer
Hartford Hospital
80 Seymour Street
Hartford, CT 06101
(860) 545 - 4346 FAX: (860) 545 - 1500

Please address inquiries and replies to:

Timothy Macfarlane
Varian Medical Systems
11 Commerce Drive
Second Floor
Cranford, NJ 07016
(732) 499 - 2260 FAX: (732) 381 - 1060
timothy.macfarlane@oscs.varian.com

Your Reference:	*Quotation Firm Until:* **December 9, 2009**
FOB Point:	*Shipping Allocation:*
Payment Terms:	**Varian Terms and Conditions of Sale 1652T Attached**

Acuity and Gating Move for H770168 / H780168
Customer Responsibility Section

Hartford Hospital

Quotation Total of: USD $48,500 Accepted by:

Signature: _____

Name: _____

Title: _____

Date: _____

For this purchase, we designate **NOVATION** as our Institution's Primary Group Purchasing Organization affiliation. Any change will be Indicated below:

☐ **AmeriNet**	☐ **Aptium**	☐ **BJC**	☐ **Broadlane**
☐ **CHW**	☐ **Consorta/HPG**	☐ **KP Select**	☐ **Magnet**
☐ **Matrix**	☐ **MedAssets**	☐ **Novation**	☐ **Premier**
☐ **ROI**	☐ **USO**	☐ **VA Gov**	☐ **None**

Varian Medical Systems

Submitted by:

_____
(Signature)

Name: **Timothy Macfarlane**

Title: **District Manager**

Date: **October 20, 2009**

STATE OF CONNECTICUT

DEPARTMENT OF PUBLIC HEALTH

Office of Health Care Access

April 15, 2010 Facsimile Only

Karen T. Goyette
Vice President
Strategic Planning and Business Development
80 Seymour Street
P.O. Box 5037
Hartford, CT 06102-5037

Re: Letter of Intent; Docket Number: 10-31577
Hartford Hospital
Acquisition of a Computed Tomography Simulator in Hartford

Dear Ms. Goyette,

On March 25, 2010, the Office of Health Care Access ("OHCA") received the Letter of Intent ("LOI") Form of Hartford Hospital ("Applicant") for the acquisition of a computed Tomography Simulator, with a total associated capital expenditure of $999,414.

A notice to the public regarding OHCA's receipt of a LOI was published in *The Hartford Courant* pursuant to Section 19a-639of the Connecticut General Statutes. Enclosed for your information is a copy of the notice to the public.

Sincerely,

Kaila Riggott
Planning Specialist

KR:lmg

STATE OF CONNECTICUT

DEPARTMENT OF PUBLIC HEALTH

Office of Health Care Access

April 15, 2010 Requisition #31068

Hartford Courant
285 Broad Street
Hartford, CT 06115

Gentlemen/Ladies:

Please make an insertion of the attached copy, in a single column space, set solid under legal notices, in the issue of your newspaper by no later than **Monday, April 19, 2010.**

Please provide the following **within 30 days** of publication:

- Proof of publication (copy of legal ad. acceptable) showing published date along with the invoice.

If there are any questions regarding this legal notice, please contact Steven Lazarus at 418-7001.

KINDLY RENDER BILL IN DUPLICATE ATTACHED TO THE TEAR SHEET.

Sincerely,

Kaila Riggott
Planning Specialist

Attachment

KR:SWL:lmg

c: Danielle Pare, DPH

Hartford Courant **Letter of Intent**
Docket Number: 10-31577 **April 15, 2010**

PLEASE INSERT THE FOLLOWING:

Statute Reference:	19a-639
Applicant:	Hartford Hospital
Town:	Hartford
Docket Number:	10-31577-LOI
Proposal:	Acquisition of a Computed Tomography Simulator
Capital Expenditure:	$999,414

The Applicant may file its Certificate of Need application between May 24, 2010 and July 23, 2010. Interested persons are invited to submit written comments to Cristine A. Vogel, Deputy Commissioner Office of Health Care Access, Division of Department of Public Health, 410 Capitol Avenue, MS13HCA, P.O. Box 340308 Hartford, CT 06134-0308.

The Letter of Intent is available at OHCA or on OHCA's website at www.ct.gov/OHCA. A copy of the Letter of Intent or a copy of Certificate of Need Application, when filed, may be obtained from OHCA at the standard charge. The Certificate of Need application will be made available for inspection at OHCA, when it is submitted by the Applicant.

****
*** TX REPORT ***
****

TRANSMISSION OK

TX/RX NO	1463
RECIPIENT ADDRESS	98605452127
DESTINATION ID	
ST. TIME	04/15 16:13
TIME USE	00'27
PAGES SENT	4
RESULT	OK

STATE OF CONNECTICUT
DEPARTMENT OF PUBLIC HEALTH
OFFICE OF HEALTH CARE ACCESS

FAX SHEET

TO: KAREN T. GOYETTE

FAX: (860) 545-2127

AGENCY: HARTFORD HOSPITAL

FROM: STEVEN LAZARUS

DATE: 4/15/10 **TIME:**

NUMBER OF PAGES: 4
(including transmittal sheet

Comments: Docket 10-31577

PLEASE PHONE IF THERE ARE ANY TRANSMISSION PROBLEMS.

Greer, Leslie

From: ads [ads@graystoneadv.com]
Sent: Thursday, April 15, 2010 2:18 PM
To: Greer, Leslie
Subject: Re: Legal Ad 10-31577

Good day!

Thanks so much for your ad submission.
We will be in touch shortly and look forward to serving you.

If you have any questions or concerns, please don't hesitate to contact us at the number below.

We sincerely appreciate your business.

Thank you,
Graystone Group Advertising

2710 North Avenue
Bridgeport, CT 06604
Phone: 800-544-0005
Fax: 203-549-0061
E-mail: ads@graystoneadv.com
http://www.graystoneadv.com/

On 4/15/10 2:11 PM, "Greer, Leslie" <Leslie.Greer@ct.gov> wrote:

> To Whom It May Concern,
> Please run the attached public notice in The Hartford Courant by April 19, 2010. For billing please refer to requisition 31068, if you have any questions feel free to call me.
>
> Thank you,
>
> Leslie M. Greer
> Office of Health Care Access
> A Division of Department of Public Health
> State of Connecticut
> 410 Capitol Avenue, MS#13HCA
> Hartford, CT 06134
> Phone: (860) 418-7001
> Fax: (860) 418-7053
> *Website: www.ct.gov/ohca* <http://www.ct.gov/ohca>
> Please consider the environment before printing this message

Greer, Leslie

From: Robert Taylor [RTaylor@graystoneadv.com]
Sent: Friday, April 16, 2010 12:08 PM
To: Greer, Leslie
Subject: Legal Notice 10-31577

Hello,

The notice is scheduled to run in the Hartford Courant on 4/19. The cost is $234.72.

Thanks,

Robert Taylor
Graystone Group Advertising
www.graystoneadv.com
2710 North Avenue, Suite 200
Bridgeport, CT 06604
Phone: 203-549-0060
Fax: 203-549-0061

STATE OF CONNECTICUT

DEPARTMENT OF PUBLIC HEALTH
Office of Health Care Access

April 21, 2010 via fax and email only

Karen T. Goyette
Vice President, Strategic Planning
and Business Development
Hartford Hosptial
80 Seymour Street
P.O. Box 5037
Hartford, CT 06102-5037

RE: Certificate of Need Application Forms; Docket Number: 10-31577-CON
Hartford Hospital
Acquisition of a CT Simulator

Dear Ms. Goyette:

Enclosed are the application forms for Hartford Hospital's Certificate of Need ("CON") proposal for the acquisition of a CT Simulator with associated capital expenditure of $999,441. According to the parameters stated in Section 19a-639 of the Connecticut General Statutes, the CON application may be filed between May 24, 2010 and July 23, 2010.

When submitting your CON application and any subsequent application information to this agency, you are obligated to observe the following procedural requirements. **Failure to observe these requirements will require follow-up work on your part to correct the filing.**

- Number and date each page, including cover letter and all attachments. Information filed after the initial CON application submission (i.e. completeness response letter, prefile testimony, late file submissions and the like) must be numbered sequentially from the Applicant's document immediately preceding it. For example, if the application concludes with page 100, your completeness response letter would begin with page 101.
- Submit one (1) original and six (6) hard copies of each submission in 3-ring binders.
- Submit a scanned copy of each submission in its entirety, including all attachments on CD, preferably in Adobe (.pdf) format.

- Submit an electronic copy of the documents in MS Word format with financial attachments and other data as appropriate in MS Excel format.

The OHCA analysts assigned to the CON application are Steven W. Lazarus and Ronald A. Ciesones. Please feel free to contact them at (860) 418-7001 if you have questions.

Sincerely,

Kaila Riggott

Kaila Riggott
Planning Specialist

Enclosures

State of Connecticut
Office of Health Care Access
Certificate of Need Application

Please complete all questions. If any question is not relevant to your project, Not Applicable may be an acceptable response. Your Certificate of Need application will be eligible for submission no earlier than May 24, 2010, and may be submitted no later than July 23, 2010. The Analysts assigned to your application are Steven W. Lazarus and Ronald A. Ciesones and they may be reached at the Office of Health Care Access at (860) 418-7001.

Docket Number:	10-31577-CON
Applicant Name:	Hartford Hospital
Contact Person:	Karen T. Goyette
Contact Title:	Vice President, Strategic Planning and Business Development
Contact Address:	85 Seymour Street P.O. Box 5037 Hartford, CT 06102-5037
Project Location:	Hartford
Project Name:	Acquisition of a CT Simulator
Type proposal:	Section 19a-639, C.G.S.
Est. Capital Cost:	$999,414

1. Project Description and Need

A. Provide a narrative detailing the proposal.

B. Provide the Manufacturer, Model, Number of slices/tesla strength of the proposed scanner (as appropriate to each equipment).

C. List each of the Applicant's sites and the imaging modalities and other services currently offered by location.

D. Complete **Table 1** for each scanner (of the type proposed) currently operated by the Applicant at each of the Applicant's sites.

Table 1: Existing Scanners Operated by the Applicant

Provider Name Street Address Town, Zip Code	Description of Service *	Hours/Days of Operation **	Utilization ***

* Include equipment strength (e.g. slices, tesla strength), whether scanner is open or closed (for MRI)
** Days of the week scanner is operational, and start and end time for each day; and
*** Number of scans performed on each scanner for the most recent 12-month period (identify period).

E. Provide the following regarding the proposal's location:

i) The rationale for locating the proposed equipment at the proposed site;

ii) The population to be served, including specific evidence such as incidence, prevalence, or other demographic data that demonstrates need;

iii) How and where the proposed patient population is currently being served;

iv) All existing providers (name, address) of the proposed service in the towns listed above and in nearby towns;

v) The effect of the proposal on existing providers; and

vi) If the proposal involves a new site of service, identify the service area towns and the basis for their selection.

2. Actual and Projected Volume

A. Complete the following tables for the past three fiscal years ("FY"), current fiscal year ("CFY"), and first three projected FYs of the proposal, for each of the Applicant's existing and proposed scanners (of the type proposed, at the proposed location only). In Table 2a, report the units of service by scanner, and in Table 2b,

report the units of service by type of scan (e.g. if specializing in orthopedic, neurosurgery, or if there are scans that can be performed on the proposed scanner that the Applicant is unable to perform on its existing scanners).

Table 2a: Historical, Current, and Projected Volume, by Scanner

	Actual Volume (Last 3 Completed FYs)			**CFY Volume***	**Projected Volume (First 3 Full Operational FYs)****		
	FY ****	FY ****	FY ****	FY ****	FY ****	FY ****	FY ****
Scanner***							
Total							

* For periods greater than 6 months, report annualized volume, identifying the number of actual months covered and the method of annualizing. For periods less than six months, report actual volume and identify the period covered.
** If the first year of the proposal is only a partial year, provide the first partial year and then the first three full FYs. Add columns as necessary.
*** Identify each scanner separately and add lines as necessary. Also break out inpatient/outpatient/ED volumes if applicable.
**** Fill in years. In a footnote, identify the period covered by the Applicant's FY (e.g. July 1-June 30, calendar year, etc.).

Table 2b: Historical, Current, and Projected Volume, by Type of Scan

	Actual Volume (Last 3 Completed FYs)			**CFY Volume***	**Projected Volume (First 3 Full Operational FYs)****		
	FY ****	FY ****	FY ****	FY ****	FY ****	FY ****	FY ****
Service type***							
Total							

* For periods greater than 6 months, report annualized volume, identifying the number of actual months covered and the method of annualizing. For periods less than six months, report actual volume and identify the period covered.
** If the first year of the proposal is only a partial year, provide the first partial year and then the first three full FYs. Add columns as necessary.
*** Identify each type of scan (e.g. orthopedic, neurosurgery or if there are scans that can be performed on the proposed scanner that the Applicant is unable to perform on its existing scanners) and add lines as necessary.
**** Fill in years. In a footnote, identify the period covered by the Applicant's FY (e.g. July 1-June 30, calendar year, etc.).

B. Provide a breakdown, by town, of the volumes provided in Table 2a for the most recently completed full FY.

C. Explain any increases and/or decreases in volume seen in the tables above.

D. Provide a detailed explanation of all assumptions used in the derivation/ calculation of the projected volume by scanner and scan type.

E. Provide a copy of any articles, studies, or reports that support the need to acquire the proposed scanner, along with a brief explanation regarding the relevance of the selected articles.

3. Quality Measures

A. Submit a list of all key professional, administrative, clinical, and direct service personnel related to the proposal. Attach a copy of their Curriculum Vitae.

B. Explain how this proposal contributes to the quality of health care delivery in the region.

C. Describe the impact of the proposal on the interests of consumers of health care services and the payers of such services

4. Organizational and Financial Information

a. Identify the Applicant's ownership type(s) (e.g. Corporation, PC, LLC, etc.).

b. Does the Applicant have non-profit status?
☐ Yes (Provide documentation) ☐ No

c. Provide a copy of the State of Connecticut, Department of Public Health license(s) currently held by the Applicant and indicate any additional licensure categories being sought in relation to the proposal.

d. Financial Statements

i) If the Applicant is a Connecticut hospital: Pursuant to Section 19a-644, C.G.S., each hospital licensed by the Department of Public Health is required to file with OHCA copies of the hospital's audited financial statements. If the hospital has filed its most recently completed fiscal year audited financial statements, the hospital may reference that filing for this proposal.

ii) If the Applicant is not a Connecticut hospital (other health care facilities): Audited financial statements for the most recently completed fiscal year. If audited financial statements do not exist, in lieu of audited financial statements, provide other financial documentation (e.g. unaudited balance sheet, statement of operations, tax return, or other set of books.)

e. Submit a final version of all capital expenditures/costs as follows:

Table 3: Proposed Capital Expenditures/Costs

Medical Equipment Purchase	$

Imaging Equipment Purchase	
Non-Medical Equipment Purchase	
Land/Building Purchase *	
Construction/Renovation **	
Other Non-Construction (Specify)	
Total Capital Expenditure	$
Medical Equipment Lease (Fair Market Value) ***	$
Imaging Equipment Lease (Fair Market Value) ***	
Non-Medical Equipment Lease (Fair Market Value) ***	
Fair Market Value of Space ***	
Total Capital Cost	$
Capitalized Financing Costs (Informational Purpose Only)	
Total Capital Expenditure with Cap. Fin. Costs	$

* If the proposal involves a land/building purchase, attach a real estate property appraisal including the amount; the useful life of the building; and a schedule of depreciation.
** If the proposal involves construction/renovations, attach a description of the proposed building work, including the gross square feet; existing and proposed floor plans; commencement date for the construction/ renovation; completion date of the construction/renovation; and commencement of operations date.
*** If the proposal involves a capital or operating equipment lease and/or purchase, attach a vendor quote or invoice; schedule of depreciation; useful life of the equipment; and anticipated residual value at the end of the lease or loan term.

f. List all funding or financing sources for the proposal and the dollar amount of each. Provide applicable details such as interest rate; term; monthly payment; pledges received to date; letter of interest or approval from a lending institution.

5. Patient Population Projections

a. Provide the current and projected patient population mix (based on the number of patients, not on revenue) with the CON proposal for the proposed.

Table 4: Patient Population Mix

	Current** FY ***	Year 1 FY ***	Year 2 FY ***	Year 3 FY ***
Medicare*				
Medicaid*				
CHAMPUS & TriCare				
Total Government				
Commercial Insurers*				
Uninsured				
Workers Compensation				
Total Non-Government				
Total Payer Mix				

* Includes managed care activity.
** New programs may leave the "current" column blank.
*** Fill in years. Ensure the period covered by this table corresponds to the period covered in the projections provided.

b. Provide the basis for/assumptions used to project the patient population mix.

6. Financial Attachments I & II

a. Provide a summary of revenue, expense, and volume statistics, without the CON project, incremental to the CON project, and with the CON project. **Complete Financial Attachment I.** (Note that the actual results for the fiscal year reported in the first column must agree with the Applicant's audited financial statements.) The projections must include the first three full fiscal years of the project.

b. Provide a three year projection of incremental revenue, expense, and volume statistics attributable to the proposal by payer. **Complete Financial Attachment II.** The projections must include the first three full fiscal years of the project.

c. Provide the assumptions utilized in developing **both Financial Attachments I and II** (e.g., full-time equivalents, volume statistics, other expenses, revenue and expense % increases, project commencement of operation date, etc.).

d. Provide documentation or the basis to support the proposed rates for each of the FYs as reported in Financial Attachment II. Provide a copy of the rate schedule for the proposed service(s).

e. Provide the minimum number of units required to show an incremental gain from operations for each fiscal year.

f. Explain any projected incremental losses from operations contained in the financial projections that result from the implementation and operation of the CON proposal.

g. Describe how this proposal is cost effective.

7. Other Review Criteria

A. Describe the proposal's relationship to the Applicant's long-range plans. Provide supporting documentation.

B. Specify whether any of the following apply to the proposal. If so, provide an explanation and supporting documentation.
   i) Voluntary efforts to improve productivity and contain costs;
   ii) Changes to the Applicant's teaching or research responsibilities; and/or
   iii) Special characteristics of the Applicant's patient or physician mix.

HOSPITAL AFFIDAVIT

Applicant: _____

Project Title: _____

I, _____, _____
(Name) (Position – CEO or CFO)

of _____ being duly sworn, depose and state that the (Hospital Name) information submitted in this Certificate of Need application is accurate and correct to the best of my knowledge. With respect to the financial impact related to this CON application, I hereby affirm that:

1. The proposal will have a capital expenditure in excess of $15,000,000.

   ☐ Yes ☐ No

2. The combined total expenses for the proposal's first three years of operation will exceed one percent of the actual operating expenses of the Hospital for the most recently completed fiscal year as filed with the Office of Health Care Access.

   ☐ Yes ☐ No

_____ _____
Signature Date

Subscribed and sworn to before me on_____

_____

Notary Public/Commissioner of Superior Court

My commission expires: _____

OFFICE OF HEALTH CARE ACCESS

REQUEST FOR NEW CERTIFICATE OF NEED

FILING FEE COMPUTATION SCHEDULE

APPLICANT: _____ PROJECT TITLE: _____ DATE: _____	FOR OHCA USE ONLY: 1. Check logged (Front desk) _____ _____ 2. Check rec'd (Clerical/Cert.) _____ _____ 3. Check correct (Superv.) _____ _____ 4. Check logged (Clerical/Cert).) _____ _____

SECTION A – NEW CERTIFICATE OF NEED APPLICATION	
1. Check statute reference as applicable to CON application (see statute for detail): _____ 19a-638.Additional function or service, change of ownership, service termination. **No Fee Required.** _____ 19a-639 Capital expenditure exceeding $3,000,000, or capital expenditure exceeding $3,000,000 for major medical equipment, or CT scanner, PET scanner, PET/CT scanner, MRI scanner, cineangiography equipment or linear accelerator. **Fee Required.** _____ 19a-638 and 19a-639. **Fee Required.** 2. Enter $0 on "Total Fee Due" line (SECTION B) if application is required pursuant to Section 19a-638 only, otherwise go on to line 3 of this section. 3. Enter $400 on "Total Fee Due" line (SECTION B) if application is for capital expenditure for major medical equipment, imaging equipment or linear accelerator less than $3,000,000 4. Section 19a-639 fee calculation (applicable if section 19a-639 capital expenditure for major medical equipment, imaging equipment or linear accelerator exceeding $3,000,000 or other capital expenditure exceeding $3,000,000 is checked above **OR** if both 19a-638 and 19a-639 are checked): a. Base fee: _____ b. Additional Fee: (Capital Expenditure Assessment)_____ (To calculate: Total requested Capital Expenditure/Cost excluding capitalized financing costs multiplied times .0005 and round to nearest dollar.) ($_____ x .0005) c. Sum of base fee plus additional fee: (Lines A4a + A4b)_____ d. Enter the amount shown on line A4c. on "Total Fee Due" line (SECTION B).	$ 1,000.00 $_____.00 $_____.00
SECTION B TOTAL FEE DUE: _____	$_____.00

ATTACH HERE CERTIFIED OR CASHIER'S CHECK ONLY (Payable to: Treasurer, State of Connecticut)

Hartford Hospital

11. C (i). Please provide one year of actual results and three years of projections of **Total Facility** revenue, expense and volume statistics without, incremental to and with the CON proposal in the following reporting format:

Total Facility: Description	FY Actual Results	FY Projected W/out CON	FY Projected Incremental	FY Projected With CON	FY Projected W/out CON	FY Projected Incremental	FY Projected With CON	FY Projected W/out CON	FY Projected Incremental	FY Projected With CON
NET PATIENT REVENUE										
Non-Government				$0			$0			$0
Medicare				$0			$0			$0
Medicaid and Other Medical Assistance				$0			$0			$0
Other Government				$0			$0			$0
Total Net Patient Patient Revenue	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Other Operating Revenue										
Revenue from Operations	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
OPERATING EXPENSES										
Salaries and Fringe Benefits				$0			$0			$0
Professional / Contracted Services				$0			$0			$0
Supplies and Drugs				$0			$0			$0
Bad Debts				$0			$0			$0
Other Operating Expense				$0			$0			$0
Subtotal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Depreciation/Amortization				$0			$0			$0
Interest Expense				$0			$0			$0
Lease Expense				$0			$0			$0
Total Operating Expense	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Gain/(Loss) from Operations	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Plus: Non-Operating Revenue				$0			$0			$0
Revenue Over/(Under) Expense	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
FTEs				0			0			0

*Volume Statistics:
Provide projected inpatient and/or outpatient statistics for any new services and provide actual and projected inpatient and/or outpatient statistics for any existing services which will change due to the proposal.

Hartford Hospital

Please provide **three** years of projections of incremental revenue, expense and volume statistics **attributable to the proposal** in the following reporting format:

Type of Service Description										
Type of Unit Description:										
# of Months in Operation										
FY _____	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
FY Projected Incremental		Rate	Units	Gross	Allowances/	Charity	Bad	Net	Operating	Gain/(Loss)
Total Incremental Expenses:				Revenue	Deductions	Care	Debt	Revenue	Expenses	from Operations
				Col. 2 * Col. 3				Col.4 - Col.5	Col. 1 Total *	Col. 8 - Col. 9
Total Facility by								-Col.6 - Col.7	Col. 4 / Col. 4 Total	
Payer Category:										
Medicare				$0				$0	$0	$0
Medicaid		$0		$0				$0	$0	$0
CHAMPUS/TriCare		$0		$0				$0	$0	$0
Total Governmental			0	$0	$0	$0	$0	$0	$0	$0
Commericial Insurers		$0	5	$0				$0	$0	$0
Uninsured		$0	2	$0				$0	$0	$0
Total NonGovernment		$0	7	$0	$0	$0	$0	$0	$0	$0
Total All Payers		$0	7	$0	$0	$0	$0	$0	$0	$0

****
*** TX REPORT ***
****

TRANSMISSION OK

TX/RX NO	1478
RECIPIENT ADDRESS	98605452127
DESTINATION ID	
ST. TIME	04/21 12:05
TIME USE	02'23
PAGES SENT	13
RESULT	OK

STATE OF CONNECTICUT
DEPARTMENT OF PUBLIC HEALTH
OFFICE OF HEALTH CARE ACCESS

FAX SHEET

TO: KAREN GOYETTE

FAX: 860-545-2127

AGENCY: HARTFORD HOSPITAL

FROM: OHCA

DATE: 4/21/10 **TIME:** ~11:00

NUMBER OF PAGES: _____
(including transmittal sheet

Comments:
Please see attached application for DN: 10-31577-CON.

PLEASE PHONE IF THERE ARE ANY TRANSMISSION PROBLEMS.

10-31577

Hartford Courant

Publication Date: 04/19/2010

Ad Number:	E2372276	Client Name:	GRAYSTONE GROUP / PO# 155668
Insertion Number:		Advertiser:	DPUC/LEGAL
Size:	2 x 1.75	Section/Page/Zone:	Classified/C8/FR
Color Type:	B&W	Description:	PUBLIC NOTICE STATUTE REFERENCE19A6

PUBLIC NOTICES

Connecticut

PUBLIC NOTICE

Statute Reference:	19a-639
Applicant:	Hartford Hospital
Town:	Hartford
Docket Number:	10-31577-LOI
Proposal:	Acquisition of a Computed Tomography Simulator
Capital Expenditure:	$990,414

The Applicant may file its Certificate of Need application between May 24, 2010 and July 23, 2010. Interested persons are invited to submit written comments to Cristine A. Vogel, Deputy Commissioner, Office of Health Care Access, Division of Department of Public Health, 410 Capitol Avenue, MS#13HCA, P.O. Box 340308 Hartford, CT 06134-0308.

The Letter of Intent is available at OHCA or on OHCA's website at www.ct.gov/ohca. A copy of the Letter of Intent or a copy of Certificate of Need Application, when filed, may be obtained from OHCA at the standard charge. The Certificate of Need application will be made available for inspection at OHCA, when it is submitted by the Applicant.

HARTFORD HOSPITAL

80 Seymour Street
P.O. Box 5037
Hartford, CT 06102-5037
860/545-5000

June 9, 2010

Cristine A. Vogel, Deputy Commissioner
Department of Public Health, Office of Health Care Access
MS#13HCA
410 Capitol Avenue
P.O. Box 340308
Hartford, CT 06134-0308

RE: Docket Number 10-31577-CON

Dear Commissioner Vogel:

Enclosed please find for your review and consideration an original and six copies of Hartford Hospital's Certificate of Need Application for the Acquisition of a CT Simulator - Docket Number 10-31577-CON. We feel that this proposal will greatly improve the quality of care provided to cancer patients receiving radiation oncology at the hospital's Helen and Harry Gray Cancer Center on the Hartford campus, by replacing an antiquated machine with a simulator capable of providing the standard of care associated with modern radiation oncology departments.

It is our hope that the modest capital amount associated with this proposal, and the fact that it will have no impact upon other providers in the area, will permit a favorable and expeditious review by your department. Please feel free to contact me directly at 860 545-1532 if you or your staff has any questions. Thank you in advance for your consideration of this request.

Sincerely,

Karen T. Goyette
Vice President, Strategic Planning and Business Development

Encl.

State of Connecticut
Office of Health Care Access
Certificate of Need Application

Please complete all questions. If any question is not relevant to your project, Not Applicable may be an acceptable response. Your Certificate of Need application will be eligible for submission no earlier than May 24, 2010, and may be submitted no later than July 23, 2010. The Analysts assigned to your application are Steven W. Lazarus and Ronald A. Ciesones and they may be reached at the Office of Health Care Access at (860) 418-7001.

Docket Number:	10-31577-CON
Applicant Name:	Hartford Hospital
Contact Person:	Karen T. Goyette
Contact Title:	Vice President, Strategic Planning and Business Development
Contact Address:	85 Seymour Street P.O. Box 5037 Hartford, CT 06102-5037
Project Location:	Hartford
Project Name:	Acquisition of a CT Simulator
Type proposal:	Section 19a-639, C.G.S.
Est. Capital Cost:	$999,414

1. Project Description and Need

A. Provide a narrative detailing the proposal.

RESPONSE: This is a proposal for the replacement of a Philips SLS 9 simulator with a Toshiba Aquillion 16 slice Large Bore CT Simulator, as well as for the relocation of an existing Varian Acuity simulator within the department of Radiation Oncology at Hartford Hospital's Helen and Harry Gray Cancer Center. The existing Philips conventional simulator was installed in 1992 at a cost of $400,000. Since this amount did not exceed the Certificate of Need threshold in place at the time, no CON was required nor obtained. The Philips simulator no longer provides the standard of care associated with modern radiation oncology departments. The large bore of the proposed CT will allow simulation of more patients in the treatment position with various treatment devices. Many larger patients cannot be treated in conventional (smaller bore) CT Scanners. The acquisition of this scanner will also reduce the department's dependence on other CT Scanners located in the Department of Radiology and the Emergency Department. The addition of this scanner will also allow the provision of limited diagnostic services to bariatric patients that cannot be provided elsewhere in our system. Finally, we will also be able to provide service to a limited number of Oncology patients that are in the Cancer Center that may require urgent scanning when not available elsewhere.

The services associated with this application are currently being provided. CT based treatment planning is considered to be the standard in Radiation Oncology treatment. Our patients currently receive CT scans in HH Radiology and or the Emergency Department. These facilities are used heavily and do not always permit as timely a service for our cancer patients as would be indicated. Their location is also less convenient and mandates the transportation of the patient, treatment record and treatment devices to other areas where CT scanners are available to us. The current bore size of existing HH Scanners limits the scanning of patients in the treatment position due to the size of the devices required. The Large Bore of the proposed scanner will alleviate this issue as well as enable us to provide the service within our cancer center, thus reducing the stress and enhancing access for our patients and staff. No additional licenses will be sought.

B. Provide the Manufacturer, Model, Number of slices/tesla strength of the proposed scanner (as appropriate to each equipment).

RESPONSE: The equipment to be purchased is a Toshiba Aquillion 16 slice Large Bore CT Simulator.

C. List each of the Applicant's sites and the imaging modalities and other services currently offered by location.

RESPONSE: The Applicant has a full compliment of imaging modalities consisting of three (3) CT scanners, two (2) MRI scanners, one (1) PET scanner, a multitude of convention and special procedure radiographic modalities and mammography units.

Specific to this application, the Helen and Harry Gray Cancer Center on the Hartford Campus has two (2) conventional simulators, On Board imaging and Cone Beam CT on the Trilogy linear accelerator as well as Electronic Portal Imaging Devices (EPID) on two (2) linear accelerators.

The Helen and Harry Gray Cancer Center at 80 Fisher Drive, Avon. Connecticut has a 16 slice Toshiba Aquillion large bore CT Scanner and On Board imaging and Cone Beam CT on the 21iX linear accelerator.

D. Complete Table 1 for each scanner (of the type proposed) currently operated by the Applicant at each of the Applicant's sites.

Table 1: Existing Scanners Operated by the Applicant

Provider Name Street Address Town, Zip Code	**Description of Service ***	**Hours/Days of Operation ****	**Utilization *****
Hartford Hospital, 80 Seymour Street Hartford CT	GE VCT 64 Slice and GE Lightspeed Ultra 8 Slice Both in Radiology Department	16 hours/day 7 days/week	FY 2009 – 22,420 combined
Hartford Hospital, 80 Seymour Street Hartford CT	GE Lightspeed Ultra 8 Slice	24/ hours/day 7 days/week	FY 2009 - 27,396
Hartford Hospital, 80 Seymour Street Hartford CT	Discovery LS (4 Slice CT)	8 hours /day 6 days/week	FY 2009 - 1,619 PET/CT scans
Hartford Hospital 80 Fisher Drive Avon, CT	Toshiba Aquillion LB 16 slice CT Scanner	Mon – Fri 7am – 3:30pm	205 CT Simulation Scans from 5/1/2009 – 4/30/2010

* Include equipment strength (e.g. slices, tesla strength), whether scanner is open or closed (for MRI)
** Days of the week scanner is operational, and start and end time for each day; and
*** Number of scans performed on each scanner for the most recent 12-month period (identify period).

E. Provide the following regarding the proposal's location:

i) The rationale for locating the proposed equipment at the proposed site;

RESPONSE: The proposed equipment would be located in the Helen and Harry Gray Cancer Center at 85 Retreat Avenue, Hartford, Connecticut. The clinic is located on Hartford Hospital's main campus. Locating the simulator within the clinic would eliminate the need to transport ambulatory clinic patients and equipment to other locations within the hospital. While physically adjacent and connected to the main hospital building, the clinic offers its patients the convenience of separate valet parking just outside a distinct clinic entrance.

ii) The population to be served, including specific evidence such as incidence, prevalence, or other demographic data that demonstrates need;

RESPONSE: This proposal does not result in a change to the population currently being served. The Radiation Oncology Department of the Helen and Harry Gray Cancer Center on the Hartford campus provided treatment to 658 individuals in FY 2009. A listing of patient count by town of origin for that time period can be found in Attachment A.

iii) How and where the proposed patient population is currently being served;

RESPONSE: Patients of the clinic are currently being served at Hartford Hospital in the Helen and Harry Gray Cancer Center, however, as noted above, the simulator in the clinic no longer provides the standard of care associated with modern radiation oncology departments. As a result, patients must be transported to other areas of the hospital to receive CT scans. This proposal assumes no change to the population currently receiving treatment at Hartford Hospital.

iv) All existing providers (name, address) of the proposed service in the towns listed above and in nearby towns;

RESPONSE: Hartford Hospital's Helen and Harry Gray Cancer Center is the primary provider of this service in the area. Other providers of CT simulations for radiation oncology in the immediate area are:

St, Francis Hospital and Medical Center – Woodland Street, Hartford, CT

University of Connecticut Medical Center – Farmington Avenue, Farminton, CT

MidState Medical Center – 435 Lewis Avenue, Meriden, CT

Manchester Hospital – 71 Haynes Street, Manchester, CT

v) The effect of the proposal on existing providers; and

RESPONSE: This proposal will have no effect upon existing providers as this service is currently being provided at Hartford Hospital, and there is no anticipated increase in patient volume associated with the proposal.

vi) If the proposal involves a new site of service, identify the service area towns and the basis for their selection.

RESPONSE: Not applicable. This proposal does not involve a new site of service.

2. Actual and Projected Volume

A. Complete the following tables for the past three fiscal years ("FY"), current fiscal year ("CFY"), and first three projected FYs of the proposal, for each of the Applicant's existing and proposed scanners (of the type proposed, at the proposed location only). In Table 2a, report the units of service by scanner, and in Table 2b, report the units of service by type of scan (e.g. if specializing in orthopedic, neurosurgery, or if there are scans that can be performed on the proposed scanner that the Applicant is unable to perform on its existing scanners).

Table 2a: Historical, Current, and Projected Volume, by Scanner

	Actual Volume (Last 3 Completed FYs)			**CFY Volume* Actual Oct – April**	**Projected Volume (First 3 Full Operational FYs)****		
	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Radiology-Inpt	15,618	15,316	16,848	16,100	16,100	16,100	16,100
Radiology – Outpt	5,129	4,926	5,572	5,100	5,100	5,100	5,100
Emergency Room	25,918	25,786	27,396	25,800	25,800	25,800	25,800
Total	**46,665**	**46,028**	**49,816**	**47,000**	**47,000**	**47,000**	**47,000**

NOTE: 1. Applicant's fiscal year is October 1st through September 30th; 2. Applicant does not track the volume of the 2 scanners in the Radiology Department separately. In these tables the two scanners are combined.

* For periods greater than 6 months, report annualized volume, identifying the number of actual months covered and the method of annualizing. For periods less than six months, report actual volume and identify the period covered.

** If the first year of the proposal is only a partial year, provide the first partial year and then the first three full FYs. Add columns as necessary.

*** Identify each scanner separately and add lines as necessary. Also break out inpatient/outpatient/ED volumes if applicable.

**** Fill in years. In a footnote, identify the period covered by the Applicant's FY (e.g. July 1-June 30, calendar year, etc.).

Table 2b: Historical, Current, and Projected Volume, by Type of Scan

	Actual Volume (Last 3 Completed FYs)			CFY Volume* Actual Oc tober – April	Projected Volume (First 3 Full Operational FYs)**		
	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
General Inpatient	15,354	15,114	16,660	15,910	15,910	15,910	15,910
General Outpatient	4,281	4,197	4,847	4,360	4,360	4,360	4,360
Emergency Room	25,918	25,786	27,396	25,800	25,800	25,800	25,800
Cardiology	466	289	291	300	300	300	300
Radiation Oncology Patients	646	642	622	630	630	630	630
Total	**46,665**	**46,028**	**49,816**	**47,000**	**47,000**	**47,000**	**47,000**

NOTE: 1. Applicant's fiscal year is October 1st through September 30th; 2. Applicant does not track the volume of the 2 scanners in the Radiology Department separately. In these tables the two scanners are combined.

* For periods greater than 6 months, report annualized volume, identifying the number of actual months covered and the method of annualizing. For periods less than six months, report actual volume and identify the period covered.
** If the first year of the proposal is only a partial year, provide the first partial year and then the first three full FYs. Add columns as necessary.
*** Identify each type of scan (e.g. orthopedic, neurosurgery or if there are scans that can be performed on the proposed scanner that the Applicant is unable to perform on its existing scanners) and add lines as necessary.
**** Fill in years. In a footnote, identify the period covered by the Applicant's FY (e.g. July 1-June 30, calendar year, etc.).

B. Provide a breakdown, by town, of the volumes provided in Table 2a for the most recently completed full FY.

RESPONSE: A listing of patient count by town of origin for the past fiscal year can be found in Attachment A.

C. Explain any increases and/or decreases in volume seen in the tables above.

RESPONSE: As noted on the tables above, volumes are not anticipated to change.

D. Provide a detailed explanation of all assumptions used in the derivation/ calculation of the projected volume by scanner and scan type.

RESPONSE: Projected volumes are directly based upon current and historical volumes. As noted above, no changes are anticipated.

E. Provide a copy of any articles, studies, or reports that support the need to acquire the proposed scanner, along with a brief explanation regarding the relevance of the selected articles.

RESPONSE: CT Simulation has become the standard of care in radiation oncology, permitting the radiation oncologist to utilize a 3 dimensional anatomy construct to develop idealized target and avoidance structures. A benefit to the scan being performed by radiation oncology staff is that the patient can be positioned in the treatment position, with the appropriate radiation oncology customized immobilization devices, thus simulating the patient's actual treatment position. Physics and dosimetry staff can then utilize this image set and appropriate planning directives to develop an optimized treatment plan, which can be further tweaked in consultation with the radiation oncologist for final checks.

Numerous articles support the utilization of CT scanning in the radiation oncology simulation and treatment planning process(1-6). As compared with conventional 2 dimensional radiographic imaging utilizing bony anatomy to establish radiation field boundaries, CT scanning in the treatment position allows the radiation oncologist to contour selected soft tissue targets and avoidance structures so that precise 3 dimensional radiation therapy treatment planning can be undertaken. These studies point out that CT is far more precise than radiographic imaging, permitting identification of nodal and other soft tissue structures which vary in location from one patient to the next. In addition, a much more precise identification of avoidance structures can be undertaken. For example, in the treatment of prostate cancer, the precise 3 dimensional prostate anatomy can be identified, along with avoidance structures such as bladder, rectum, and small bowel. Intensity modulated radiation therapy(IMRT) treatment planning, which permits the development of highly shaped concave radiation dose distributions, can then be carried out resulting in the ability to safely deliver doses approximately 15-20% higher than what we could deliver with more conventional conformal radiation techniques. This planning would not be possible without CT as a routine utilized imaging modality for radiation treatment planning. In the example of prostate cancer, because of potential organ motion, a daily cone beam CT image is taken on the linear accelerator to ascertain organ position each day, and staff then perform computer based alignment immediately prior to treatment. This image guided radiation therapy(IGRT) requires accurate CT simulation initially to serve as registration images.

Four problems exist when utilizing CT scanners in the hospital's Radiology Department. First, the scanners there are highly utilized for high volume procedures(ie biopsy or interventional techniques) or images(trauma, stroke, etc) during day time hours, leaving less access for cancer patients needing elective radiation therapy treatment planning. Second, the CT scanners are located at a significant distance from the cancer center, requiring inconvenient travel for our patients, who are frequently debilitated, and staff. Third, a team of technologists and physicists and at time radiation oncologist may be required during the imaging procedure, making the logistics of acquiring such key data most difficult. Fourth, the

Radiology scanners have been optimized for image acquisition, and frequently don't easily accommodate radiation oncology immobilization devices due to small apertures or setups due to curved table tops. A dedicated radiation oncology CT simulator would offer immediate and proximate access, wide aperture, flat table top, and access to the entire team who are immediately adjacent within the department.

Newer CT simulators now offer innovative technologies which will aid in the delivery of highly focused radiation techniques such as stereotactic radiosurgery(SRS), stereotactic radiation therapy(SRT), and gated radiation therapy. These techniques utilize images taken in various phases of the respiratory cycle(4D) so that tumor tracking can assure accurate delivery of the focused radiation even while the patient breathes in and out resulting in tumor motion. A dedicated CT simulator can have parameters developed which allow individualized settings and protocols for imaging. These are most difficult to accomplish in a busy diagnostic imaging department.

Hartford Hospital's radiation oncology department offers many state-of–the-art therapies which require extremely accurate data for radiation treatment planning. In addition to IMRT, IGRT, SRS, and SRT, various brachytherapy procedures also require immediate access to CT for optimal patient care. Breast brachytherapy(accelerated partial breast irradiation) utilizing mammosite, contura, or savi devices all require CT based planning. Temporary high dose rate brachytherapy utilized to treat endometrial, cervix, and vaginal cancers, as well as endobronchial, esophageal, and other sites similarly benefits from access to CT simulation for treatment planning. Prostate brachytherapy, both temporary and permanent requires particular image sets of CT for treatment planning, and the temporary patients might require more than one image set if the perineal catheters require manipulation. Head and neck cancer brachytherapy similarly requires CT based planning.

In conclusion, CT simulation is a necessary element of radiation oncology simulation and treatment planning. The synergy provided by location of a scanner equipped with the radiation oncology hardware and software, in the radiation oncology department, enables vastly enhanced patient care and satisfaction, staff satisfaction, and efficient and effective care delivery.

The following articles referenced above may be found in Attachment B:

1. "Implementation and characterization of a 320-slice volumetric CT scanner for simulation in radiation oncology"; Medical Physics. 36(11):5120-7, 2009 Nov. Coolens C. Breen S. Purdie TG. Owrangi A. Publicover J. Bartolac S. Jaffray DA.; Radiation Medicine Program, Princess Margaret Hospital, Toronto, Ontario M5G 2M9, Canada.

2. "Evaluation of three different CT simulation and planning procedures for the preoperative irradiation of operable rectal cancer"; Radiotherapy & Oncology 87(3):350-6, 2008 Jun.; Borger, Jacques H. van den Bogaard, Jorgen. de

Haas, Danielle F M. Braeken, Anna P B M. Murrer, Lars H P. Houben, Ruud M A. Lammering, Guido; MAASTRO clinic, Maastricht, The Netherlands.

3. "Treatment optimization using computed tomography-delineated targets should be used for supraclavicular irradiation for breast cancer"; International Journal of Radiation Oncology, Biology, Physics. 69(3):711-5, 2007 Nov 1.; Liengsawangwong, Raweewan. Yu, Tse-Kuan. Sun, Tzouh-Liang. Erasmus, Jeremy J. Perkins, George H. Tereffe, Welela. Oh, Julia L. Woodward, Wendy A. Strom, Eric A. Salephour, Mohammad. Buchholz, Thomas A.; Department of Radiation Oncology, University of Texas M. D. Anderson Cancer Center, Houston, TX 77030, USA.

4. "From new frontiers to new standards of practice: advances in radiotherapy planning and delivery"; Frontiers of Radiation Therapy & Oncology. 40:18-39, 2007; Purdy, James A.; Department of Radiation Oncology, UC Davis Medical Center, Sacremento, CA 95816, USA.

5. "Localization: conventional and CT simulation"; British Journal of Radiology, 79 Spec No 1:S36-49, 2006 Sep; Baker, G R.; Kent Oncology Centre, Maidstone Hospital, Maidstone, Kent ME16 9QQ, UK.

6. "Use of CT simulation for treatment of cervical cancer to assess the adequacy of lymph node coverage of conventional pelvic fields based on bony landmarks" Int J Radiat Oncol Biol Phys. 2006 Aug 1;65(5):1594; Finlay, Marisa H. Ackerman, Ida. Tirona, Romeo G. Hamilton, Paul. Barbera, Lisa. Thomas, Gillian; Department of Radiation Oncology, Toronto Sunnybrook Regional Cancer Centre, Sunnybrook, Toronto, Ontario, Canada.

3. Quality Measures

A. Submit a list of all key professional, administrative, clinical, and direct service personnel related to the proposal. Attach a copy of their Curriculum Vitae.

RESPONSE: Curriculum Vitae for the following individuals can be found in Attachment C:

Hospital Administrative Staff
Elliot Joseph – President and CEO
Jeffrey A. Flaks – Senior Vice President and COO
Thomas J. Marchozzi, CPA – Senior Vice President and CFO

Department Administrative Staff
Gene Anthony Cardarelli, PhD, MPH, FACMP
Donna M. Handley, MA, RN, BSN
Susan A. O'Connell, M.Ed., R.T.
Andrew L. Salner, MD, FACR

Medical Staff
Helaine F. Bertsch, MD
Timothy S. Boyd, MD
Judith A. Buckley, MD
Stephen A. Hauser, MD
Kenneth A. Leopold, MD

Clinical & Direct Service Staff
Christine Bak
Francis Blanchard
Allison Connors
Karl Harris
Rovert F. Hoffman
Blanche Jackson
Rober M. Lindeyer
Deborah Nelson RTT, CMD
Kevin J. Norton, M.S., DABMP
Kevin Pacini
Monica C. Rossi
Theodore R. Steger, III, PhD

B. Explain how this proposal contributes to the quality of health care delivery in the region.

RESPONSE: As noted throughout this proposal, this will replace antiquated equipment with a state-of-the-art unit that provides the standard of care associated with modern radiation oncology departments. The location of this unit within the clinic will eliminate the need to transport patients to other areas of the hospital to receive the treatment they require. Both factors will improve the quality of care provided at the Helen and Harry Gray Cancer Center and, therefore, the region.

C. Describe the impact of the proposal on the interests of consumers of health care services and the payers of such services

RESPONSE: Consumers will only benefit from the approval of this proposal as it will provide greater access to state-of-the-art equipment. Payers will not be effected as volumes are not anticipated to increase.

4. Organizational and Financial Information

a. Identify the Applicant's ownership type(s) (e.g. Corporation, PC, LLC, etc.).

RESPONSE: Hartford Hospital is a 501(c)3 corporation.

b. **Does the Applicant have non-profit status?**
☒ **Yes (Provide documentation)** ☐ **No**

RESPONSE: See Attachment D

c. **Provide a copy of the State of Connecticut, Department of Public Health license(s) currently held by the Applicant and indicate any additional licensure categories being sought in relation to the proposal.**

RESPONSE: See Attachment E. No additional license categories are being sought.

d. **Financial Statements**

i) **<u>If the Applicant is a Connecticut hospital:</u> Pursuant to Section 19a-644, C.G.S., each hospital licensed by the Department of Public Health is required to file with OHCA copies of the hospital's audited financial statements. If the hospital has filed its most recently completed fiscal year audited financial statements, the hospital may reference that filing for this proposal.**

RESPONSE: The Hospital has its 2009 audited financial statements on file with OHCA as part of its annual reporting requirements.

ii) **<u>If the Applicant is not a Connecticut hospital (other health care facilities):</u> Audited financial statements for the most recently completed fiscal year. If audited financial statements do not exist, in lieu of audited financial statements, provide other financial documentation (e.g. unaudited balance sheet, statement of operations, tax return, or other set of books.)**

RESPONSE: Not applicable as the applicant is a Connecticut hospital..

e. **Submit a final version of all capital expenditures/costs as follows:**

Table 3: Proposed Capital Expenditures/Costs

Medical Equipment Purchase	$ 58,929
Imaging Equipment Purchase	719,152
Non-Medical Equipment Purchase	9,333
Land/Building Purchase *	
Construction/Renovation **	212,000
Other Non-Construction (Specify)	
Total Capital Expenditure	**$ 999,414**
Medical Equipment Lease (Fair Market Value) ***	$
Imaging Equipment Lease (Fair Market Value) ***	
Non-Medical Equipment Lease (Fair Market Value) ***	
Fair Market Value of Space ***	
Total Capital Cost	**$ 999,414**
Capitalized Financing Costs (Informational Purpose Only)	
Total Capital Expenditure with Cap. Fin. Costs	$ 999,414

* If the proposal involves a land/building purchase, attach a real estate property appraisal including the amount; the useful life of the building; and a schedule of depreciation.
** If the proposal involves construction/renovations, attach a description of the proposed building work, including the gross square feet; existing and proposed floor plans; commencement date for the construction/ renovation; completion date of the construction/renovation; and commencement of operations date.
*** If the proposal involves a capital or operating equipment lease and/or purchase, attach a vendor quote or invoice; schedule of depreciation; useful life of the equipment; and anticipated residual value at the end of the lease or loan term.

RESPONSE: Vendor quotes and depreciation schedule may be found in Attachment F

f. List all funding or financing sources for the proposal and the dollar amount of each. Provide applicable details such as interest rate; term; monthly payment; pledges received to date; letter of interest or approval from a lending institution.

RESPONSE: This proposal assumes that the expenditure will be paid out of internal capital funds. However, Hartford Hospital is in the process with CHEFA of securing funds, some of which may be applied to this project.

5. Patient Population Projections

a. Provide the current and projected patient population mix (based on the number of patients, not on revenue) with the CON proposal for the proposed.

Table 4: Patient Population Mix

	Current** FY 2010	Year 1 FY 2011	Year 2 FY 2012	Year 3 FY 2013
Medicare*	38%	38%	38%	38%
Medicaid*	21%	21%	21%	21%
CHAMPUS & TriCare	0	0	0	0
Total Government	**59%**	**59%**	**59%**	**59%**
Commercial Insurers*	39%	39%	39%	39%
Uninsured	2%	2%	2%	2%
Workers Compensation				
Total Non-Government	**41%**	**41%**	**41%**	**41%**
Total Payer Mix	**100%**	**100%**	**100%**	**100%**

* Includes managed care activity.
** New programs may leave the "current" column blank.
*** Fill in years. Ensure the period covered by this table corresponds to the period covered in the projections provided.

Please note that Workers Compensation is included in Commercial Insurers.

b. Provide the basis for/assumptions used to project the patient population mix.

RESPONSE: This is based on the Hospital's actual payer mix.

6. **Financial Attachments I & II**

   a. **Provide a summary of revenue, expense, and volume statistics, without the CON project, incremental to the CON project, and with the CON project. Complete Financial Attachment I. (Note that the actual results for the fiscal year reported in the first column must agree with the Applicant's audited financial statements.) The projections must include the first three full fiscal years of the project.**

      RESPONSE: Please see Attachment I.

   b. **Provide a three year projection of incremental revenue, expense, and volume statistics attributable to the proposal by payer. Complete Financial Attachment II. The projections must include the first three full fiscal years of the project.**

      RESPONSE: Financial Attachment II is not applicable since there is no incremental volume or revenue impact associated with this proposal.

   c. **Provide the assumptions utilized in developing both Financial Attachments I and II (e.g., full-time equivalents, volume statistics, other expenses, revenue and expense % increases, project commencement of operation date, etc.).**

      RESPONSE: The financial projections assume that this project will be operational on October 1, 2010. It should be noted that this proposal does not include any additional volume since these are existing patients that are treated on the other CT scanners in the hospital. Therefore, there is no revenue impact. The only expenses associated with this proposal are depreciation which is outlined in Attachment F, and a maintenance contract that will begin in the second year. Depreciation expense is calculated based on AHA guidelines. Consistent with Hospital policy, 50% of the annual depreciation will be applied in the first year.

   d. **Provide documentation or the basis to support the proposed rates for each of the FYs as reported in Financial Attachment II. Provide a copy of the rate schedule for the proposed service(s).**

      RESPONSE: A copy of the rate schedule may be found in Attachment G. No change to the existing rates is anticipated.

   e. **Provide the minimum number of units required to show an incremental gain from operations for each fiscal year.**

      RESPONSE: There is no new/incremental volume associated with this proposal and, therefore, no incremental gain from operations.

f. **Explain any projected incremental losses from operations contained in the financial projections that result from the implementation and operation of the CON proposal.**

RESPONSE: The projected losses are due to depreciation and a maintenance contract, and do not have a significant impact on the Hospital's operations.

g. **Describe how this proposal is cost effective.**

RESPONSE: There are no anticipated savings/cost reductions associated with this proposal, however, there is a minor positive impact upon staff time/resources per scan associated with locating the equipment in closer proximity to the clinic.

7. **Other Review Criteria**

A. **Describe the proposal's relationship to the Applicant's long-range plans. Provide supporting documentation.**

RESPONSE: Hartford Hospital is presently in the process of updating its strategic plan. The current document (2007 – 2010) identifies oncology as one of the service lines of focus for expansion.

B. **Specify whether any of the following apply to the proposal. If so, provide an explanation and supporting documentation.**
i) Voluntary efforts to improve productivity and contain costs;
ii) Changes to the Applicant's teaching or research responsibilities; and/or
iii) Special characteristics of the Applicant's patient or physician mix.

RESPONSE: This proposal represents the replacement of the existing unit with a modern/state-of-the-art scanner. As such, it will not have a significant impact upon productivity/cost containment, teaching/research activities or the patient/physician mix.

Hartford Hospital

6.a. Please provide one year of actual results and three years of projections of **Total Facility** revenue, expense and volume statistics without, incremental to and with the CON proposal in the following reporting format:

Total Facility: / Description	FY 2009 Actual Results	FY 2011 Projected W/out CON	FY 2011 Projected Incremental	FY 2011 Projected With CON	FY 2012 Projected W/out CON	FY 2012 Projected Incremental	FY 2012 Projected With CON	FY 2013 Projected W/out CON	FY 2013 Projected Incremental	FY 2013 Projected With CON
NET PATIENT REVENUE										
Non-Government	$336,656,312	$419,886,052		$419,886,052	$454,682,748		$454,682,748	$502,281,812		$502,281,812
Medicare	$283,035,628	$318,029,147		$318,029,147	$322,149,862		$322,149,862	$330,266,229		$330,266,229
Medicaid and Other Medical Assistance	$85,048,920	$96,295,801		$96,295,801	$97,669,390		$97,669,390	$100,154,959		$100,154,959
Other Government	$2,439,473	$2,500,000		$2,500,000	$2,600,000		$2,600,000	$2,700,000		$2,700,000
Total Net Patient Patient Revenue	$707,180,333	$836,711,000	$0	$836,711,000	$877,102,000	$0	$877,102,000	$935,403,000	$0	$935,403,000
Other Operating Revenue	$122,717,827	$119,787,000		$119,787,000	$123,579,000		$123,579,000	$127,476,000		$127,476,000
Revenue from Operations	$829,898,160	$956,498,000	$0	$956,498,000	$1,000,681,000	$0	$1,000,681,000	$1,062,879,000	$0	$1,062,879,000
OPERATING EXPENSES										
Salaries and Fringe Benefits	$442,544,426	$514,917,000		$514,917,000	$538,630,000		$538,630,000	$563,736,000		$563,736,000
Professional / Contracted Services	$32,848,360	$37,445,000		$37,445,000	$38,831,000		$38,831,000	$40,268,000		$40,268,000
Supplies and Drugs	$114,234,925	$125,423,000		$125,423,000	$125,147,000		$125,147,000	$132,047,000		$132,047,000
Bad Debts	$23,850,530	$33,527,000		$33,527,000	$35,185,000		$35,185,000	$35,628,000		$35,628,000
Other Operating Expense	$155,545,588	$155,519,000		$155,519,000	$156,734,000	$50,000	$156,784,000	$162,866,000	$53,000	$162,919,000
Subtotal	$769,023,829	$866,831,000	$0	$866,831,000	$894,527,000	$50,000	$894,577,000	$934,545,000	$53,000	$934,598,000
Depreciation/Amortization	$40,686,788	$46,858,000	$99,831	$46,957,831	$49,153,000	$199,662	$49,352,662	$52,464,000	$199,662	$52,663,662
Interest Expense	$607,197	$3,974,000		$3,974,000	$6,488,000		$6,488,000	$6,673,000		$6,673,000
Lease Expense	$14,520,485	$19,705,000		$19,705,000	$20,493,000		$20,493,000	$21,313,000		$21,313,000
Total Operating Expense	$824,838,299	$937,368,000	$99,831	$937,467,831	$970,661,000	$249,662	$970,910,662	$1,014,995,000	$252,662	$1,015,247,662
Gain/(Loss) from Operations	$5,059,861	$19,130,000	($99,831)	$19,030,169	$30,020,000	($249,662)	$29,770,338	$47,884,000	($252,662)	$47,631,338
Plus: Non-Operating Revenue	($4,240,807)	$10,504,000		$10,504,000	$10,504,000		$10,504,000	$10,504,000		$10,504,000
Revenue Over/(Under) Expense	$819,054	$29,634,000	($99,831)	$29,534,169	$40,524,000	($249,662)	$40,274,338	$58,388,000	($252,662)	$58,135,338
FTEs	5,396.30	5,576.50		5,576.50	5,476.50		5,476.50	5,539.87		5,539.87
CT Scans	49,816	47,000		47,000	47,000		47,000	47,000		47,000

Provide projected inpatient and/or outpatient statistics for any new services and provide actual and projected inpatient and/or outpatient statistics for any existing services which will change due to the proposal.

Index of Attachments

Attachment A – Listing of Unique Patient Count by Town of Origin

Attachment B – Articles Supporting the Need for Proposed Acquisition

Attachment C - Curriculum Vitae of Key Personnel Related to Proposal

Attachment D – Verification of Non-Profit Status

Attachment E – License

Attachment F – Vendor Quotes and Schedule of Depreciation

Attachment G – Current Rate Schedule

Attachment A

Listing of Unique Patient Count by Town of Origin

Radiation Oncology Patients - Hartford Campus - By Town of Origin - FY 2009

CityOrTownship	# Pts		CityOrTownship	# Pts
ALEXANDRIA BAY	1		NORTH WINDHAM	3
AMSTON	2		NORTHFIELD	1
ANDOVER	1		OLD LYME	1
ASHFORD	2		OLD SAYBROOK	2
AVON	13		PALM COAST	1
BERLIN	6		PLAINVILLE	5
BLOOMFIELD	34		POMFRET CENTER	1
BOLTON	2		PORTLAND	1
BRATTLEBORO	1		QUINEBAUG	1
BRIDGEWATER	1		ROCKY HILL	18
BRISTOL	5		Scotland	1
Broadbrook	2		SIMSBURY	12
BURLINGTON	1		Somers	1
CANTON	4		SOMERSVILLE	1
CENTERBROOK	1		SOUTH GLASTONBURY	7
COLCHESTER	9		SOUTH WINDSOR	9
COLUMBIA	2		SOUTHBURY	2
COVENTRY	13		SOUTHINGTON	3
CROMWELL	8		Stafford Springs	2
DEEP RIVER	1		STONINGTON	3
EAST GRANBY	1		STORRS MANSFIELD	4
EAST HADDAM	1		SUFFIELD	2
EAST HAMPTON	5		TOLLAND	7
EAST HARTFORD	41		TORRINGTON	3
EAST ORANGE	1		UNIONVILLE	2
EAST WINDSOR	5		VENICE	2
ELLINGTON	4		VERNON	5
ENFIELD	7		VERNON ROCKVILLE	16
FARMINGTON	1		W HARTFORD	1
GALES FERRY	1		WAKEFIELD	1
GLASTONBURY	37		WATERBURY	1
GRANBY	4		WATERTOWN	1
HADDAM	1		WATHERBURY	1
HARTFORD	81		WEATOGUE	2
HEBRON	5		WEST GRANBY	1
HIGGANUM	2		WEST HARTFORD	49
KENSINGTON	3		WEST SIMSBURY	3
LEBANON	3		WETHERSFIELD	38
MADISON	1		WILLIMANTIC	5
MANCHESTER	19		WILLINGTON	7
Mansfield	1		WINDHAM	1
MARLBOROUGH	5		WINDSOR	32
MERIDEN	2		WINDSOR LOCKS	6
MIDDLETOWN	16		WOODSTOCK VALLEY	1
MOODUS	1		WORCESTER	1
NEW BRITAIN	5			
NEWINGTON	27		TOTAL	391
NIANTIC	1			
NORTH CANTON	1			

Attachment B

Articles Supporting the Need for Proposed Acquisition

Implementation and characterization of a 320-slice volumetric CT scanner for simulation in radiation oncology

C. Coolens,[a] S. Breen, and T. G. Purdie
Radiation Medicine Program, Princess Margaret Hospital, Toronto, Ontario M5G 2M9, Canada and Department of Radiation Oncology, University of Toronto, Toronto, Ontario M5G 2M9, Canada

A. Owrangi, J. Publicover, and S. Bartolac
Radiation Medicine Program, Princess Margaret Hospital, Toronto, Ontario M5G 2M9, Canada

D. A. Jaffray
Radiation Medicine Program, Princess Margaret Hospital, Toronto, Ontario M5G 2M9, Canada and Department of Radiation Oncology, University of Toronto, Toronto, Ontario M5G 2M9, Canada

(Received 11 June 2009; revised 27 August 2009; accepted for publication 19 September 2009; published 8 October 2009)

Purpose: Effective target definition and broad employment of treatment response assessment with dynamic contrast-enhanced CT in radiation oncology requires increased speed and coverage for use within a single bolus injection. To this end, a novel volumetric CT scanner (Aquilion One, Toshiba, Tochigi Pref., Japan) has been installed at the Princess Margaret Hospital for implementation into routine CT simulation. This technology offers great advantages for anatomical and functional imaging in both scan speed and coverage. The aim of this work is to investigate the system's imaging performance and quality as well as CT quantification accuracy which is important for radiotherapy dose calculations.

Methods: The 320-slice CT scanner uses a 160 mm wide-area (2D) solid-state detector design which provides the possibility to acquire a volumetric axial length of 160 mm without moving the CT couch. This is referred to as "volume" and can be scanned with a rotation speed of 0.35–3 s. The scanner can also be used as a 64-slice CT scanner and perform conventional (axial) and helical acquisitions with collimation ranges of 1–32 and 16–32 mm, respectively. Commissioning was performed according to AAPM Reports TG 66 and 39 for both helical and volumetric imaging. Defrise and other cone-beam image analysis tests were performed.

Results: Overall, the imaging spatial resolution and geometric efficiency (GE) were found to be very good (>10 lp/mm, <1 mm spatial integrity and $GE_{160\ mm}$=85%) and within the AAPM guidelines as well as IEC recommendations. Although there is evidence of some cone-beam artifacts when scanning the Defrise phantom, image quality was found to be good and sufficient for treatment planning (soft tissue noise <10 HU). Measurements of CT number stability and contrast-to-noise values across the volume indicate clinically acceptable scan accuracy even at the field edge.

Conclusions: Initial experience with this exciting new technology confirms its accuracy for routine CT simulation within radiation oncology and allows for future investigations into specialized dynamic volumetric imaging applications. [DOI: 10.1118/1.3246352]

Key words: computed tomography, oncology, calibration

I. INTRODUCTION

With IMRT and increased treatment delivery accuracy with IGRT, effective target definition and assessment of treatment response are paramount in radiation oncology. Reduction in motion artifacts (especially for lung and liver) in CT simulation and the use of more functional imaging information in treatment design are key components in achieving this goal. To this end, a novel volumetric CT scanner (Aquilion One, Toshiba, Tochigi Pref., Japan) has been installed for implementation into routine CT simulation. The Aquilion One scanner is a 320-slice CT scanner providing craniocaudal coverage at the isocenter of 160 mm in a single rotation of 0.35 s. This offers great advantages over conventional CT studies as it provides increased speed and increased coverage, whereas conventional multidetector scanners are still limited in cradiocaudal extent during dynamic acquisition. This not only affects tumor motion assessment but also limits the scan frequency and temporal resolution of dynamic contrast-enhanced CT studies.

Volume scanning has the potential to reduce scan time and motion artifacts compared to helical scanning as the craniocaudal volume coverage of 160 mm can encompass, e.g., the entire brain, heart, prostate, bladder, thyroid, most metastases, brain tumors, and solitary lung tumors within a single gantry rotation.

The aim of this work is to characterize the imaging performance of the volumetric CT capabilities with a view to

specialized applications within radiation oncology. The scanner capabilities as well as some logistical issues related to the integration of the system within our radiotherapy department will be described.

II. METHODS AND MATERIALS

The CT scanner was installed in June 2008 for implementation into routine radiotherapy CT simulation. Special considerations were required in designing the room shielding due to the extra scatter generated from the wider x-ray cone angle (15.2°) and scan volume. An additional 1 mm Pb was added to the existing 3 mm Pb to shield the room to remain below 1 mSv/yr exposure limits. Commissioning included x-ray generation tests, such as kVp accuracy and current-exposure time product linearity but did not require special consideration from conventional multislice CT commissioning tests[1,2] so they will not be discussed in further detail. Similarly, measurements of $CTDI_w$ were done based on the standardized $CTDI_{100}$ phantoms and with a single slice scan to allow for comparison with other multislice scanners and techniques. Values for a typical head and body scan were found to be in good agreement with our previous 64-slice CT scanner ($CTDI_w$ was 11.4 mGy for a typical body scan and 18.6 mGy a head scan). However, the usefulness of this measure in multislice CT is questionable and the validation of this concept falls outside the scope of this report but some further details can be found in Ref. 3.

II.A. Volumetric CT

The 320-slice CT scanner uses a 160 mm wide-area (2D) solid-state detector design mounted on slip-ring gantry technology. This provides 286 720 elements (896 channels × 320 segments) with an isotropic element size of approximately 0.5 mm at the isocenter. The axial field of view (FOV) ranges from 180 to 500 mm using a 50-cm-wide bore. It is possible to acquire a volumetric axial length of 160 mm without moving the CT couch. This is referred to as "volume" and can be scanned with a rotation speed of 0.35–3 s. Wide volumes of 320 and 480 mm can currently be acquired in 1.5 and 3 s by automatically stitching together two and three adjacent volumes, respectively. In addition, the scanner can also be used as a 64-slice CT scanner and perform conventional (axial) and helical scanning with collimation ranges of 1–32 and 16–32 mm, respectively. In conventional mode, a half scan can be performed in 0.23 s.

Unless otherwise stated, all measurements in this work were done in volume imaging mode at 0.5 mm acquisition thickness and reconstructed at 0.5 mm slice thickness. CT values are expressed in terms of CT numbers, which are the Hounsfield unit (HU) values as defined by $CT=[(\mu_{tissue}-\mu_{water})/\mu_{water}]\times 1000$, i.e., water=0 HU and air=−1000 HU.

II.B. Image acquisition

II.B.1. Radiation profile

The radiation profile width was measured with Polaroid film (Kodak X-OmatV) placed on the couch top in the plane of the isocenter. The tube was fixed at the top of the gantry (80 kVp, 100 mA s, 0.5 s exposure, Focus: Small, Wedge: Medium). Exposed films were developed and, consequently, scanned with a film densitometer (Vidar Systems Corporation, Herndon, VA) for detailed analysis. The profile of the beam was measured for different collimation settings. This test is dated because modern scanners have multiple detectors, and the radiation beam is collimated so that it extends past the edges of the detectors that are used for a particular acquisition. Therefore, the geometric efficiency was measured to describe the use of x-ray dose along the z axis and defined as the ratio of the integral of the dose profile falling within the active detector width to the integral of the dose profile along its total length as per IEC specifications.[4] This definition was chosen to incorporate the scatter tails present in cone-beam CT, as opposed to the FWHM that is often quoted.

II.B.2. Sensitivity width profile

The CATPHAN® phantom (The Phantom Laboratory, USA) was used to measure the thickness of slices on reconstructed tomographic images with the phantom origin at the scan isocenter. Images of a series of wires placed obliquely (at an angle of 23°) to the scan plane were obtained at several slice thicknesses (120 kVp, 200 mA, and 1.0 s exposure) and reconstruction filters. The maximum intensity of the wire was determined when the window was set to 1; the level was reduced to half of the maximum intensity corrected for background, as described in the CATPHAN® manual.

II.C. Spatial resolution and modulation transfer function

High contrast spatial resolution was assessed with two techniques and for several reconstruction filters. The first method was by scanning the CATPHAN through the section containing the wires (120 kV, 200 mA, and 1.0 s exposure). The modulation transfer function (MTF) was calculated from the discrete Fourier transform of the average vertical and horizontal line spread functions of the point spread function from the bead or wire test section. The smallest distinguishable line pair was noted for different scan reconstruction filters. Secondly, MTF analysis was done by imaging the central section of PentaGuide phantom (Modus Medical Devices, Inc., Ontario, Canada), which includes an air sphere surrounded by a uniform medium.[5] By plotting the CT number along a line from the center of the sphere an edge response function is created and this can be done in any direction. Differentiating the edge response function produces a plane spread function that is then Fourier transformed for frequency analysis. Using this method, the spatial resolution at the CT isocenter was measured in all cardinal directions.

Finally, geometric integrity was measured with the RMI phantom (Gammex) that has a number of small holes that are spaced on a rectilinear 5 cm grid. Distances between pairs of holes were measured on the reconstructed images. The distance between pairs of points on the periphery of the RMI phantom was also measured. These points are located in 1 mm divots on the phantom circumference, and so the distances correspond to the cord length, less than about 2 mm for the depth of the divots.

II.D. Image quality

II.D.1. Uniformity

Uniformity measurements were performed in cylindrical phantoms, positioned both at the isocenter and off axis, for different collimation settings to evaluate the impact of cone-beam scatter with increasing cone angle. Firstly, large (520 mm in diameter), uniform water-equivalent phantoms supplied by Toshiba were scanned (120 kV and 500 mA s) and square regions of interest were analyzed for HU variation with different FOVs (small: 150×150 mm^2, medium: 150×150 mm^2, and Large: 250×250 mm^2). Secondly, in-plane variation in noise and uniformity was measured using the CATPHAN uniformity module (120 kV and 200 mA s) in 10×10 mm^2 ROIs at the isocenter and 5 cm offsets in each direction. The material's CT number is designed to be within 2% of water's at standard scanning protocols.

Noise measurements were also done within a rod insert representing liver ($\rho=1.07$) and cortical bone CB2 ($\rho=1.69$) material that was suspended at the center of a water tank. A 1.5×1.5 cm^2 ROI was defined at the center of the 7-cm-long rod and the variation in HU recorded. This was then repeated with the phantom offset along the longitudinal z axis by 2, 4, and 6 cm in each direction. Finally, these measurements were repeated with collimation settings varying between 40 and 160 mm to investigate the impact of cone-angle settings.

II.D.2. Contrast-to-noise ratio

Measurements of contrast-to-noise ratio (CNR) as a function of cone angle were performed for different inserts of the RMI density phantom, fixed consecutively inside a water tank as in the noise measurements. The CNR was calculated relative to CT water according to

$$\mathrm{CNR}_{AB} = 2\frac{S_A - S_B}{\sigma_A + \sigma_B},$$

where S and σ are the signal (mean HU) and standard deviation, respectively, in the ROI within the (A) insert and (B) water background. Contrast measurements were made at the center of the cylinders to avoid the influence of possible cone-beam artifacts that may occur and which are most severe at the planar surfaces. These measurements were then repeated with the whole phantom setup moved to $z=2$, 4, and 6 cm offsets along the longitudinal scan axis.

II.D.3. Cone-beam reconstruction

Volumetric scans are achieved using a circular source and detector trajectory about the patient. Cone-beam data, acquired using this geometry, are known to be insufficient for accurate reconstruction, which suggests that cone-beam artifacts may be present in the final image.[6–8] A common method for testing for the presence of cone-beam artifacts is to image a Defrise phantom or stack of disks.[9] This phantom is known to exhibit very severe artifacts at the planar surfaces of the disks with distance from the central slice.[10] A similar experiment was performed in this study by imaging a single, solid-water disk (diameter=20 cm, width=1 cm) at increased longitudinal distances of 2.5 and 5 cm from the isocenter and observing the induced artifacts as a function of shift in the couch position.

The reconstruction method for volumetric scans on the Aquilion One makes use of a "ConeExact" algorithm, which is a modified FBP algorithm. At the time of this publication, theoretically exact reconstruction algorithms are not known for circular cone-beam CT. Nevertheless, there are many approaches to reducing the appearance of artifacts. A qualitative test for artifacts at planar surfaces as compared to anatomical features was made using the RANDO phantom (The Phantom Laboratory, USA). The chest section of the RANDO phantom was scanned in volume mode at different gantry tilts with a 1 mm thick paper sheet between some of the slabs. Similar to the disks, one may observe cone-beam artifacts at the planar sheets with greater distance from the central slice. In addition, one can also observe the effects of gantry tilt. As the gantry tilt increases, the relationship between the planes of the slabs and the circular trajectory changes, typically allowing for better reconstruction of the flat edges.[10] Changes in the reconstruction quality to the surrounding anatomy can also be observed for comparison. Volume scans were done at gantry tilt $G=0°$, 3°, and 8° to, respectively, mimic a tilt roughly half and larger than the 7.6° cone angle.

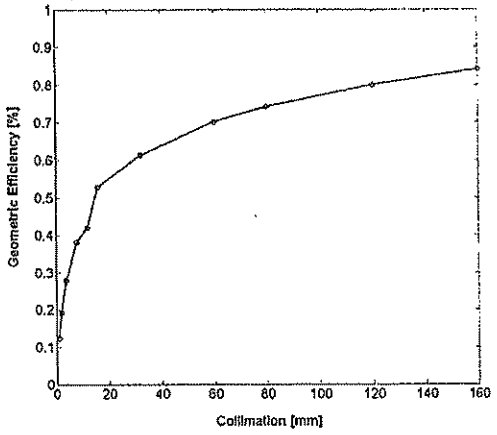


FIG. 1. Geometric efficiency, defined as per IEC recommendations, as a function of beam collimation.

TABLE I. Radiation profile width at different collimation settings.

Slice opening (mm)	No. of slices	Reference profile width (mm)	FWHM (mm)
0.5	2	7.0±2.4	6.1
0.5	4	8.0±2.4	7.1
1	4	10.0±2.4	9.1
2	4	13.0±3.6	13.0
2	8	20.0±4.3	20.9
2	16	37.0±5.0	38.8
0.5	160	86.0±5.0	87.7
1	160	171.0±5.0	172.5

II.E. Quantitative CT

CT number accuracy measurements were done by scanning various tissue and water equivalent materials using the RMI electron density phantom[2] (Scan parameters: 120 kVp, 300 mA, 1.0 s exposure, 2 mm thick, FC04). The CT numbers in a 20 mm diameter circle were recorded for all inserts on the central slice. This was repeated with the phantom positioned at ±2, 4, and 6 cm offsets from the isocenter along the longitudinal axis to evaluate HU consistency across the volume. The stability of CT numbers with respect to cone-angle collimation was obtained during the CNR measurements in liver and lung as described in Sec. II D 2.

III. RESULTS

III.A. Image acquisition

III.A.1. Radiation profile width

The measured profile width was generally within 1 mm of the reference profile provided by the manufacturer. As can be seen from Table I, the radiation profile is collimated so that it extends past the edges of the detectors that are used for a particular acquisition. This is a typical effect for multislice detectors that is more pronounced at small collimation settings. Lower collimation settings are generally not recommended for routine clinical use. This is also illustrated by means of the geometric efficiency shown in Fig. 1, which typically is very low at small collimations but reaches over 85% at the maximum collimation of 160 mm.

TABLE II. Sensitivity width profile for different reconstruction filters.

Reconstruction	Programed thickness	Measured thickness (mm)	Difference (mm)
FC 23 (head)	0.5	1.3	0.8
volume	1.0	1.3	0.3
	2.0	2.1	0.1
	3.0	3.2	0.2
	5.0	5.6	0.6
FC 03 (abdomen)	0.5	0.8	0.3
volume	1.0	1.1	0.1
	2.0	2.0	0.0
	3.0	3.1	0.1
	5.0	5.0	0.0
FC 81 (sharp)	1.0	1.1	0.1
helical pitch 0.828	2.0	2.0	0.0
	3.0	2.8	0.2
	5.0	4.9	0.1
	10.0	9.6	0.4

TABLE III. MTF critical frequencies for different reconstruction filters.

lp mm	MTF 50 (%)	MTF 20 (%)	MTF 10 (%)
FC04	4.51	8.42	20.88[a]
FC23	3.50	7.77	15.39[a]
FC41	2.90	5.12	6.34

[a]Exceeding Nyquist frequency of 10.6 lp/mm.

III.A.2. Sensitivity width profile

Table II details the measurements of reconstructed slice thicknesses for different reconstruction filters based on 0.5 mm volume scan acquisitions. Discrepancies were noted for 0.5 and 5 mm slice thicknesses using an average reconstruction filter for the head. The use of a sharper reconstruction filter (FC03) resulted in better agreement to the programed thickness. Overall, differences were within the tolerance of 0.5 mm (i.e., minimum slice thickness) and deemed acceptable.

III.B. Spatial resolution and modulation transfer function

MTF analysis with the CATPHAN phantom was done for different reconstruction filters ranging from an average filter for abdominal scanning (FC04) and head scanning (FC23) with beam-hardening correction (BHC) to a smooth filter for head scanning without BHC (FC41). A summary is shown in Table III. Generally up to 10 lp/mm were visible using these clinical algorithms. $MTF_{10\%}$ for all cardinal directions is shown in Table IV and was calculated from scans of the PentaGuide's central sphere (120 kV and 200 mA s). These line pair values represent a 1D system resolution for each direction and illustrate the slight superiority of in-plane resolution due to cone-beam reconstruction (see Sec. IV).

Finally, spatial integrity was assessed at different locations within the FOV as shown in Fig. 2. Values were found

Line	True Distance [mm]	Measured Distance [mm]
AB	50.0	50.0
BC	50.0	50.0
AG	141.0	141.0
AH	150.0	150.0
DC	111.8	111.7
RMI cord	231	230.0
RMI diameter	327	328.0

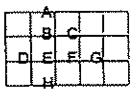


FIG. 2. Distance measurements based on pairs of holes in RMI phantom.

TABLE IV. Values of $MTF_{10\%}$ at the isocenter for all cardinal directions.

lp/mm	Left	Right	Ant	Post	Sup	Inf
MTF 10 (%)	6.54	5.87	8.18	8.39	5.90	5.86

to correspond to within 1 mm.

III.C. Image quality

III.C.1. Uniformity

The variation in CT number within large uniform water-equivalent phantoms, supplied by Toshiba, was found to be within manufacturer specification (Table V). Noise and uniformity values in ROIs at the isocenter, as measured with the CatPhan uniformity module, are not distinguishable within the isocentre axial plane. The HU variation between different ROIs is within the intrinsic noise level tolerance.

Noise values in water, as a function of increasing cone-angle collimation, were not significantly different either at the isocenter or offset longitudinally within the volume. The same observation applies to the noise measurements in the liver and CB2 rod immersed in water, with the standard deviation of less than 10 HU for all measurements.

III.C.2. Contrast-to-noise measurements

CNR measurements for the liver insert in water are shown in Fig. 3. The cone-angle collimation (i.e., longitudinal FOV) was varied between 40 and 160 mm symmetrically around the scan isocenter. For the liver insert, it is clear that the CNR decreases with increasing cone angle both for the insert setup at the scan isocenter and at 2 cm off axis. Placing the insert at further distances from the isocenter leads to more difficult interpretation as the center of the insert might not fall within the FOV for small collimation settings and, hence, a more representative ROI had to be chosen closer to the edge of the insert. For the 6 cm offset setup, it was not possible to measure at all for the small collimations and hence these data points are not shown.

Repeating these measurements for the cortical bone insert (CB2) revealed no decrease in CNR with increasing cone-angle collimation. To verify the symmetry of the beam, the phantom was also offset inferiorly, again with no significant change in CNR. The mean CNR for the bone insert in water across all cone-angle collimations was 46.1 ± 1.4.

TABLE V. CT number uniformity in water-equivalent phantoms for different FOVs.

Field of view	Phantom (mm)	Mean CT number	StDev CT number	StDev specification
Small	240	−0.80	4.6	3.6–6.4
Medium	320	1.9	8.4	8.0–12.0
Large	400	1.6	11.0	9.5–14.4

III.C.3. Cone-beam reconstruction

Figure 4 shows the cross section of the solid water disk at different longitudinal positions along the scan axis. Distortion of the planar surfaces and associated streaking and shading artifacts are seen to worsen as the disk is positioned further from the isocenter. These artifacts are characteristics of cone-beam artifacts and are strong evidence that they will be present in the reconstruction data.[6] Nevertheless, the severity of the artifacts is known to be somewhat object dependent,[10] where a disk is generally considered a worst case. In addition, the artifact suppression algorithm used may also depend on the object imaged and the ability for the algorithm to approximate the missing information.

Figure 5 shows the coronal view of the RANDO chest phantom volume scanned with different gantry tilts. At $G = 0°$, the 1 mm paper sheets suffer more severe artifacts with distance from the central slice similar to the disk phantom. This may be partly a result of the difficulty in setting up the RANDO phantom with minimal residual gaps between the slabs and of axial truncation effects. Increasing gantry tilt results in a much clearer definition of the planar sheets, however, giving evidence that the original blurring is primarily a result of cone-beam artifacts. This illustrates the existence of some cone-beam reconstruction insufficiency at the field edges for this worst case of a very thin 1 mm axial object. Comparison with anatomy shows no obvious change in the reconstruction quality and the cone-beam artifact is not readily visible in more clinically realistic settings. The latter was also confirmed when analyzing the sphere used for MTF

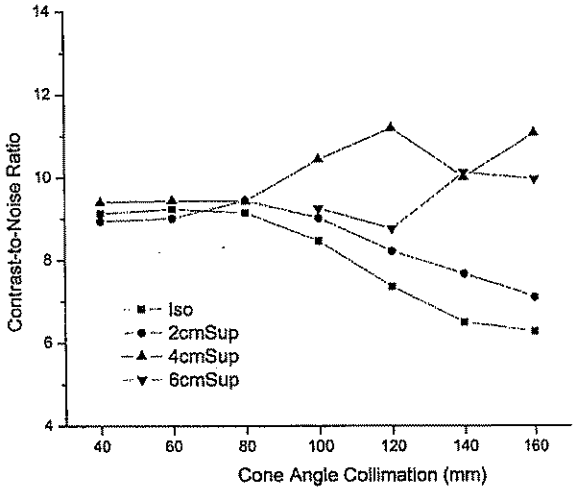


FIG. 3. CNR for the liver insert in water for different collimations and phantom setup along the longitudinal axis.

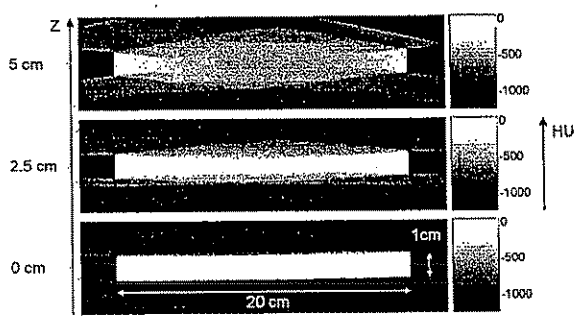


FIG. 4. Axial scans through a Defrise disk at different longitudinal positions along the scanner axis without window leveling.

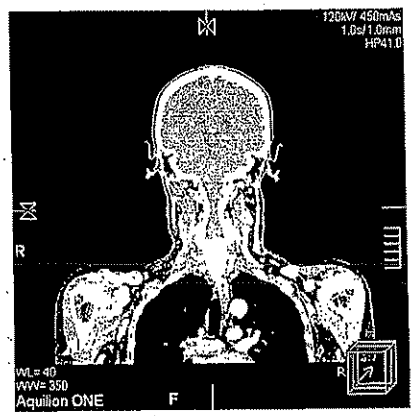


FIG. 6. Coronal view of helical scan acquisition for a patient with upper body disease. Window leveling was set to WL=40, WW=350 to show some detail in both the brain and mediastinum.

measurements which showed no qualitative evidence of artifacts. As a comparison, a helical scan of a patient with head and neck disease is shown in Fig. 6 using a windowing level to show some detail in both the brain and mediastinum (WL=40, WW=350). This illustrates the stable behavior of image quality on the scanner. A fuller analysis of the manifestation of cone-beam artifacts in anthropomorphic phantoms using this system may be an area of future work. In addition, quantitative analysis of the CB artifact reduction capabilities of the ConeExact algorithm is best performed by comparing the algorithm with a nonmodified FBP algorithm where no artifact reduction method is utilized (see Fig. 6).

III.D. Quantitative CT

CT number calibration was performed with the different-density inserts of the RMI phantom and is shown in Fig. 7 for a range of phantom setups within the scan volume. The CT number stability across the scan volume was investigated within a fixed full-length volume of 160 mm collimation. The results in Fig. 7 indicate that stability across the volume is better than 10% for materials with a density less than or equal to water. For higher densities, the discrepancy widens slightly but is still within the variation that can arise from using different tube potentials and scatter conditions.

The variation in CT number, as a function of cone-angle collimation, for the liver insert in water is shown in Fig. 8. This indicates that the CT numbers within the liver insert decrease with increasing collimation when the object is close to the CT isocenter. This could illustrate the impact of scatter, lowering the effective HU of the actual object. In the case of the cortical bone insert, the HU is very stable irrespective of the cone-angle collimation (not shown here). The HU values for collimation between 40 and 80 mm at 4 cm offset are lower than for the larger collimation due to the phantom offset from the isocenter as mentioned in Sec. II.C.2. For the 6 cm phantom offset, the insert was not in the field of view. Overall, the variation in CT number across the field length was less than the variation in CT calibration curves from other CT simulators.

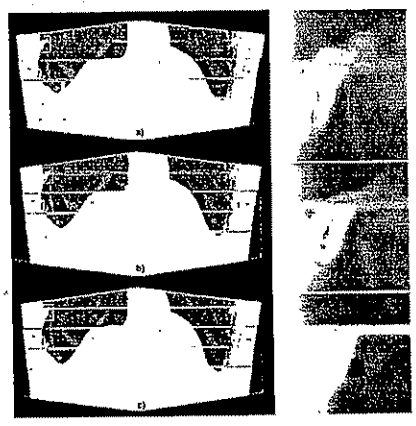


FIG. 5. Coronal view of a volume scan of the chest RANDO phantom with 1 mm paper sheets in between certain slabs for gantry tilts of (a) 0°, (b) 3°, and (c) 8°. The associated image on the right shows the magnification of the ROI around the rib as indicated on the left.

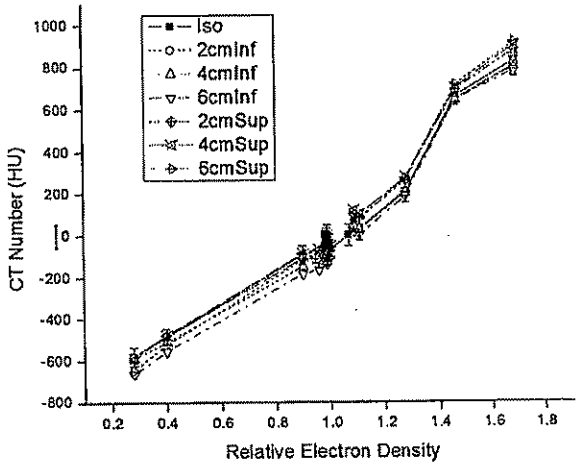


FIG. 7. Electron density calibration curves for RMI phantom setup at several locations within the scan volume for volumetric acquisition. As the CT value for water is the same for all setups only one data point is shown.

III.E. Data production and storage

The system contains a 3.8 Tbyte magnetic hard disk as standard equipment, permitting online storage of approximately 800 000 images and 1700 rotations of raw data. One volume scan takes up approximately 160 Mbytes so that dynamic volume studies quickly can run up to the order of 10 Gbytes. Additional storage was set aside on our clinical data server to accommodate for this. Currently, limitations exist on the import of CT data in our planning system (Pinnacle 8.0h, Philips Radiation Oncology Systems, Andover, MA) that allows a maximum of 511 slices per image set. Wide-volume scans will contain a larger number of slices than this if the reconstruction is done at less than a 2 mm slice thickness and should therefore be taken into consideration.

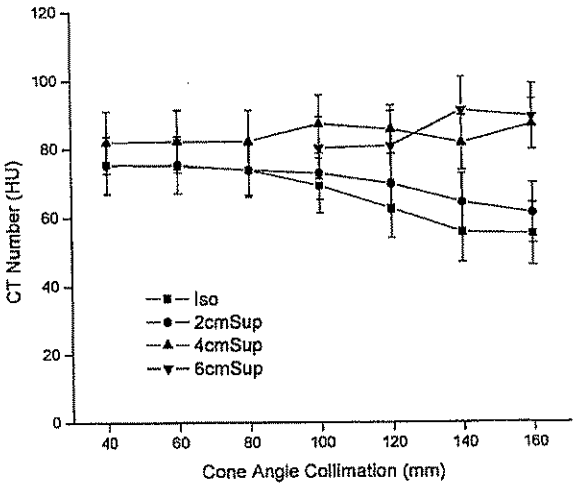


FIG. 8. CT number of liver in water as a function of cone-angle collimation for the phantom origin placed at the isocenter and 2, 4, and 6 cm superiorly.

IV. DISCUSSION

Attention was focused in this paper to the characteristics of volumetric scanning on a 320-slice CT scanner for implementation into routine radiotherapy simulation. Image spatial resolution was investigated through MTF analysis and geometric fidelity tests. Although the MTF analysis was done for all three cardinal angles, it still only contains 1D frequency information per orientation. A true 3D MTF analysis would require a full 3D Fourier transform, which is very object dependent and is subject to cone-beam artifact correction algorithms. Therefore, the MTF analysis was only done at the CT isocenter where the linear approximation is likely to be sufficient. The fact that the sphere used for MTF measurements showed no qualitative evidence of artifacts seems to support this assumption. Although there is evidence of cone-beam artifacts when scanning the Defrise phantom, measurements of CT number stability and CNR indicate clinically acceptable scan accuracy even at the field edge. A fuller analysis of the manifestation of cone-beam artifacts in anatomical phantoms using this system may be an area of future investigation.

As can be seen from Fig. 3 and other noise measurements, the noise is comparable to other multislice scanners and stable within the described phantom experiments. This applies both at the isocenter and across the scan volume. Therefore, the variation in CT number and CNR are proportionally linked, which is confirmed in Fig. 8. Figures 3 and 8 illustrate the complex superposition of contributing factors to the overall CT number and CNR for different materials. There is the additional scatter from the surrounding medium when increasing the collimation, seen when measuring close to the CT isocenter. This scattered radiation increases the effective energy of photons reaching the detector, resulting in an apparent lower HU for the liver. In the case of the bone insert, this does not occur and it could be postulated that the scattered radiation is being absorbed by the bony insert and is a second order effect, therefore not impacting the CT number stability and CNR. When the object is farther away from the isocenter cone-beam artifacts, beam penumbra, and beam hardening all contribute to the final CT number and CNR.

Further work is needed on CT number accuracy to understand the relative importance of these effects when performing "nonstandard" volumetric acquisitions, i.e., at collimations larger than the conventional 160 mm. Nevertheless, for standard volume acquisitions, however, it was noted (Fig. 7) that the CT number across the volume is relatively stable as compared to the data at the isocenter and for helical scanning as the variation in HU across the scan volume is within the inherent HU measurement uncertainty. Furthermore, the variation in HU falls within the range of calibration curves obtained from different scanners and energies and therefore seems unlikely to impact the resulting dose calculation accuracy.[11,12] In diagnostic CT there is an assumption that the relationship between CT number and electron density is linear. Although this is true for most soft tissues or even soft bone, this assumption starts to break down for higher density materials for which the larger influence of the photoelectric effect over Compton interactions makes the CT number less representative of electron density.[13] Within radiation oncology, the implementation of this calibration curve for radiotherapy dose calculations involves a bilinear electron density curve pivoting around bone density. The correlation coefficient of performing a linear fit (as is sometimes done with the CATPHAN phantom) is therefore not necessarily a true measure of accuracy but more a baseline measurement for easier quality assurance.

Image quality of patient scans has been well received by the radiation oncologists and treatment planners. Clinically realistic phantoms were used to finalize the volumetric scan parameters that optimize image quality for each specific tumor site. These early results therefore warrant further exploration into the exciting possibilities for dynamic imaging with this technology. This includes 4D motion assessment as well as functional analysis with dynamic contrast-enhanced volumetric imaging. Many radiotherapy institutions now rely on retrospectively correlated 4D CT to assess intrafraction

respiratory motion of lung and liver tumors for margin design and respiratory-correlated treatment delivery. This technique, based on retrospective resorting of time-correlated axial scanning, is still subject to artifacts as different parts of the volume are scanned at different times; this also enhances the susceptibility to variability in breathing motion. Using dynamic volume scanning could provide a 'true' 4D assessment of organ motion as the volume within a single rotation can be acquired in a time shorter than the temporal resolution of a typical conventional 4DCT. This offers a new outlook on motion management that could support not only an improvement in treatment simulation but in treatment delivery through improved 4D image matching with online kV verification.

For dynamic contrast-enhancement, this increased speed and coverage also offers great advantages over conventional CT perfusion imaging studies where the dynamic scan range within a single bolus injection is limited, in practice, to a 2D dynamic acquisition and breathing-induced anatomical motion drastically limits the scanning frequency and hence accuracy.

V. CONCLUSION

The use of daily soft tissue imaging during radiation therapy has accelerated the importance of individualized and biologically adapted treatment. Using dynamic volumetric CT information for improved target definition and assessment of treatment response will be a major step forward toward more targeted radiotherapy. To this end, a novel 320-slice wide-area CT scanner has been successfully implemented and commissioned for routine radiotherapy simulation in our department. Initial experience indicates that the image quality and CT number uniformity in the standard volumetric mode are sufficiently accurate to be used for anatomical radiotherapy simulation. Future work will investigate the characteristics of dynamic volumetric imaging for specialized applications such as 4D motion analysis and contrast-enhanced dynamic CT scanning.

ACKNOWLEDGMENTS

The authors are much obliged to the useful interactions with Toshiba Medical Canada, as well as discussions with Dr. Jeff Siewerdsen.

[a]Electronic mail: catherine.coolens@rmp.uhn.on.ca

[1]AAPM Radiation Therapy Committee Task Group No. 39, "Specification and acceptance testing of computed tomography scanners," American Institute of Physics, New York, 1993.
[2]S. Mutic, J. R. Palta, E. K. Butker, I. J. Das, M. S. Huq, L. N. Loo, B. J. Salter, C. H. McCollough, and J. Van Dyk, "Quality assurance for computed-tomography simulators and the computed-tomography-simulation process: Report of the AAPM Radiation Therapy Committee Task Group No. 66," Med. Phys. **30**, 2762–2792 (2003).
[3]J. D. Silverman, N. S. Paul, and J. H. Siewerdsen, "Investigation of lung nodule detectability in low-dose 320-slice computed tomography," Med. Phys. **36**, 1700–1170 (2009).
[4]IEC, "Medical electrical equipment: Particular requirements for the safety of x-ray equipment for computed tomography," IEC CT Safety Standard 60601-2-44, 2nd ed. (2001), Amendment (2003).
[5]M. M. Thornton and M. J. Flynn, "Measurement of the spatial resolution of a clinical volumetric computed tomography scanner using a sphere phantom," Proc. SPIE **6142**, 707–716 (2006).
[6]H. K. Tuy, "An inversion formula for cone-beam reconstruction," SIAM J. Appl. Math. **43**, 547–552 (1983).
[7]D. Finch, "Cone beam reconstruction with sources on a curve," SIAM J. Appl. Math. **43**, 546–552 (1985).
[8]B. D. Smith, "Image reconstruction from cone-beam projections: Necessary and sufficient conditions and reconstruction methods," IEEE Trans. Med. Imaging **4**, 14–25 (1985).
[9]M. Defrise and R. Clack, "A cone-beam reconstruction algorithm using shift-variant filtering and cone-beam backprojection," IEEE Trans. Med. Imaging **13**, 186–195 (1994).
[10]S. Bartolac, R. Clackdoyle, F. Noo, J. Siewerdsen, D. Moseley, and D. Jaffray, "A local shift-variant Fourier model and experimental validation of circular cone-beam computed tomography artifacts," Med. Phys. **36**, 500–512 (2009).
[11]W. Kilby, J. Sage, and V. Rabett, "Tolerance levels for quality assurance of electron density values generated from CT in radiotherapy treatment planning," Phys. Med. Biol. **47**, 1485–1492 (2002).
[12]S. J. Thomas, "Relative electron density calibration of CT scanners for radiotherapy treatment planning," Br. J. Radiol. **72**, 781–786 (1999).
[13]C. Coolens and P. J. Childs, "Calibration of CT Hounsfield units for radiotherapy treatment planning of patients with metallic hip prostheses: The use of the extended CT-scale," Phys. Med. Biol. **48**, 1591–1603 (2003).

Radiotherapy and Oncology 87 (2008) 350–356
www.thegreenjournal.com

Rectal cancer

Evaluation of three different CT simulation and planning procedures for the preoperative irradiation of operable rectal cancer

Jacques H. Borger*, Jørgen van den Bogaard, Daniëlle F.M. de Haas, Anna P.B.M. Braeken, Lars H.P. Murrer, Ruud M.A. Houben, Guido Lammering

MAASTRO clinic, Maastricht, The Netherlands

Abstract

Purpose: To find the best procedure regarding quality and work load for treatment planning in operable non-locally advanced rectal cancer using 3D CT-based information.

Methods: The study population consisted of 62 patients with non-locally advanced tumours, as defined by MRI in the lower ($N = 16$), middle ($N = 25$) and upper ($N = 21$) rectum referred for preoperative short-course radiotherapy. In procedure 1 (Pr1), planning in one central plane was performed (field borders/shielding based on bony anatomy). In procedure 2 (Pr2), field borders were determined by 2 markers for the extension of the CTV in the cranial and ventral direction. Dose optimization was performed in one central and two border planes. In procedure 3(Pr3) the PTV volume (CTV was contoured on CT) received conformal treatment (3D dose optimization).

Results: Conformity index reached 1.6 for Pr3 vs. 2.2 for Pr2 ($p < 0.001$). PTV coverage was 87%, 94%, 99% in Pr1, Pr2, Pr3, respectively ($p = 0.001$). In Pr2 target coverage was below 95% for low/middle tumours. PTV coverage was reduced by narrow field borders (18–23%) and shielding (28%). A total of 43.5% (1–100) of the bladder volume was treated in Pr2 in contrast to 16% (0–68) in Pr3 ($p < 0.001$). The maximum dose was exceeded in 10 patients (26–298 cc) and 2 patients (21–36 cc) in procedures 1 and 2, respectively. The overall time spent by technologists was 86 min for Pr3 vs 17 min in Pr2 and Pr1 ($p < 0.001$), for radiation oncologists this difference was 24 vs 4 min ($p < 0.001$).

Conclusions: Pr1 does not fulfill todays quality requirements. Pr3 provides the best quality at the cost of working time. Pr2 is less time consuming, however, the PTV coverage was insufficient, with also much larger treatment volumes. An optimization of the PTV coverage in Pr2 even further enlarged the treatment volume.
 Radiotherapy and Oncology 87 (2008) 350–356

Keywords: Rectal cancer; Preoperative radiotherapy; CT planning; CT simulation

Preoperative short-course hypofractionated radiotherapy is nowadays a commonly used treatment for rectal cancer. Usually in our country this short hypofractionated course (5×5 Gy) is given immediately before total mesorectal excision (TME) surgery to those patients, who have been staged as operable rectal cancer patients [9,19,21]. Interestingly, this short-course hypofractionated radiotherapy might also prove to be effective in down-sizing non-resectable rectal cancer, if the surgical excision is delayed, as has been recently published [3,17].

In more and more centers, the patient selection nowadays for short-course preoperative radiotherapy is based on Magnetic Resonance (MR) imaging with a special attention to the circumferential resection margins (CRM). The clinical target volume (CTV) consists of the primary tumour and involved lymph nodes (GTV), the mesorectal fat area including the fascia and the regional lymph nodes [18]. The introduction of Computed Tomography scans in the treatment planning of radiotherapy has had an enormous impact on planning procedures and daily clinical practice. The patient contouring and attenuation correction can nowadays be performed in 3D using today's computer technology. In addition, dose calculation and adaptation per voxel have become the basis of modern radiotherapy techniques. Importantly, the use of the CT scanner as a simulator has also had a big impact on the delineation of the target volumes [18]. The modern radiation field design to cover primary tumour extension and regional lymph nodes is often no longer based on the classical bony landmarks. The GTV and CTV can be delineated as soft tissue anatomy on CT images, often accompanied by other imaging modalities (Positron Emission Tomography (PET), MRI). On the

0167-8140/$ - see front matter doi:10.1016/j.radonc.2008.03.024

other hand, the delineation of all the target structures is time consuming and may not always be necessary if new anatomic landmarks could be defined. Nevertheless, many centers still perform the classical planning procedure by using bony landmarks, although no studies have ever been done to verify the equality of the classical method with the 3D-conformal technique. Therefore, we felt it is important to perform a study, in which the classical 2D bony landmark method will be evaluated for its Planning Target Volume (PTV) coverage quality and dose homogeneity by comparing it with the 3D-conformal technique as reference. In addition, we developed a CT-3D based technique without target delineation but with the help of 2 defined landmarks in order to reduce working time and also evaluate its quality in comparison to the reference 3D-conformal technique.

Patients and methods

Patients

The CT scans of 62 patients with rectal carcinoma were used to perform the study. In the period between January 2004 and December 2005 almost all the resectable rectal cancer cases referred for preoperative hypofractionated radiotherapy were selected with a special focus on a comparable distribution of the tumour localization overall 3 levels of the rectum (Level I 3–7 cm (21 patients), Level II 7–10 cm (25 patients), Level III >10 cm (16 patients) from the anocutaneous border). The median age was 68 years (range: 34–82 years). All the patients received an MRI of the abdomen as a standard work-up before treatment decision making. The resectability criteria were judged in multidisciplinary teams. All the patients with non-locally advanced tumours received short-course preoperative radiotherapy. This treatment was given in supine position and with a full bladder instruction. The PTV was treated to a total dose of 25 Gy in 5 fractions of 5 Gy. CT scans were made with 3 mm slice intervals. To identify the anal verge, we localized it at the most caudal CT-slice of the anus. Anal markers were not used for that purpose, because they were found to be unuseful in most cases due to misplacement. The isocenter was located at the midline, upper border of the symphysis os pubis and 8 cm above the treatment couch (promontorium).

Planning procedures

In procedure 1 (Fig. 1c) CT scans were used to design the fields based on bone anatomy: promontorium (superior), promontorium +2 cm (anterior), pelvic rim +1.5 cm (lateral). The promontorium in this study is defined as the most prominent part of S1. The inferior field border was determined depending on the position of the primary tumour. In tumours closer than 4 cm from the anorectal verge the anal verge was included with a caudal margin of 2 cm (caudal field border). In all other cases the inferior field border was set 3 cm above the anal verge, as defined on CT slices The sacrum was included in the posterior field border for the Left Lateral and Right Lateral fields (LL, RL). Standard shielding of hip joints and sacrum (posterior one third) was applied according to the guidelines from the Dutch TME trial. Using 3 fields (LL, RL, postero–anterior (PA)) the treatment plan was evaluated in one central plane according to the ICRU 50 criteria [15,16].

In procedure 2 (Fig. 1c) upper, lower and anterior field (LL/RL) borders were determined on basis of the extent of the tumour (GTV), the submucosal axial margin of 3 cm proximal and distal from the primary tumour (Surgical Target Volume (STV)), the mesorectum and the bifurcation of the common iliac vessels. The posterior (LL/RL fields) and lateral (Antero–posterior (AP) field borders were defined identical to those described in procedure 1. The most cranial and anterior extension of the CTV was manually marked with a cross symbol (Fig. 1a) by a radiation oncologist on the CT-slices in 3D view with transversal, coronal and sagital orientation. For the placement of this cross symbol, the primary extension of the GTV and STV was taken into account according to MRI using dual projection of both the MRI and CT images as well as the origin of the internal iliac vessels. Whatever led the most cranial and anterior extension defined the placement of the cross symbol. The second cross symbol defined the most caudal extension of the mesorectum or the GTV and STV. All the cross symbol positions were independently approved by one more radiation oncologist out of a team of three well trained radiation oncologists specialized in the treatment of rectal cancer.

The field as indicated by these two cross symbols was then extended by 2 cm in the cranial, caudal and anterior direction in order to determine the definitive field border. Dose distribution was optimized in one central and two border planes (2 cm inside cranial/caudal field border). Four fields were choosen in the case of >80% dose in the central plane on the hips or under the cutis or in case of an overdosage in the 3 planes with more than 107% dose. Dose optimization in procedures 1 and 2 was done blinded without knowledge of the PTV as delineated in procedure 3.

In procedure 3, a CTV(Fig. 1b) volume was constructed from GTV (primary tumour based on MR), STV, mesorectal subsite, posterior pelvic subsite, and the regional lymph nodes at risk, which were defined by contouring the internal iliac vessels, the middle and superior rectal vessels and the obturator artery (not for tumours located in level III). The CTV of the lymph nodes was defined by the contour of the arteries and veins expanded by 0.5 cm in all the directions except for the cranial direction. The CTV of the primary tumour was obtained by circumferential expansion of the GTV with 0.5 cm. For mesorectal and posterior pelvic subsite as well as STV no margins were added for the CTV. The CTV–PTV expansion from the total CTV was 1 cm in all the directions. All the delineations for one particular patient were independently approved by another colleague out of a team of three well trained radiation oncologists specialized in the treatment of rectal cancer. MLCs were used to shield the bladder and small bowel. Dose prescription and 3D dose optimization were performed according to ICRU 50 criteria [15,16].

The PTV of procedure 3 (Fig. 1c) served as the gold standard to determine target coverage, conformity index, homogeneity index and the volume of normal tissue (blad-

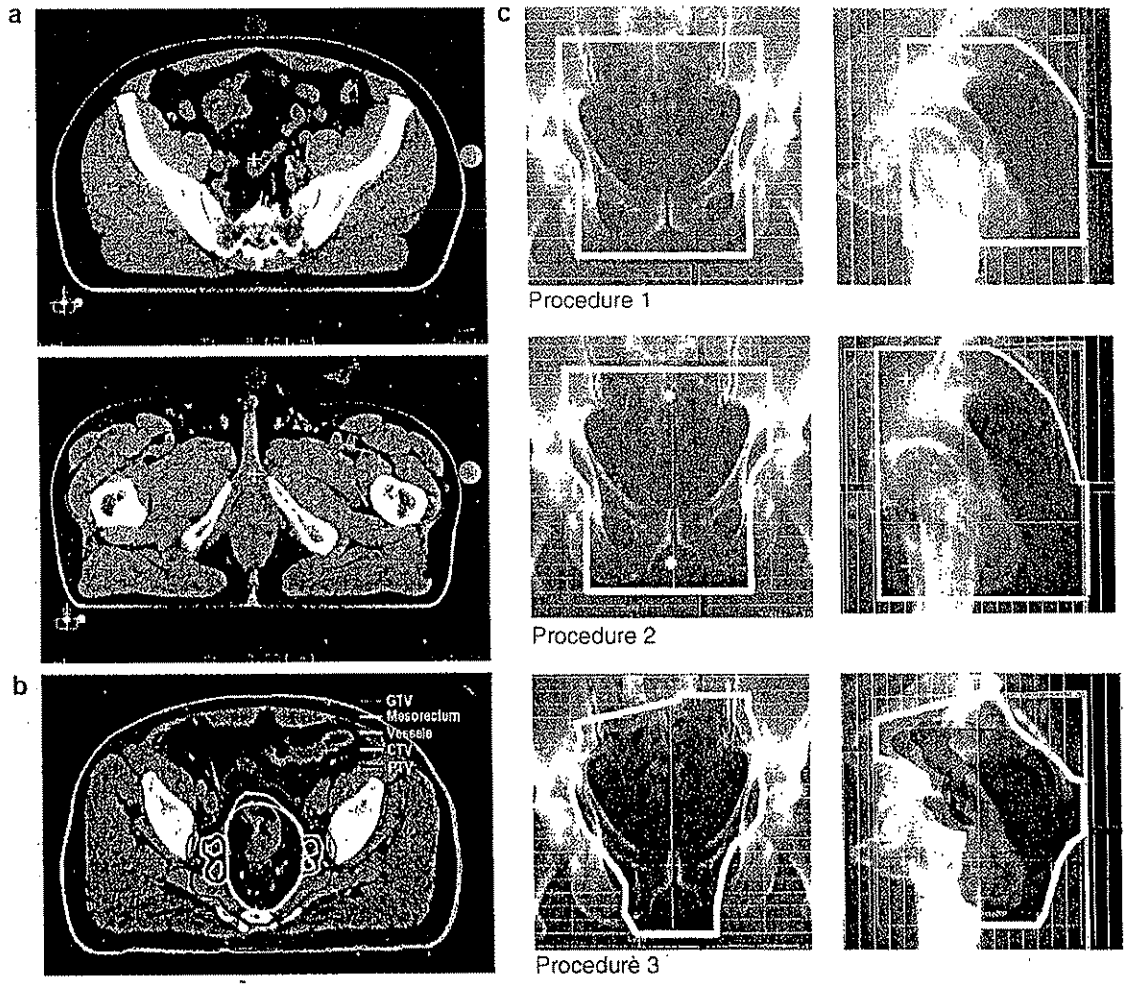


Fig. 1. (a) Transversal Ct-slices showing the cranial and caudal anatomic marker used in procedure 2. (b) Transversal Ct-slice showing all the delineated anatomical structures as well as the expanded CTV and PTV. (c) Beam's eye views of the 3 different planning procedures. The two white cross symbols indicate the anatomic markers used in procedure 2 (see text). PTV of procedure 3 shaded (dark). The level of the tumour in this example is mid-rectal with the upper level of the tumour high up in the rectum.

der) exposed to high-dose irradiation for the other two procedures. The amount of time spent by physicians and radiation technologists to perform their work per patient was registered for each procedure. Contouring of target volumes and organs at risk was done by the radiation oncologist. CT acquisition and dose planning was performed by the radiation technologist. We used the XiO planning system (CMS St. Louis, USA) for dose calculation and planning with dose specification in the center of the target volume in a region with homogeneous density. The minimum dose within the PTV accepted was defined as 95% of the specified dose. The PTV95% was defined as the percentage of the PTV that received 95% of the specified total dose. The treated volume was defined as tissue volume encompassed by the 95% isodose [15]. The conformity index was defined as the quotient of treated volume and PTV [15]. Treatment was given with linear accelerators (10 MV photons).

Statistics

Statistical analysis was performed with SPSS version 14.0 (SPSS Inc. (2006). Since most of the data regarding target coverage were not normally distributed, but rather skewed to the top end of the scale, non-parametric Friedman tests for repeated measures had to be performed in order to compare the three procedures as a function of the three different levels of the rectum. Data regarding the amount of time spent on each procedure, the homogeneity index (quotient of PTV within 95–107% dose range and PTV95%) and volume of normal tissue (bladder) irradiated were distributed normally and could therefore be analyzed using repeated measures Analysis of Variance (ANOVA). An alpha value of 0.05 was used for these analyses. Post hoc Wilcoxon rank sign tests were carried out to determine the pairwise differences when the Friedman test yielded a significant result. To account for multiple testing, an alpha of 0.01 was chosen for these post hoc comparisons.

Results

The number of patients planned with a four-field technique was 0, 3 and 48 for procedures 1, 2 and 3, respectively. The volume of the PTV within the 95% isodose (PTV95%) reached the highest levels in procedure 3 (941 cc) and the lowest in procedure 1 (803 cc). The treated volume was the smallest in procedure 3 (1489 cc) and the largest in procedure 2 (1973 cc). The conformity index of procedure 3 reached 1.6 in contrast to only 2.2 in procedure 2.

Coverage of target volumes

The PTV median coverage (PTV95%) was calculated as being 87.0 (54–100), 94.0 (78–100), 99.0 (94–100) in procedure 1, 2 and 3, respectively (Fig. 2). These differences in target volume coverage were due to an underdosage of the STV and the internal iliac lymph node regions in procedure 1, however, for procedure 2 no clear explanation could be identified. The GTV coverage reached ICRU standards [15,16] in procedures 2 and 3 (Table 1). After stratification for the three different tumour levels procedure 1 performed worst in level II and III tumours due to an insufficient coverage of the STV and iliac lymph nodes (Table 2). For procedure 2 no specific uncovered subsite could be identified. For all the three tumour levels an underdosage was observed. An interference with PTV coverage was noted from narrow cranial and ventral field borders (23% and 18%, respectively). In 28% of the cases the sacrum shielding was placed too tight and in 5% of the cases the caudal field border or the hip shieldings caused an underdosage (data not shown). The median PTV coverage percentages with minimum dose (PTV95%) may not fully comply with quality requirements, because this implies that only 50% of all the cases receive the minimum dose. In daily practice, we would like to achieve a minimum dose coverage in 95% of the cases (Fig. 3). Clearly procedures 1 and 2 did not meet these quality criteria. Procedure 1 failed in all the PTV subsites, whereas procedure 2 only undertreated the CTV and nodal areas in particular (data not shown). Due to the fact that we mainly used a three field technique in procedure 2 and a four-field technique in procedure 3, the results could have been biased. Therefore, we replanned procedure 2 for all the patients with a four-field technique. To compare the coverage percentage between the three and the four-field technique, a paired sample *T*-test was used. This test did not reveal any significant difference for any of the tested parameters. We further evaluated a possible optimization step for procedure 2. In order to achieve for 95% of the population a 95% coverage of the PTV within the 95% isodose, the cranial border would have to be extended from the cross symbol by a total of 3.2 cm and the ventral field border by 5.2 cm. This extension of the field did not depend on any of the three tumour localisations.

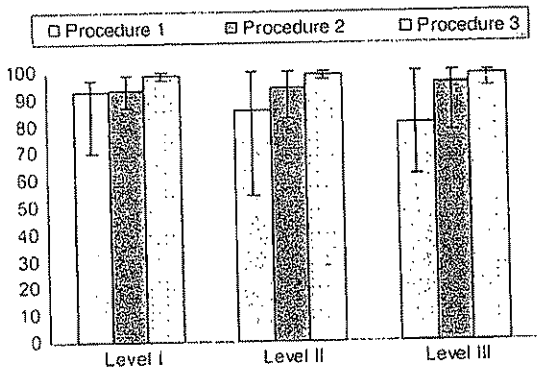


Fig. 2. Volume percentages of the PTV covered by the 95% isodose (PTV95%) (median values and range) for the three procedures as a function of the tumour level.

Normal tissue

The three procedures also differed significantly in the percentage of treated bladder volume. More than forty percent (range 11–100%) of the bladder was treated with the minimum target dose level in procedure 2 (Table 1), whereas in procedure 3 only 16% of the bladder was treated. Volumes (more than 1% of treated volume) above maximum dose (>107%) were seen in 10 patients (range 26–298 cc) and 2 patients (range 21–36 cc) for procedures 1 and 2, respectively.

Labour time per procedure

Procedure 3 was more time consuming than procedures 2 and 1 for radiation technologists: 86 vs 17 min ($p < 0.001$). The same held true for the radiation oncologists: 24 vs 4 min ($p < 0.001$).

Table 1
Median volume percentages covered by minimum dose (95% isodose) in different procedures

	Procedure 1	Procedure 2	Procedure 3	*P*-value
PTV95%	87.0 (54–100)	94.0 (78–100)	99.0 (94–100)	<0.001 (2 vs 3; 1 vs 3)
CTV95%	96.0 (64–100)	99.5 (87–100)	100.0 (97–100)	<0.001 (2 vs 3; 1 vs 3)
GTV95%	100.0 (27–100)	100.0 (75–100)	100.0	<0.001 (2 vs 3; 1 vs 3)
STV95%	91.0 (40–100)	100.0 (43–100)	100.0 (96–100)	<0.001 (2 vs 3; 1 vs 3)
Mesorectum95%	99.0 (6–100)	100.0 (95–100)	100.0	<0.001 (2 vs 3; 1 vs 3)
Vessels95%	95.0 (45–100)	100.0 (69–100)	100.0 (90–100)	<0.001 (2 vs 3; 1 vs 3)
Bladder95%	19.0 (0–84)	43.5 (11–100)	16 (0–68)	<0.001 (2 vs 3; 1 vs 3)

Range in brackets.

Table 2
Median volume percentages covered by minimum dose in different procedures and tumour levels

Level I	Procedure 1	Procedure 2	Procedure 3	P-value
PTV95%	93.0 (70–97)	93.5 (87–99)	99.0 (97–100)	<0.001(2 vs 3; 1 vs 3)
CTV95%	99.0 (83–100)	99.5 (92–100)	100.0 (97–100)	<0.001 (2 vs 3; 1 vs 3)
GTV95%	100.0 (69–100)	100.0	100.0	NS
STV95%	100.0 (90–100)	100.0 (96–100)	100.0	<0.001(2 vs 3; 1 vs 3)
Mesorectum95%	100.0 (92–100)	100.0 (98–100)	100.0	NS
Vessels95%	100.0 (54–100)	99.5 (71–100)	100.0 (90–100)	NS
Level II				
PTV95%	86.0 (54–100)	94.0 (83–100)	99.0 (97–100)	<0.001 (2 vs 3; 1 vs 3)
CTV95%	95.0 (64–100)	99.0 (92–100)	100.0	<0.001 (2 vs 3; 1 vs 3)
GTV95%	100.0 (27–100)	100.0	100.0	NS
STV95%	83.0 (52–100)	100.0 (67–100)	100.0	<0.001 (2 vs 3; 1 vs 3)
Mesorectum95%	98.0 (69–100)	100.0 (95–100)	100.0	<0.001 (2 vs 3; 1 vs 3)
Vessels95%	94.0 (61–100)	100.0 (69–100)	100.0 (99–100)	<0.001 (2 vs 3; 1 vs 3)
Level III				
PTV95%	81.0 (62–100)	96.0 (78–100)	99.0 (94–100)	<0.001 (2 vs 3; 1 vs 3)
CTV95%	93.5 (73–100)	100.0 (87–100)	100.0 (99–100)	<0.001 (2 vs 3; 1 vs 3)
GTV95%	98.0 (70–100)	100.0 (75–100)	100.0	<0.001 (2 vs 3; 1 vs 3)
STV95%	82.0 (40–100)	100.0 (43–100)	100.0 (96–100)	<0.001 (2 vs 3; 1 vs 3)
Mesorectum95%	98.0 (6–100)	100.0 (97–100)	100.0	<0.001 (1 vs 3)
Vessels95%	94.5 (45–100)	100.0 (94–100)	100.0 (23–100)	<0.001 (1 vs 3)

Range in brackets.

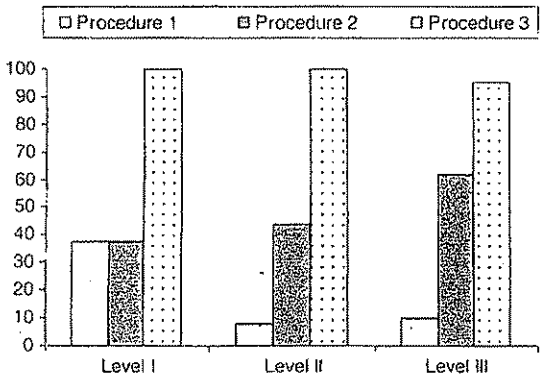


Fig. 3. Percentage of the patient cohort in which at least 95% of the PTV is covered by the 95% isodose (PTV95% ≥ 95%) as a function of the tumour level.

Discussion

The study presented herein was undertaken to evaluate the quality and the time efficiancy of three different radiotherapy procedures, which have been used at our institution to treat non-locally advanced rectal cancer preoperatively with 5 fractions of 5 Gy. Procedure 1, although time efficient did perform insufficient to cover the defined target volume, mostly due to an underdosage of the upper iliac internal lymph node regions. This underdosage could have been reduced to some point through placing the upper and anterior border of the fields less rigid, which however would have led to an unacceptable large-treatment volume.

Procedure 2 using two markers based on organ and lymphatic anatomy was very time efficient. However, this approach may result in suboptimal PTV coverage in tumours at all the levels. There appears to be no part of the PTV particularly involved in underdosage. Too narrow ventral and cranial field borders as well as sacrum shielding were the main causes of insufficient PTV coverage. In order to achieve a sufficient PTV coverage with 95% of the tested patient population presenting with a 95% coverage of the PTV within the 95% isodose, the cranial marker would have to be extended by almost 5.2 cm. in the anterior direction for the anterior field border and by 3.2 cm in the cranial direction for the cranial field border. Nevertheless, this would have led to an unacceptable large-treatment volume. Therefore, although this simplified technique with standardized landmarks on CT is advantageous in terms of its non-dependency on an individualized and time consuming contouring technique, it leads to substantially larger treatment volumes.

The preoperative irradiation of rectal cancer has an impact on local/regional recurrence but a benefit for overall survival has not clearly been proven up until now [4]. In fact after optimal surgery (TME), treatment results with regard to local control can be improved by preoperative radiotherapy. The 5 × 5 Gy fractionated radiation scheme equals to a biological effective dose (BED) of 38, 7 Gy in 2 Gy fractions, when using an α/β ratio of 10 Gy and a repair rate γ/α of 0, 6 Gy/ day [7]. Whether this dose is high enough to control microscopic tumour residuals left behind after apparently complete resections, remains unclear, as has been recently discussed [5,8]. Rather it seems that if the mesorectal area is completely removed through a proper adequate surgical procedure, it does not form the source for a local failure [18,20]. Instead, the majority of the local recurrences seem to arise in the dorsal pelvis or at the anastomosis, although this has not been sufficiently studied after TME up until now [18,20]. This however would make the potential underdo-

sage of procedures 1 and 2 at the upper anterior part of the iliac internal lymph nodes less relevant. On the other hand, we cannot be sure of an always adequately performed TME surgical procedure, as has been demonstrated by a radiologically performed recent study on postoperative images [20], and we do not know, whether a technically sufficient irradiation of the upper areas of the iliac lymph node region would still translate into an overall survival benefit after a longer follow up period [13,20].

Therefore, we prefer the conformal method, even if it is very time consuming due to the target volume delineation and more detailed treatment planning because it guarantees optimal target volume coverage and dose homogeneity. However, special attention should be given to the reproducibility of contouring which can be achieved by special training and peer review. Fortunately, a recent publication has given a profound definition of the CTV delineation for rectal cancer, which should help to reduce the inter-observer variability in the delineation of the target volume[18].

Possible side effects

Dose inhomogeneity with considerable volumes exceeding maximum dose constraints may occur in procedure 2. At the dose levels used some side effects should be expected. In the Stockholm II trial [12] excess mortality due to cardiovascular disease has been reported in the early period post surgery in the irradiated group (5 vs 1%). In the meta-analysis [4] this effect of increased non-rectal cancer mortality in the early period after surgery was confirmed, cardiovascular and inflammatory disorders being the main causes of death. The largest impact in this regard was seen in patients treated pre-operatively with high-dose (BED $\geqslant$30 Gy) and in the elderly patients ($\geqslant$75 years). However, no increase in non-rectal mortality was seen in studies applying adequate radiotherapy doses and techniques [4]. In the later period (more than 1 year after surgery) no difference in non-rectal cancer mortality was seen between patients treated with pre-operative radiotherapy and those treated with surgery alone.

Early side effects are limited to neuropathies and wound healing problems [6,11]. Late complications seen after the 5×5 Gy scheme mainly consist of large bowel problems, impaired sexual function and secondary cancers in the vicinity of the radiation fields [1,2,10,14]. Most side effects come from organs situated in the center of the PTV (rectum) while some may find their origin more peripherally (sexual dysfunction, secondary tumours). Hypogastric nerve damage is more frequent in irradiated cases and could be caused by high-maximum doses as seen in procedures 1 and 2 in this study. Genito-urinary problems and increased risk of ileus are seen when larger volumes are irradiated (older 2-field techniques). Procedure 1 with the lowest irradiated volume does not fulfill todays quality requirements due to dose inhomogeneity and clearly insufficient PTV coverage. The dose inhomogeneity problem in procedure 2 could have been solved only with a full 3 D dose evaluation in every case. This would have however substantially increased the time needed to perform the technique. The suboptimal PTV coverage would have been solved with much larger extensions of the field borders in the cranial and anterior direction, which however would consequently lead to further larger volumes of irradiated normal tissue. These volumes would be larger than previously used radiation procedures. Experience with such large volumes with respect to late side effects however is missing so far.

Conclusion

Procedure 1 does not fulfill todays quality requirements. Optimization of procedure 2 results in intermediate labour intensiveness and larger fields with unacceptable increasing normal tissue burden. Procedure 3 has therefore now become the method of choice at our institute.

* Corresponding author. Jacques H. Borger, MAASTRO clinic, Dr. Tanslaan 12, 6229 ET Maastricht, The Netherlands. *E-mail address:* jacques.borger@maastro.nl

Received 1 June 2007; received in revised form 27 March 2008; accepted 30 March 2008; Available online 29 April 2008

References

[1] Birgisson H, Påhlman, Gunnarsson U, Glimelius B. Adverse effects of preoperative radiation therapy for rectal cancer: long-term follow-up of the Swedish rectal cancer trial. J Clin Oncol 2005;23:8697–705.
[2] Birgisson H, Påhlman, Gunnarsson U, Glimelius B. Occurrence of second cancers in patients treated with radiotherapy for rectal cancer. J Clin Oncol 2005;23:6126–31.
[3] Bujko K, Kolodziejczyk M. The 5×5 Gy with delayed surgery in non-resectable rectal cancer: a new treatment option. Radiother Oncol. 2008 [Ahead of print].
[4] Colorectal cancer collaborative group. Adjuvant radiotherapy for rectal cancer: a systematic overview of 8507 patients from 22 randomised trials. Lancet 2001;358:1291–1304.
[5] Courdi A. Fractionation sensitivity and equivalent doses. Commenting on the editorial by Glimelius. Acta Oncol 2007;46:395–6.
[6] Frykholm GJ, Isacsson U, Nygård K, et al. Preoperative radiotherapy in rectal carcinoma-aspects of acute adverse effects and radiation technique. Int J Radiat Oncol Biol Phys 1996;35:1039–48.
[7] Glimelius B, Grönberg H, Järholt J, Wallgren A, Cavallin-Ståhl E. A systematic overview of radiation therapy effects in rectal cancer. Acta Oncologica 2003;42:476–92.
[8] Glimelius B. Long course, short course or something else? Acta Oncologica 2006;45:1013–7.
[9] Kapiteijn E, Marijnen CAM, Nachtegaal ID, et al. Preoperative radiotherapy combined with total mesorectal excision for resectable rectal cancer. N Engl J Med 2001;345:638–46.
[10] Marijnen C, van de Velde C, Putter H, et al. Impact of short-term preoperative radiotherapy on health-related quality of life and sexual functioning in primary rectal cancer: report of a multicenter randomized trial. J Clin Oncol 2005;23:1847–58.
[11] Marijnen CA, Kapiteijn E, van de Velde CJ, et al. Acute side effects and complications after short-term preoperative radiotherapy combined with total mesorectal excision in primary rectal cancer: report of a multicenter randomized trial. J Clin Oncol 2002;20:817–25.
[12] Martling A, Holm T, Rutqvist LE, Cedermark B. The Stockholm II trial on preoperative radiotherapy in rectal carcinoma: long-term follow-up of a population-based study. Cancer 2001;92:896–902.

[13] Moriya Y, Sugihara K, Akasu T, Fujita S. Importance of extended lymphadenectomy with lateral node dissection for advanced lower rectal carcinoma. World J Surg 1997;21:728–32.
[14] Peeters KC, van de Velde CJ, Leer JW, et al. Late side effects of short-course preoperative radiotherapy combined with total mesorectal excision for rectal cancer: increased bowel dysfunction in irradiated patients – a Dutch colorectal cancer group study. J Clin Oncol 2005;23:6199–206.
[15] Prescribing, Recording, and Reporting Photon Beam Therapy (Supplement to ICRU 50). ICRU report 62, 1999.
[16] Prescribing, Recording, and Reporting Photon Beam Therapy. ICRU report 50, 1993.
[17] Radu C, Berglund K, Påhlman L, Glimelius B. Short-course preoperative radiotherapy with delayed surgery in rectal cancer – a retrospective study. Radiother Oncol 2007 [Ahead of print].
[18] Roels S, Duthoy W, Haustermans K, et al. Definition and delineation of the clinical target volume for rectal cancer. Int J Radiat Oncol Biol Phys 2006;65:1129–42.
[19] Swedish Rectal Cancer Trial. Improved survival with preoperative radiotherapy in resectable rectal cancer. N Engl J Med 1997;336:980–987.
[20] Syk E, Torkzad MR, Blomqvist L, Ljungqvist O, Glimelius B. Radiological findings do not support lateral residual tumour as a major cause of local recurrence of rectal cancer. Br J Surg 2006;93:113–9.
[21] Vulto A, Louwman M, Rodrigus P, Coebergh JW. Referral rates and trends in radiotherapy as part of primary treatment of cancer in South Netherlands, 1988–2002. Radiother Oncol 2006;78:131–7.

Int. J. Radiation Oncology Biol. Phys., Vol. 69, No. 3, pp. 711–715, 2007

0360-3016/07/$-see front matter

ELSEVIER

doi:10.1016/j.ijrobp.2007.05.075

ASTRO Online CME

CLINICAL INVESTIGATION

Breast

TREATMENT OPTIMIZATION USING COMPUTED TOMOGRAPHY-DELINEATED TARGETS SHOULD BE USED FOR SUPRACLAVICULAR IRRADIATION FOR BREAST CANCER

RAWEEWAN LIENGSAWANGWONG, M.D.,* TSE-KUAN YU, M.D., PH.D.,* TZOUH-LIANG SUN, M.S.,† JEREMY J. ERASMUS, M.D.,‡ GEORGE H. PERKINS, M.D.,* WELELA TEREFFE, M.D.,* JULIA L. OH, M.D.,* WENDY A. WOODWARD, M.D.,* ERIC A. STROM, M.D.,* MOHAMMAD SALEPHOUR, PH.D.,† AND THOMAS A. BUCHHOLZ, M.D.*

Departments of *Radiation Oncology, †Medical Physics, and ‡Diagnostic Imaging, The University of Texas M. D. Anderson Cancer Center, Houston, TX

Background: The purpose of this study was to determine whether the use of optimized CT treatment planning offered better coverage of axillary level III (LIII)/supraclavicular (SC) targets than the empirically derived dose prescription that are commonly used.

Materials/Methods: Thirty-two consecutive breast cancer patients who underwent CT treatment planning of a SC field were evaluated. Each patient was categorized according to body mass index (BMI) classes: normal, overweight, or obese. The SC and LIII nodal beds were contoured, and four treatment plans for each patient were generated. Three of the plans used empiric dose prescriptions, and these were compared with a CT-optimized plan. Each plan was evaluated by two criteria: whether 98% of target volume receive >90% of prescribed dose and whether < 5% of the irradiated volume received 105% of prescribed dose.

Results: The mean depth of SC and LIII were 3.2 cm (range, 1.4–6.7 cm) and 3.1 (range, 1.7–5.8 cm). The depth of these targets varied according across BMI classes ($p = 0.01$). Among the four sets of plans, the CT-optimized plans were the most successful at achieving both of the dosimetry objectives for every BMI class (normal BMI, $p = .003$; overweight BMI, $p < .0001$; obese BMI, $p < .001$).

Conclusions: Across all BMI classes, routine radiation prescriptions did not optimally cover intended targets for every patient. Optimized CT-based treatment planning generated the most successful plans; therefore, we recommend the use of routine CT simulation and treatment planning of SC fields in breast cancer. © 2007 Elsevier Inc.

Supraclavicular, Axillary, Lymph node, Treatment planning, Computed tomography.

INTRODUCTION

Simulation using CT simulation is now widely available for radiation treatment planning to treat breast cancer. It is an important tool to help define the tumor target and normal tissue based on anatomical features of an individual patient. However, despite the availability of this technology, a common practice for delivering radiation to supraclavicular (SC) nodal bed during breast cancer treatment is to use 6MV photons empirically prescribed to the depth of maximum dose (Dmax), or 3 cm (1, 2). Indeed, a pattern of care analysis showed that in two thirds of breast cancer treatments to a SC field, the radiation dose was prescribed to a specific depth in 67.5% and to midplane in 17% of the patients (1). It is likely that empiric prescription depth points may not properly cover the target nodal basin in all patients. Previously, Bentel *et al.* (3) reported that the depth of the SC lymph nodes is related to the anterior–posterior diameter and that the nodes are deeper for those who are thicker or heavier. In their report, the depth ranged from 2.4 to 9.5 cm. With such a wide range, a better approach may be to use CT information to optimize treatment delivery to the target volume.

Supraclavicular radiation fields are typically used in patients who have undergone an axillary level I/II dissection and are found to have positive lymph nodes. For such patients,

Note—An online CME test for this article can be taken at http://asro.astro.org under Continuing Education.

Reprint requests to: Thomas A. Buchholz, M.D., Department of Radiation Oncology, University of Texas M. D. Anderson Cancer Center, 1515 Holcolmbe Boulevard, Unit 1202, Houston, TX 77030; Tel: (713) 563-2335; Fax: (713) 563-6940; E-mail: tbuchhol@mdanderson.org

Supported in part by National Cancer Institute grants CA16672 and T32CA77050 and the Arlette and William Coleman Foundation.

This work was presented at the 48th Annual Meeting of the American Society of Therapeutic Radiology and Oncology (ASTRO), Philadelphia, PA 2006.

Conflict of interest: none.

Received Feb 6, 2007, and in revised form April 27, 2007. Accepted for publication May 24, 2007.

the areas of greatest risk for residual nodal disease are in the level III (LIII) axilla (the region superomedial to the pectoralis minor muscle) and the SC fossa. Information from CT can be used to identify and delineate these regions. Interestingly, little available research focuses on the techniques for properly covering the LIII nodal basin in radiation fields.

The purpose of this study was to compare different treatment planning techniques for treating the LIII and SC, using different choices of beam energy together with varying the calculation points. We examined whether higher energy photons or optimized CT treatment planning would offer better coverage of LIII and SC nodal basins than using 6-MV photon prescribed conventionally.

METHODS AND MATERIALS

This study was approved by the Institutional Review Board at the University of Texas M. D. Anderson Cancer Center. Thirty-two consecutive breast cancer patients treated with postmastectomy radiation that included a SC field were selected for the study. Each patient underwent CT-simulation for radiation treatment planning. Patients were immobilized in supine position with the ipsilateral shoulder abducted and head rotated slightly toward the contralateral side. The CT scan images were obtained with high-speed helical scanner at 2.5-mm to 3-mm slice thickness through the region of interest. The SC field was designed with the lower half of the beam blocked to match with the tangential fields inferiorly, with this border typically placed below the head of the clavicle. A 15-degree lateral gantry rotation was used to avoid treating the spinal cord. Customized blocks were used to shield the spinal cord and the ipsilateral humeral head. The treatment plans were generated using Philips Pinnacle treatment planning software (version 6.2). The regions of interest were identified initially with the assistance of the thoracic radiologist (J.J.E.). Medially, the SC fossa extended to the lateral edge of the trachea. Superiorly, this region extended to the level of the lower edge of the cricoid cartilage. Anteriorly, the SC nodal bed was bounded by the posterior border of the sternocleidomastoid muscle. The posterolateral border of SC nodal bed was defined by the anterior border of the anterior scalene muscle. The inferior border of the SC nodal bed was defined by the subclavian artery.

The superior border the axillary level III (LIII) nodal bed was defined as the most superior aspect of the pectoralis minor muscle. The inferior border was defined at the level of the insertion of the clavicle into the manubrium. Anteriorly, the LIII nodal bed was bounded by pectoralis major muscle. Posterior border of the LIII nodal bed was defined by subclavian-axillary artery. Laterally, the LII nodal bed extended to the medial aspect of the pectoralis minor muscle. Medially, the LIII nodal bed extended to the lateral border of the clavicle. For the purpose of this study, the LIII and SC nodal beds were considered to be a single target. The maximum depth of the LIII and SC nodal bed was measured vertically from the skin surface.

In total, 128 plans were generated for the study. For each patient, four treatment planning techniques for the SC field were evaluated. Conventional plans that used 6MV photons prescribed to 1.5 cm (Dmax, 6MV-1.5) and to 3 cm depth (6MV-3.0) were generated. Separate plans, one using 18MV photons prescribed to 3.3 cm (D max, 18MV) and one that combined 6MV and 18MV photons manually optimized to cover the target volume with 90% of the prescribed dose (CT opt), were created for comparison. For the CT opt, we also used individual calculation points for each patient to achieve the best coverage of the targets. Each plan was evaluated and scored using two criteria; one point was awarded for meeting each of the criteria. The first criterion was the ability to cover 98% of target volume with 90% or greater of the prescribed dose (V90). The second criterion was the avoidance of hot spots so that no more than 5% of the irradiated volume received more than 105% of the prescribed dose (V105). The irradiated volume was determined by the volume that received 90% or more of the prescribed dose. The combined score of 0, 1, and 2 were designated poor, good, and best scores, respectively.

We hypothesized that the improvement in accuracy of CT-guided treatment planning would vary with the body mass index (BMI). Therefore, we calculated BMI for each patient using the formula: weight (kg) / (height [m])^2. The patients were divided into three groups: normal (BMI 18.5–24.9), overweight (BMI, 25.0–29.9), and obese (BMI $\geq$30.0). The patient's BMI was correlated with the depth of SC and L III nodal beds using linear regression analysis. The score of evaluated treatment plans were correlated with the patient's BMI using the Chi-square test. A p value $\leq$0.05 (two-sided) was considered significant. SPSS statistical software (version 11.5) was used for analysis.

RESULTS

Eight patients were classified as having a normal BMI, 14 as overweight, and 10 as obese. The mean BMI was 29.1 (range, 19.2–57.9). Figure 1 shows an example of the

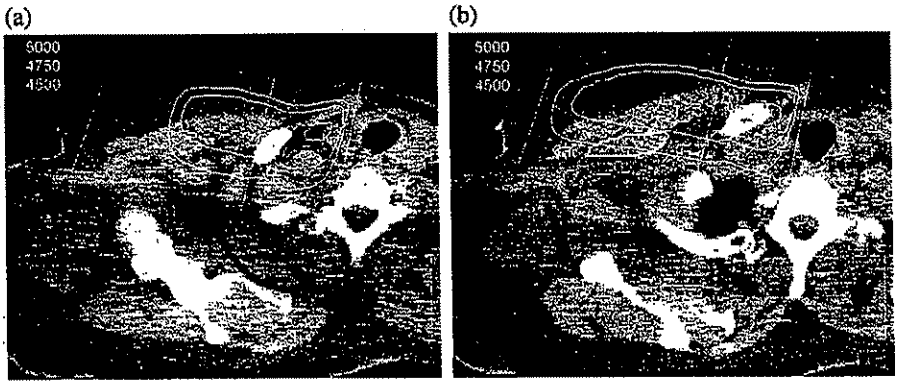


Fig. 1. (a) Axial computed tomography (CT) from the CT simulation showing the supraclavicular nodal region outlined in black. The isodose line display is from the "CTopt" plan. (b) Axial CT from the CT simulation showing the axillary level III (LIII) nodal region outlined in black and pectoralis minor muscle was outlined in white. The isodose line display is from the "CTopt" plan.

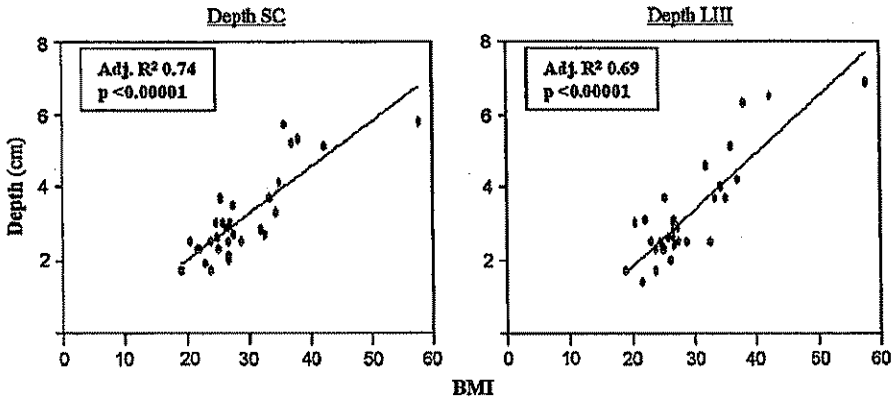


Fig. 2. The relationship of body mass index (BMI) to depth of anatomical targets. This graph shows that BMI is significantly correlated with the depth of the supraclavicular (SC) and the axillary level III (LIII) nodal region using linear regression analysis (p <0.0001).

contours of SC and LIII nodal beds. The mean maximum depth of SC and LIII nodal beds were 3.2 cm (range, 1.4–6.7 cm) and 3.1 cm (range, 1.7–5.8 cm), respectively. Body mass index significantly correlated with the depth of SC and LIII using linear regression analysis with significant p value <0.0001 as shown in Fig. 2.

Table 1 shows the success rate of each plan in each of the BMI groups. Computed-tomography-optimized plans were the most successful among four plans for every BMI group (normal BMI, $p = 0.003$; overweight BMI, $p < 0.0001$; obese BMI, $p < 0.001$). For the normal and overweight BMI classes, the 6MV-1.5 plans yielded a score of 2 in 75% and 92.9% of the patients, respectively. In these groups of patients, 18MV plans would have led to undertreatment of the target superficially. Conversely, in obese BMI classes, the 18MV plans achieved a score of 2 in 80% of patients compared with 20% for the 6MV-1.5 plans ($p = 0.023$). The 6MV-3.0 plans provided a low rate of best scores in all BMI categories (50% normal, 64% overweight, 20% obese).

Table 1. The success rates of various radiation plans according to body mass index groups.

		Score (%)			
BMI group	Plan	Poor	Good	Best	p value*
Normal	6MV-1.5	0	25	75	
	6MV-3.0	0	50	50	
	18MV	0	88	13	
	CTopt	0	0	100	0.003
Overweight	6MV-1.5	0	7	93	
	6MV-3.0	0	36	64	
	18MV	0	79	21	
	CTopt	0	0	100	<0.0001
Obese	6MV-1.5	0	80	20	
	6MV-3.0	30	50	20	
	18MV	0	20	80	
	CTopt	0	0	100	<0.001

Abbreviation: BMI = body mass index.
* CTopt vs. others.

Overall, the 6MV-3.0 plan scored the worst of the various plan. This plan created a hot spot in most of the patients in each BMI group. Figure 3 shows stem-and-leaf plots that provide details of the coverage and dose homogeneity of each plan according to BMI group as shown.

DISCUSSION

In this study, we found that radiation of SC fields using prescriptions of radiation dose to empiric depths often leads to suboptimal coverage of targeted volumes, unnecessary degrees of dose inhomogeneity, or both. Specifically, a routine prescription of 6MV to Dmax provided the adequate coverage only in some patients in the normal and overweight BMI groups and was optimal in only 20% of the obese patients. Alternatively, the routine prescription of 6MV to a fixed depth of 3 cm generated "hot spots" in the irradiated volume in most of the patients. Finally, the plan using 18MV photons to Dmax led to an underdosage of superficial target regions for patients who had normal or overweight BMI, but it gave acceptable coverage for obese patients.

Our conclusion from these data is that the best way to prescribe radiation dose to SC fields used in breast cancer treatment is to use CT simulation, delineate the SC/LIII as a target, and generate an optimized treatment plan for each individual patient. We found that this method gave the best combination of target coverage and homogeneity. To achieve this success, we used not only a combination of 6MV and 18MV photon beams but also individualized calculation points.

The anatomical location of the supraclavicular and infraclavicular nodes has been well described in the literature, and SC fields have been treated routinely by assuming that the radiation coverage will be acceptable if this region is treated with 6MV photons with the dose prescribed to a specific depth, most commonly 3 cm. However, the anatomical locations of the supraclavicular and axillary nodal beds vary from patient to patient, and the use of a standard depth does not take into account this difference. We found that the mean

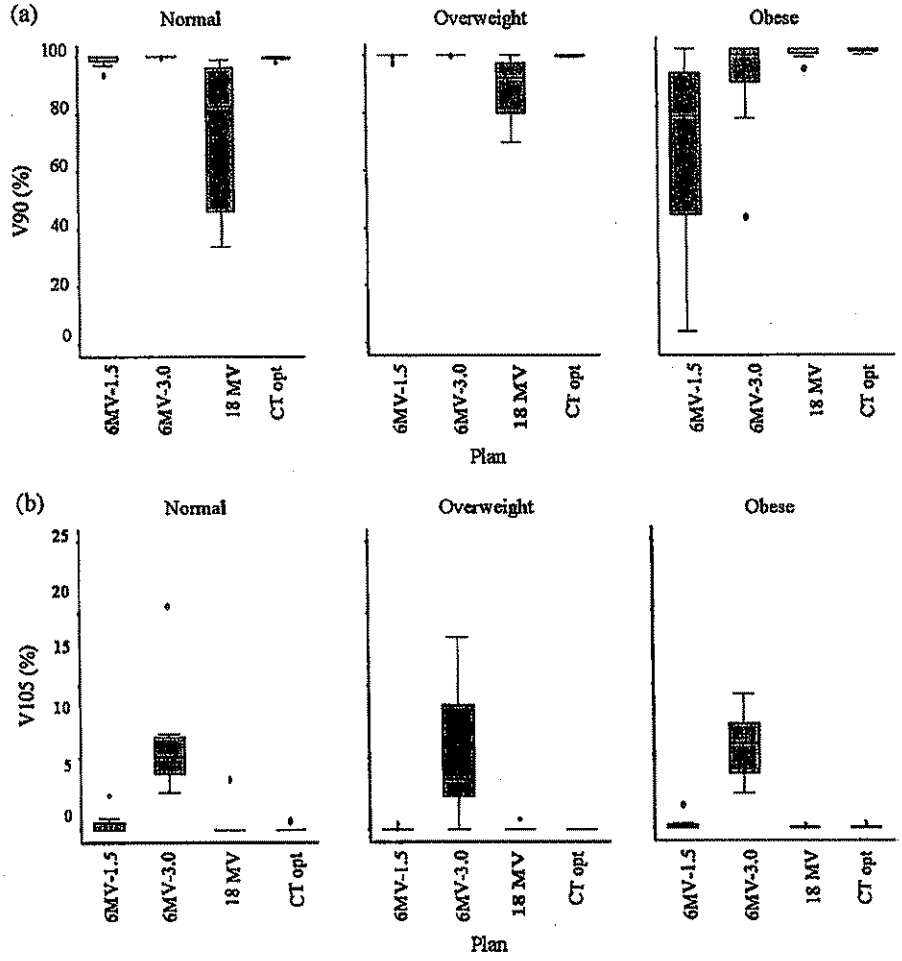


Fig. 3. (a) A stem-and-leaf plot showing the V90 coverage for each plan in each body mass index (BMI) group. The criterion to achieve a score of 1 was when V90 cover more than 98% of the target. (b) A stem-and-leaf plot showing the V105 coverage for each plan in each BMI group. The criterion to achieve a score of 1 was when V105 cover less than 5% the target.

maximum depth of supraclavicular and axillary level III nodal beds was 3.2 cm (range, 1.4–6.7 cm) and 3.1 cm (range, 1.7–5.8 cm), respectively. These findings were comparable with the previous reports that showed the mean depth of SC nodes was 3.9–6 cm (range, 2.1–8.3 cm) (4–8), and the mean depth of the axillary level III nodal bed was 3.6–6.7 cm (range, 1.9–7.4 cm). This variation in the depth of both nodal beds suggested the need for customized radiation treatment rather than the use of routine radiation prescription. Our study is the first to show a significant linear relationship between the BMI and the maximum depth of the SC and LIII nodal beds with a p value of <0.001. Patients with higher BMI tend, logically, to have deeper nodal beds. This finding is consistent with those reported by Bentel *et al.* (3) who used A/P diameter as a surrogate of the size of the patients.

Recently, CT simulation has increasingly been used in treatment planning for breast cancer patients. However, only a few studies have been done to improve treatment planning or radiation coverage for this region (4, 8–10). Madu *et al.* (4) reported the improvement of the SC/L III nodal beds coverage by using conformal optimized plans for individual patients. They used CT simulation for localization of the target and different gantry angles, as well as individualized normalization points, to achieve coverage of 90% of the target. Cavey *et al.* (8) reported the superior target volume coverage of three-dimensional conformal radiation therapy (3D CRT) or intensity-modulated radiation therapy (IMRT) plans over conventional plans for the SC field. For the 3D CRT or IMRT plans, they used opposing AP/PA fields angled 10–15 degrees to avoid the spinal cord and used heavier weighting of the anterior field for 2:1 or greater. This study showed that using 6MV photons and routine prescription to the depth of 3 and 5 cm not only produced significantly inferior target volume coverage (V90-107) to IMRT ($p = 0.55$ and $p = 0.014$, respectively) but also produced significantly greater dose heterogeneity (D95-5) ($p = 0.031$ and $p = 0.043$, respectively). Our study differs from the report by Cavey *et al.* (8) in that we used anterior–posterior approach for the treatment planning and used individualized calculation point as well as combination of 6MV and 18MV

photons. Our approach can achieve a good coverage of the targets while avoiding excess radiation dose to surrounding structures.

Irradiation of the SC fossa is associated with the risks of injury to normal tissue. For selected patients with positive lymph nodes found on axillary dissection, these risks are warranted to avoid the risk posed by having persistent disease within this area. However, when treatments are given, it is critical that every effort is made to ensure that the target volumes are adequately covered and the dose inhomogeneity within the treatment field is minimized. The data from our study support the use of CT-based treatment planning because this best meets the requirements for appropriate target coverage and dose homogeneity.

CONCLUSIONS

Routine radiation prescriptions did not optimally cover the SC and LIII nodal beds for patients categorized by BMI. Optimized CT-based treatment planning generated the most successful plans for proper target coverage with only small hot spots; therefore, we recommend the use of routine CT-simulation and treatment planning of SC fields in breast cancer.

REFERENCES

1. Pierce LJ, Moughan J, White J, *et al.* 1998-1999 patterns of care study process survey of national practice patterns using breast-conserving surgery and radiotherapy in the management of stage I-II breast cancer. *Int J Radiat Oncol Biol Phys* 2005;62: 183–192.
2. White J, Moughan J, Pierce LJ, *et al.* Status of postmastectomy radiotherapy in the United States: A patterns of care study. *Int J Radiat Oncol Biol Phys* 2004;60:77–85.
3. Bentel GC, Marks LB, Hardenbergh P, *et al.* Variability of the depth of supraclavicular and axillary lymph nodes in patients with breast cancer: Is a posterior axillary boost field necessary? *Int J Radiat Oncol Biol Phys* 2000;47:755–758.
4. Madu CN, Quint DJ, Normolle DP, *et al.* Definition of the supraclavicular and infraclavicular nodes: implications for three-dimensional CT-based conformal radiation therapy. *Radiology* 2001;221:333–339.
5. Dijkema IM, Hofman P, Raaijmakers CP, *et al.* Loco-regional conformal radiotherapy of the breast: delineation of the regional lymph node clinical target volumes in treatment position. *Radiother Oncol* 2004;71:287–295.
6. Qatarneh SM, Kircuta IC, Brahme E, *et al.* Three-dimensional atlas of lymph node topography based on the visible human data set. *Anat Rec B New Anat* 2006;289:98–111.
7. Goodman RL, Grann A, Saracco P, *et al.* The relationship between radiation fields and regional lymph nodes in carcinoma of the breast. *Int J Radiat Oncol Biol Phys* 2001;50:99–105.
8. Cavey ML, Bayouth JE, Endres EJ, *et al.* Dosimetric comparison of conventional and forward-planned intensity-modulated techniques for comprehensive locoregional irradiation of post-mastectomy left breast cancers. *Med Dosim* 2005;30:107–116.
9. Jephcott CR, Tyldesley S, Swift CL. Regional radiotherapy to axilla and supraclavicular fossa for adjuvant breast treatment: A comparison of four techniques. *Int J Radiat Oncol Biol Phys* 2004;60:103–110.
10. Krueger EA, Fraas BA, McShan DL, *et al.* Potential gains for irradiation of chest wall and regional nodes with intensity modulated radiotherapy. *Int J Radiat Oncol Biol Phys* 2003;56: 1023–1037.

Introduction

Meyer JL (ed): IMRT, IGRT, SBRT – Advances in the Treatment Planning and Delivery of Radiotherapy. Front Radiat Ther Oncol. Basel, Karger, 2007, vol. 40, pp 18–39

From New Frontiers to New Standards of Practice: Advances in Radiotherapy Planning and Delivery

James A. Purdy

Department of Radiation Oncology, UC Davis Medical Center, Sacramento, Calif., USA

Abstract

Radiation therapy treatment planning and delivery capabilities have changed dramatically since the introduction of three-dimensional treatment planning in the 1980s and continue to change in response to the implementation of new technologies. CT simulation and three-dimensional radiation treatment planning systems have become the standard of practice in clinics around the world. Medical accelerator manufacturers have employed advanced computer technology to produce treatment planning/delivery systems capable of precise shaping of dose distributions via computer-controlled multileaf collimators, in which the beam fluence is varied optimally to achieve the plan prescription. This mode of therapy is referred to as intensity-modulated radiation therapy (IMRT), and is capable of generating extremely conformal dose distributions including concave isodose volumes that provide conformal target volume coverage and avoidance of specific sensitive normal structures. IMRT is rapidly being implemented in clinics throughout the USA. This increasing use of IMRT has focused attention on the need to better account for both intrafraction and interfraction spatial uncertainties, which has helped spur the development of treatment machines with integrated planar and volumetric advanced imaging capabilities. In addition, advances in both anatomical and functional imaging provide improved ability to define the tumor volumes. Advances in all these technologies are occurring at a record pace and again pushing the cutting-edge frontiers of radiation oncology from IMRT to what is now referred to as image-guided IMRT, or simply image-guided radiation therapy (IGRT). A brief overview is presented of these latest advancements in conformal treatment planning and treatment delivery.

An Evolution of Technology Redefining Clinical Practice

Three-dimensional conformal radiation therapy (3DCRT) is now well established in routine clinical practice as an effective means of achieving higher tumor doses without increasing doses to critical normal structures. The transition from this new frontier in radiation oncology in the late 1980s to early 1990s to a standard of practice today did not come easily and was met with some resistance. 3DCRT represented a radical change in practice for the radiation oncologist and treatment planner moving from the older two-dimensional treatment planning approach, which emphasized geometric beam portal design based on standardized techniques applied to whole classes of comparable patients. The two-dimensional approach was much less laborious than 3DCRT, particularly for the radiation oncologist; however, it greatly limited the ability to escalate dose. This transition to 3DCRT was well documented in a previous volume in this series [1]. Three-dimensional treatment planning emphasized the delineation of image-based tumor volume(s) and the associated microscopic disease volume(s), as well as the critical normal structures, for the individual patient – the gross tumor volume (GTV), clinical target volume (CTV), and organs at risk (OARs). Beam apertures could then be shaped to conform to the planning target volume (PTV) and avoid OARs using beam's eye view displays [2, 3]. This 'forward planning' approach to conformal therapy is now rapidly giving way to an 'inverse planning' approach referred to as intensity-modulated radiation therapy (IMRT), which can achieve even greater conformity by optimally modulating the individual beamlets that make up the radiation beams [4].

IMRT dose distributions can be created to conform much more closely to the PTV, particularly for those volumes having complex/concave shapes, and to avoid OARs. Sharp dose gradients near the boundaries of both the PTV and the OARs can be achieved, but this results in IMRT treatments being much more sensitive to geometric uncertainties than the two-dimensional or 3DCRT approaches. Also, during a single fraction, IMRT techniques treat only a portion of the PTV at any instance (i.e., beamlets or beam segments). Thus, there is the potential for significant dosimetric consequences if the patient and/or the GTV/CTV move during IMRT treatment (i.e., referred to as *intrafraction* geometric uncertainties as opposed to *interfraction* uncertainties associated with patient treatment setup). Furthermore, since IMRT treatments typically take longer than two-dimensional radiotherapy or 3DCRT treatments, the patient must remain in the fixed treatment position for a longer period of time, increasing the susceptibility to intrafraction geometric uncertainties. All of these factors contribute to IMRT being a 'less forgiving' form of radiation therapy with regard to the effects of geometric uncertainties, and this imposes more stringent requirements to account for both intrafraction and interfraction uncertainties.

This recognition of the need to better account for the spatial uncertainties when using IMRT has spurred the development of treatment machines with integrated planar and volumetric advanced imaging capabilities [5]. In addition, advances in both anatomical and functional imaging are providing improved ability to define the tumor volumes. These advances in treatment machine imaging technology and diagnostic imaging are occurring at a record pace and again pushing the edge of our frontiers in radiation oncology from IMRT to what is now referred to as image-guided IMRT, or simply image-guided radiation therapy (IGRT) [6].

Of course, the concept of image guidance is not new, and really should be viewed as evolutionary. We are all aware of the development and use of various systems to help better localize the patient for treatment, including dedicated simulators, megavoltage (MV) port films, electronic portal imaging devices, use of implanted radiopaque markers, ultrasound imaging systems, or optical tracking systems. Even the early cobalt-60 teletherapy machines could be equipped with a kilovoltage (kV) X-ray tube attached to the beam stop.

However, it is the development of the modern IMRT delivery system with integrated imaging capability that can provide three-dimensional volumetric imaging of soft tissues (including tumors) that has resulted in the term IGRT and the following IGRT hypothesis.

The IGRT hypothesis:

> *IGRT can reduce setup uncertainties and provide improved management of internal organ motion, and therefore will allow further dose escalation and/or conformal avoidance than IMRT alone, which will lead to improved treatment outcome.*

Like with the 3DCRT hypothesis, clinical trials should be conducted to test the IGRT hypothesis, but to date no such cooperative group studies specifically addressing this hypothesis are in place.

These new image-guided treatment machines are also spurring other exciting developments, including the further investigation of hypofractionation using what has been termed stereotactic body radiation therapy (SBRT) [7], which clinically integrates the results of new biologic studies looking at tumor responses to single high-dose fractionation [8] with the new technical capabilities to deliver highly focused therapy.

These are exciting developments and times for radiation oncology, but, as stated above, clinical trials should be initiated to validate and help determine the IGRT's most effective use. Certainly, its adoption should not be driven by reimbursement. A brief overview is presented of the latest advancements in three-dimensional treatment planning and delivery that are leading to our new standards of practice.

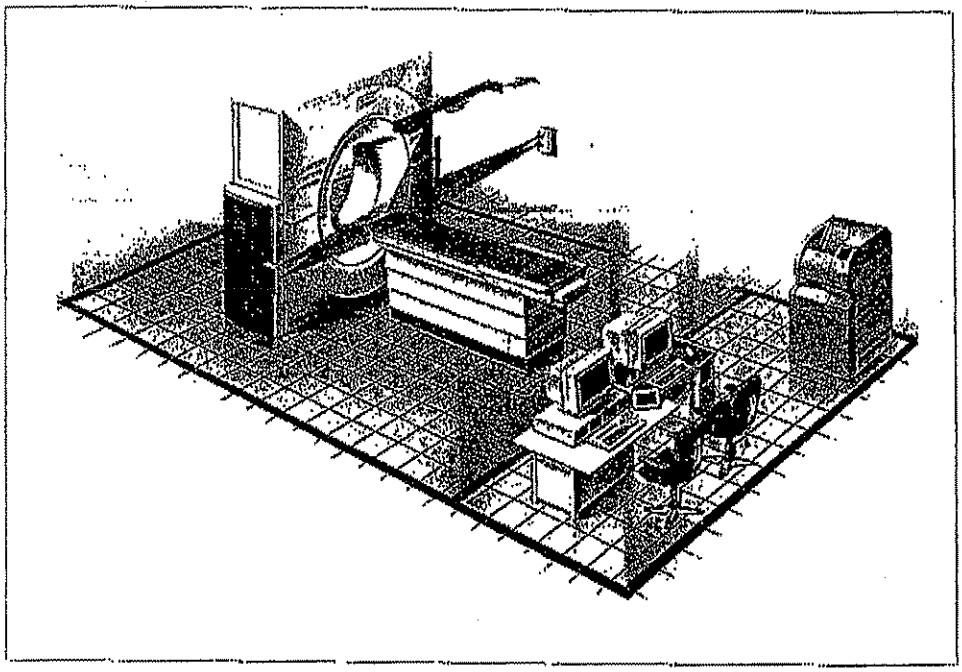


Fig. 1. CT simulator room layout consisting of a diagnostic CT scanner, external laser positioning system, and a virtual simulation software workstation. Courtesy of Philips Medical Systems, Cleveland, Ohio, USA.

CT Simulation and Three-Dimensional Treatment Planning

The radiation oncology community eagerly embraced the concept of virtual simulation and three-dimensional treatment planning in the early 1990s when robust commercial packages, including dedicated CT simulation systems, became available (fig. 1) [9]. Both CT simulation and three-dimensional treatment planning systems (3DTPS) have now matured to a point where they are the cornerstones of a modern radiation oncology facility [10]. Today's CT simulation systems incorporate large-bore CT scanners, especially designed for radiation oncology, with multislice capability, high-quality laser marking/patient positioning systems, and sophisticated virtual simulation software features. Also, many 3DTPS now include virtual simulation software features. The tremendous computational power of today's 3DTPS workstations permits near real-time interactivity for many of the treatment planning tasks. Beam's eye view displays (fig. 2) allow the treatment planner to efficiently develop plans, including those utilizing noncoplanar beams. Extremely high-quality digitally reconstructed radiographs (DRRs), in which the delineated contours and the projected beam apertures can be overlaid, can be quickly generated. Room's eye view displays (fig. 3) provide a powerful

Fig. 2. 3DTPS beam's eye view display used to identify the best gantry, collimator and couch angles at which to irradiate target and avoid irradiating adjacent critical structures. Critical structures and target volumes outlined on patient's CT sections and outline of multileaf collimator aperture are shown (Varian Eclipse TPS).

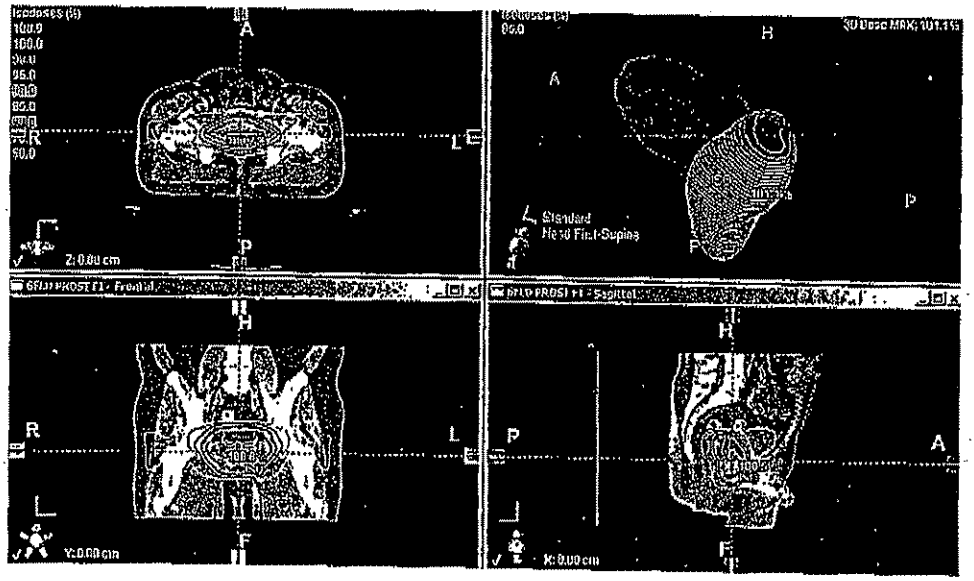


Fig. 3. 3DTPS four-panel isodose review display showing three orthogonal planes and room's eye view for planned dose distribution. The room's eye view display shown in the upper right panel is useful to quickly evaluate where the hot or cold spots occurred after dose-volume histogram review.

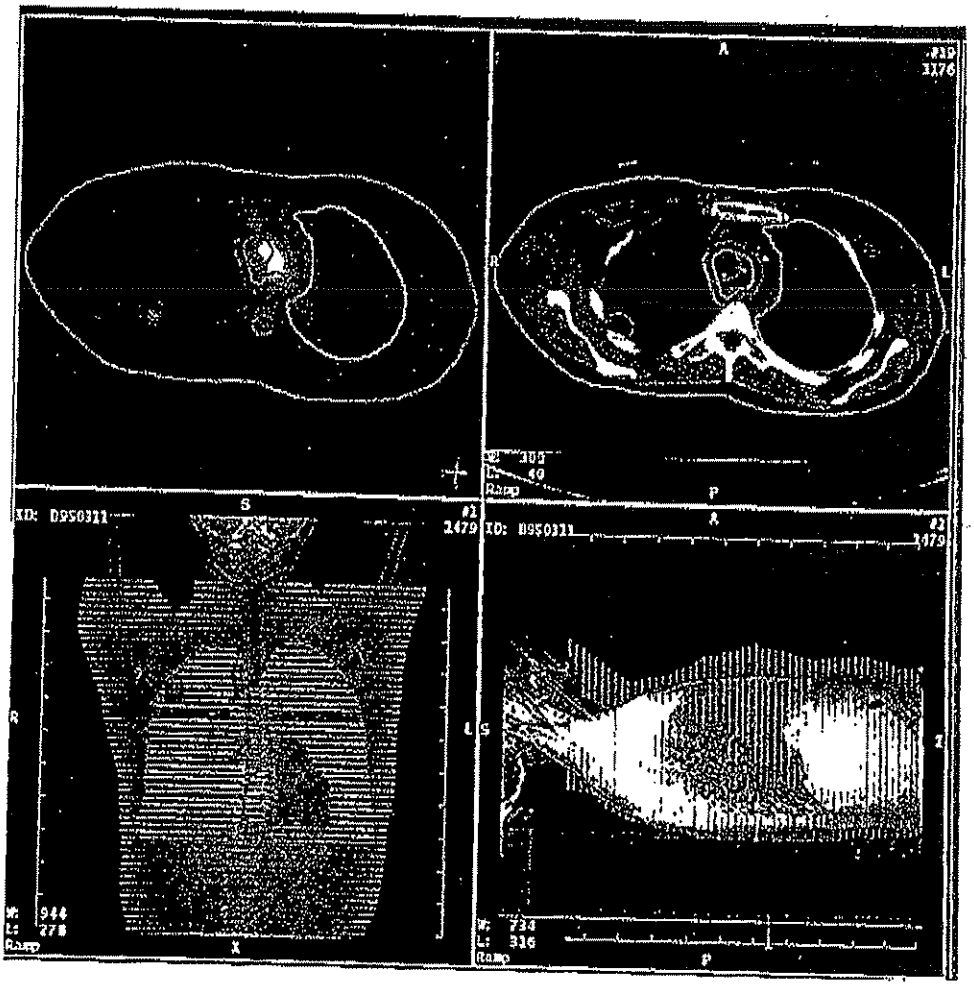


Fig. 4. 3DTPS software for contouring target volumes and organs at risk (image segmentation) continues to be improved, but is still not automated to the extent needed for IGRT. CT data are displayed and contours are drawn by the radiation oncologist around the tumor/target volumes, and organs at risk on a slice-by-slice basis, as seen in the upper right panel. At the same time, planar images from both anterior-posterior and lateral projections are displayed in the bottom right and left panels. The upper left panel shows PET scan data with overlying contours after image registration with the CT data. Continued development in automated image segmentation and image fusion (deformable registration) software should remain a high priority for the field.

plan evaluation tool in which a three-dimensional isodose volume can be viewed and rotated in real time, allowing evaluation of target volume coverage and search for excess dose hot spots to critical normal structure volumes. Unfortunately, even though software for contouring normal structures and target volumes (image segmentation) has been significantly improved in recent years, it is still not automated to the extent needed for IGRT (fig. 4). The contouring task remains too time con-

suming, and secondly complex sites such as head and neck are extremely challenging. Thus, continued development in automated segmentation and image fusion (deformable registration) software should remain a high priority for the field.

Those readers interested in more details regarding the historical development of CT simulators and 3DTPS are referred to the following references [10, 11].

Oncological Imaging

CT is still the principal source of imaging data used for defining the GTV for most sites, but this imaging modality presents several potential pitfalls. First, when contouring the GTV, it is essential that the appropriate CT window and level settings be used in order to determine the maximum dimension of what is considered potential gross disease. Secondly, for those treatment sites in which there is considerable organ motion, such as for tumors in the thorax, CT images do not correctly represent either the time-averaged position of the tumor or its shape [12–14]. This can be understood by appreciating the fact that today's single-slice CT simulators rely almost exclusively on the use of fast spiral CT technology, and thus acquire data essentially in two dimensions. This has the effect of capturing the tumor cross section images at particular positions in the breathing cycle. If the tumor motion is significant, different, and possibly noncontiguous, transverse sections of the tumor could be imaged at different points of the breathing cycle, leading to volume uncertainties [12–14]. The interpolation process in spiral CT technology adds further to the uncertainty. As a result, the three-dimensional reconstruction of the GTV from temporally variant two-dimensional images often results in a poor representation of the tumor and its motion. Thus, multislice CT technology (so-called *four-dimensional CT imaging*) is rapidly becoming the standard for CT simulators [15]. In addition, other technologies and methodologies to explicitly help manage respiratory motion (to the order of less than 5 mm during treatment) continue to be developed, including respiratory-gated techniques, respiration-synchronized techniques, breath-hold techniques, and forced shallow-breathing methods [16].

In some sites, MR is already known to be a better anatomic imaging modality for defining the boundaries of the target volume, e.g. prostate. This has led to the development of dedicated MR simulators for radiation oncology [17]. As IGRT matures, there is likely to be more interest in further developing MR simulators from the low tesla units that are available today.

Unfortunately, in many sites anatomic imaging techniques do not always distinguish malignant from normal tissues. There is growing use of the complementary information available from functional imaging studies, such as PET, when defining the GTV [18–20]. The benefit from such functional information has been

pointed out by studies such as that by Caldwell et al. [21], who showed high observer variability in the CT-based definition of the GTV for non-small-cell lung cancer patients when compared with the GTV defined using FDG-hybrid PET images coregistered with CT. Integrated PET-CT units have already been implemented in some radiation oncology departments. It is very likely that over the next 5 years large-bore PET-CT simulators will be developed for radiation oncology. However, such dedicated radiation oncology imaging systems will not be as easily assimilated into the planning and follow-up process as was CT, and will require close collaboration with our imaging colleagues (both physicians and physicists).

Delineating the CTV is a much more complicated task than delineating either the GTV or most OARs. At this time, it is more of an art than a science, since current imaging techniques are not capable of detecting subclinical tumor involvement directly. When defining GTVs, CTVs and OARs on axial CT slices, particularly for sites such as head and neck cancer, assistance from a diagnostic radiologist is often helpful. Publications and symposiums addressing the problems of establishing consistent CTVs for the various clinical sites are now becoming commonplace [22, 23]. There is no question that image-based cross-sectional anatomy training should be a requirement in radiation oncology residency training programs. The radiation oncologist of the future will need to become much more expert in image recognition of normal tissue anatomy and gross tumor changes in order to take full advantage of the many advances in imaging. Research efforts that will allow a more accurate determination of the CTV (and facilitate a safe reduction in PTV margin when an appropriate motion management system is used) may be the single most important area to further advance the safe and effective use of IGRT.

Dose Calculations

Advanced three-dimensional algorithms that compute the photon beam dose distribution from more of a first-principle approach (i.e., convolution/superposition), rather than correcting parameterized dose distributions measured in a water phantom, are now commercially available [24]. These models utilize convolution energy deposition kernels that describe the distribution of dose about a single primary photon interaction site, and provide accurate results even for complex heterogeneous geometries. It is the author's opinion that heterogeneity-corrected treatment plans generated using such advanced algorithms should be the standard of practice for IGRT. The study by Frank et al. [25] provides a clear methodology for safely transitioning clinical use from one based on planning that assumes a homogeneous unit density patient, to one using a heterogeneous patient model.

Even the convolution/superposition dose calculation algorithms will eventually be replaced by the Monte Carlo technique [26–28]. Monte Carlo is, in prin-

ciple, the only method capable of computing the dose distribution accurately for all situations encountered in radiation therapy. This includes being able to accurately predict the dose near interfaces of materials with very dissimilar atomic number such as near metal prostheses, or different densities such as tumors in lung tissue. I believe that accurate Monte-Carlo-based dose calculations, combined with the advantages of IGRT for managing motion uncertainties, hold great promise in the treatment of lung cancer.

Treatment Plan Optimization

Presently, most (if not all) optimization engines in IMRT treatment planning systems utilize dose- and/or dose-volume-based objective functions in which the failure to achieve the prescribed dose distribution is proportional to the dose difference (or the square of the difference) between the planned and prescribed doses. The limitations of dose- or dose-volume-based criteria have led a number of investigators to propose dose response models, such as tumor control probabilities and normal tissue complication probabilities (see the review by Brahme [29]). More recently, Niermierko [30] and Wu et al. [31] have proposed IMRT optimization based on a dose response using equivalent uniform dose. Such work should be encouraged, as the development of robust dose response models that accurately predict clinical outcome is an important research area for radiation oncology, particularly for furthering the automation of the IGRT planning process.

Image-Guided Treatment Machines

Cone Beam CT Linear Accelerator IGRT

The first commercially available cone beam CT (CBCT) IGRT system was the Elekta Synergy™ (Elekta, Crawley, UK) [5, 32]; the other medical linear accelerator (linac) manufacturers have also now embraced the IGRT concept and have either produced their own version of an IGRT linac, Varian Trilogy™ (Varian Medical Systems, Palo Alto, Calif., USA), or are in the process of such developments, Siemens ARTÍSTE™ (Siemens Medical Solutions USA, Inc., Malvern, Pa., USA). The Synergy (fig. 5) consists of a retractable kV X-ray source, an amorphous silicon flat panel imager mounted on the linear accelerator perpendicular to the radiation beam direction, and a software module (referred to as the XVI system). The system provides planar, motion, and volumetric images. Figure 6 depicts the IGRT data flow and work process currently used at UC Davis. For CBCT image acquisitions, the gantry is rotated around the patient for a preset angle (between 180 and 360° to allow sufficient data acquisition) and images are acquired via an

Fig. 5. Elekta Synergy consists of a conventional multimodality medical linac with a retractable kV X-ray source, an amorphous silicon flat panel imager mounted on the linear accelerator perpendicular to the radiation beam direction, and a software module (referred to as the XVI system). The upper panel shows the X-ray tube amorphous silicon flat panels retracted and the lower panel shows them extended.

amorphous silicon panel. Volumetric image reconstruction is performed simultaneously with the acquisition to expedite the process. The reconstructed three-dimensional geometry is subsequently registered with the reference geometry planning image, either manually or automatically (using either soft tissue or bone mode). For some disease sites, such as prostate cancer, the soft tissue mode is conceptually ideally suited, since the prostate often moves relative to the bones. However, at present, it is difficult to visualize the prostate in all cases, and thus implanted radiopaque seeds are used to make the registration process more efficient. Based on the registration, the difference between the data sets is calculated and displayed as translation along and rotation about the three axes. Subsequent treatment table adjustments are made (fig. 7) and the patient treated. One can clearly appreciate that CBCT-based IGRT shows great potential for objective, precise positioning of patients for treatment, matching the treatment setup image model to that of the planning image model. It remains to be determined exactly which imaging features on the integrated CBCT linacs (i.e., kVp CBCT, planar, motion, and MV electronic portal imaging device) are best suited for a particular disease site.

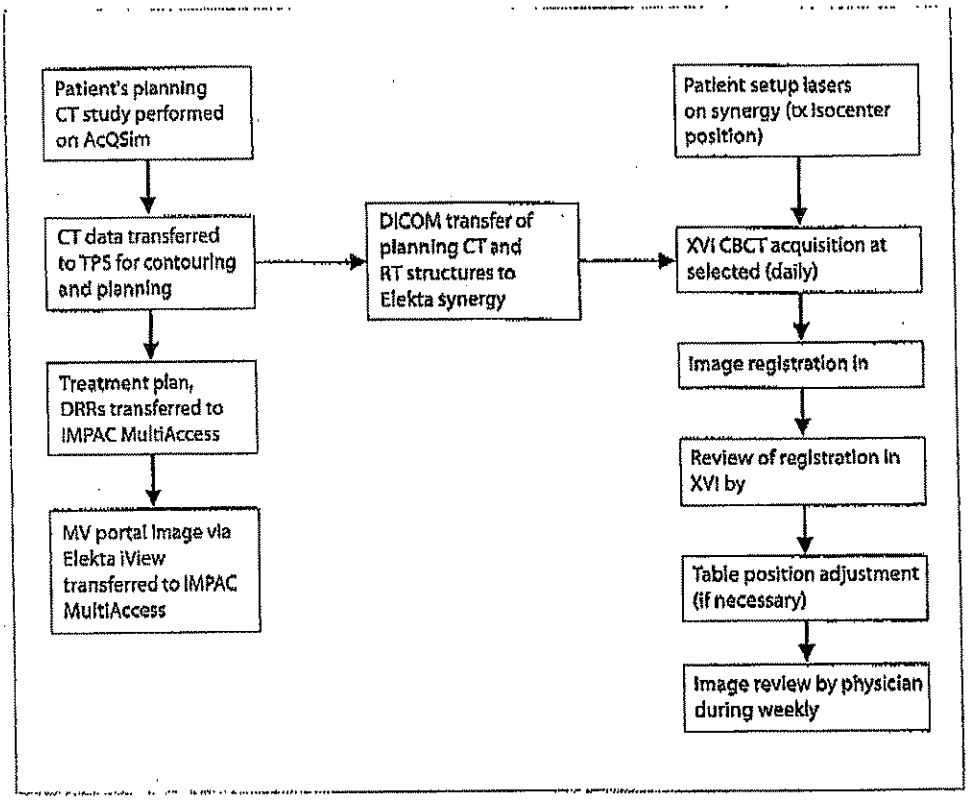


Fig. 6. Elekta IGRT data flow and work process used at UC Davis. Physician performs initial reviews and later delegates to therapists after communicating objectives and verifying registration success in initial sessions.

Helical Tomotherapy IGRT

Helical tomotherapy was first proposed by Mackie et al. in 1993 and is now commercially available as the TomoTherapy HI-ART system (TomoTherapy, Inc., Madison, Wisc., USA) [33–36]. A short in-line 6-MV linac (Siemens Oncology Systems, Concord, Calif., USA) rotates on a ring gantry at a source-axis distance of 85 cm. Figure 8 shows the unit installed at UC Davis. The IMRT treatment is delivered while the patient support couch is translated in the y-direction (toward the gantry) through the gantry bore, in the same way as a helical CT study is conducted. In the patient's reference frame, the treatment beam is angled inwards along a helix with the midpoint of the fan beam passing through the center of the bore. Similar to helical CT, the treatment beam pitch is defined as the distance traveled by the couch per gantry rotation, divided by the field width in the y-direction. The width of the beam in the y-direction is defined by a pair of jaws that is fixed, for any particular patient treatment, to one of three selectable values (1, 2.5 or 5 cm).

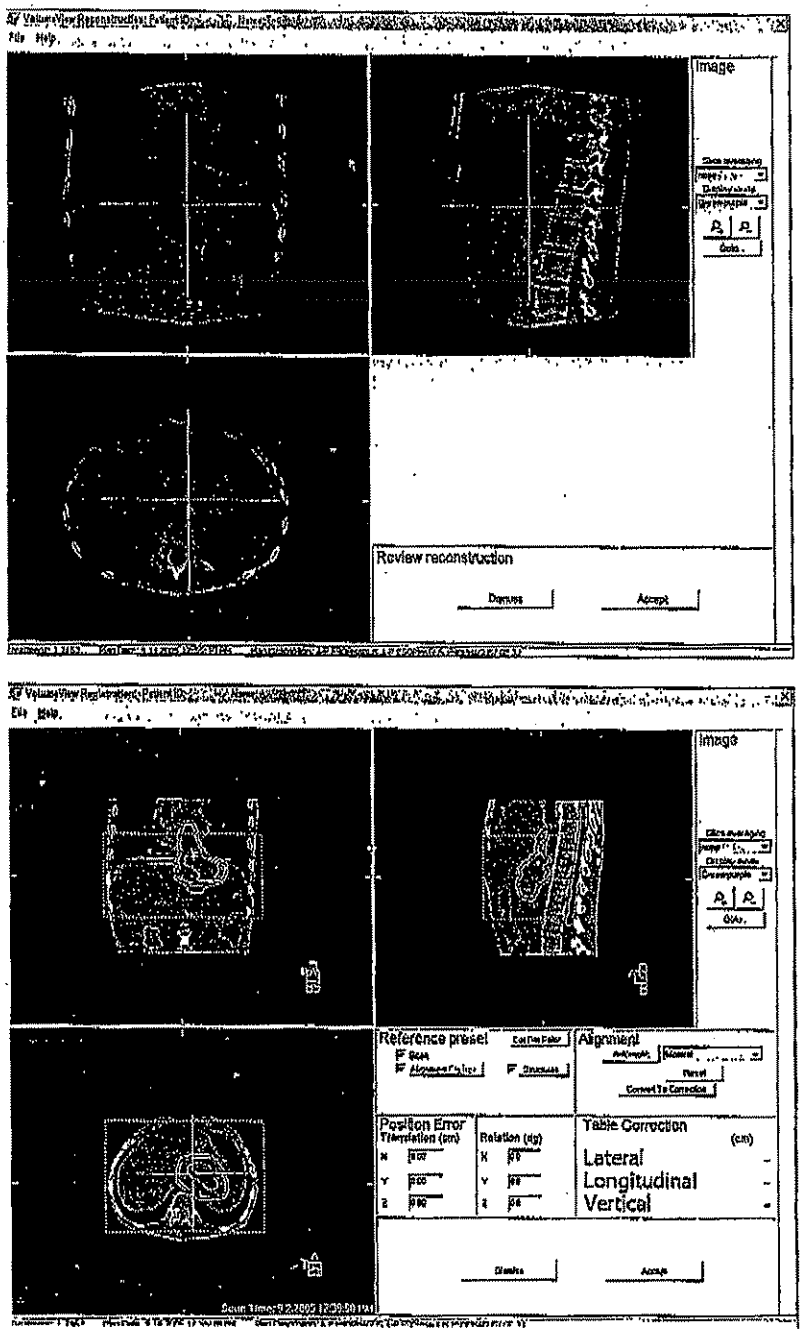


Fig. 7. Elekta Synergy XVI display screens showing the image registration process. The difference between the prescription and CBCT data sets is calculated and displayed as translation along and rotation about the three axes; subsequent treatment table adjustments are made and then the patient is treated.

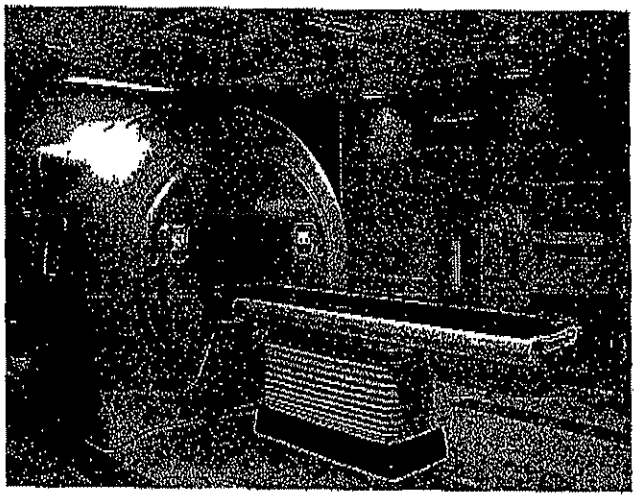


Fig. 8. TomoTherapy HI-ART system installed at UC Davis.

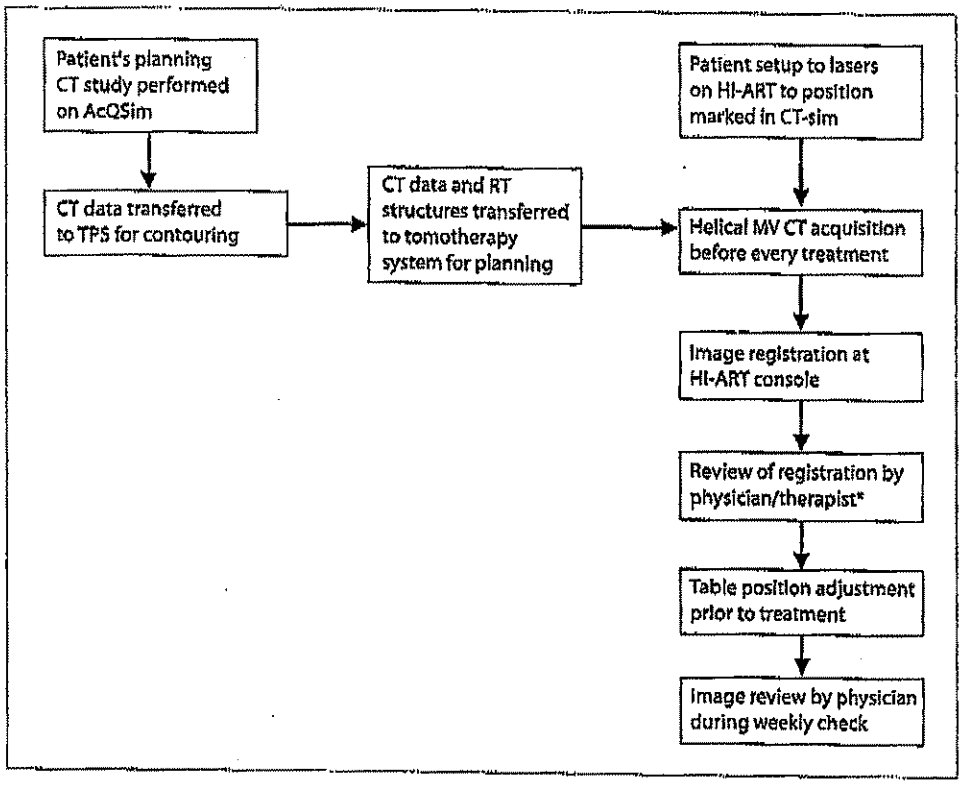


Fig. 9. The helical tomotherapy IGRT data flow and work process used at UC Davis. Physician performs initial reviews and later delegates to therapists after communicating objectives and verifying registration success in initial sessions.

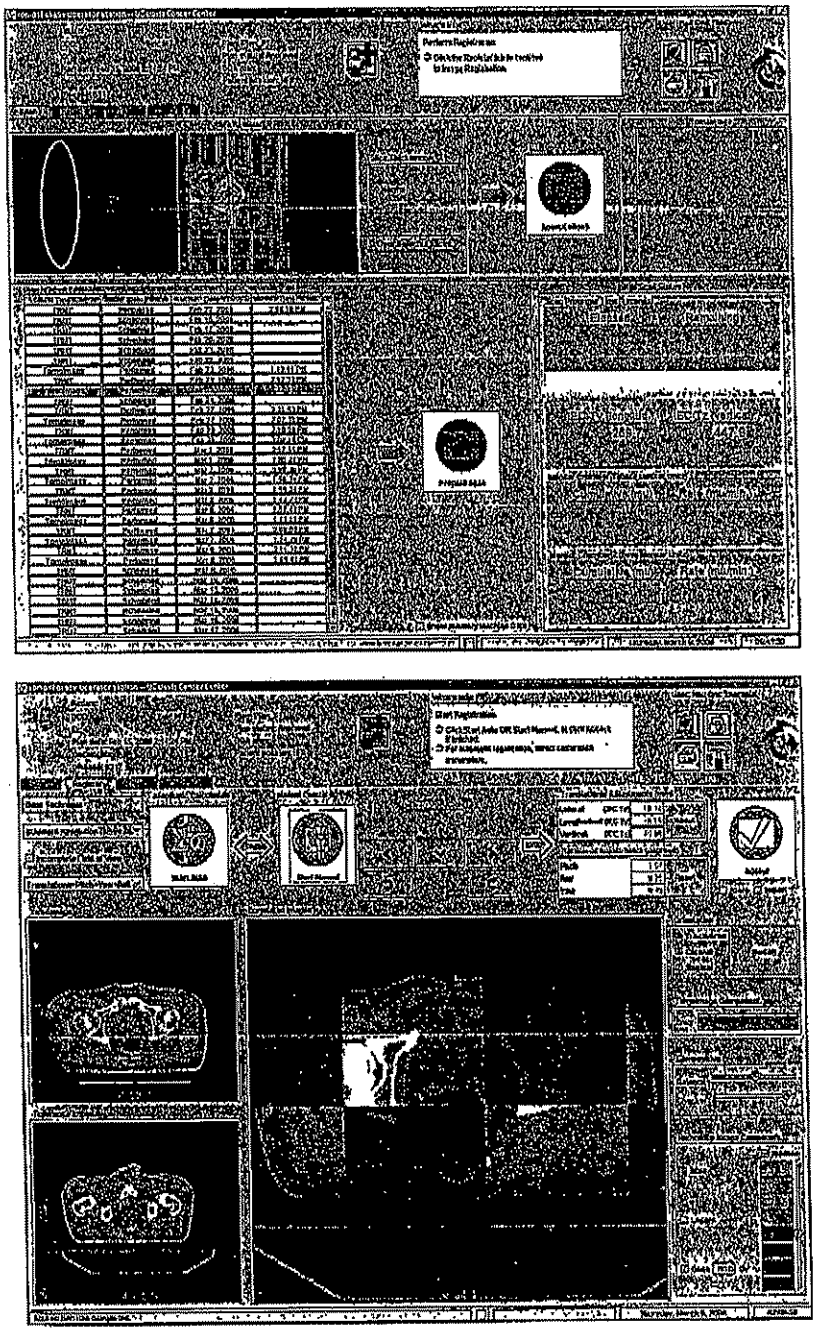


Fig. 10. TomoTherapy HI-ART display screens showing the image registration process after which table adjustments are automatically made and the patient treated.

Laterally, the treatment beam is modulated by a 64-leaf binary multileaf collimator, whose leaves transition rapidly between open and closed states providing a maximum possible open lateral field length of 40 cm at the bore center. Highly modulated treatments can achieve great conformality, though they inevitably take longer to deliver. The IGRT process in use at UC Davis is shown in figure 9. A helical MV CT image is acquired prior to treatment each day using the on-board xenon CT detector system and the 6-MV linac (detuned to 3.6 MV). Registration software is provided to compare the daily patient setup image with the stored prescription CT planning image. After image registration, table adjustments are then automatically made and the patient is then treated (fig. 10).

Cyberknife IGRT

The use of a small X-band linear accelerator mounted on an industrial robot was first developed for radiosurgery [37]. The robot provides the capability of aiming beamlets with any orientation relative to the target volume. The system uses two ceiling-mounted diagnostic X-ray sources, and amorphous silicon image detectors mounted flush to the floor. The treatment is specified by the trajectory of the robot and by the number of monitor units delivered at each robotic orientation. During the patient's treatment, the Cyberknife System correlates live radiographic images with preoperative CT or MRI scans in real time to determine patient and tumor position repeatedly over the course of treatment. More details are provided by users of this system in subsequent articles in this volume.

Image-Guided Intensity-Modulated Proton Therapy and Beyond

Establishing the optimum clinical use of the above-described IGRT machines (and their continued development) will require considerable effort over the next several years. Many practical questions need answering.

Questions in the applications of IGRT:

(1) *Which anatomical sites are best suited for IGRT treatments?*
(2) *Which type of IGRT is the most efficient, and is this site dependent?*
(3) *What are the optimum treatment time periods required for IGRT?*
(4) *What is the optimum use of daily imaging in the IGRT planning/treatment process?*
(5) *What are the most effective periodic technical quality assurance (QA) methodologies and patient-specific QA methodologies including weekly chart rounds for IGRT?*
(6) *What are the components of a dedicated radiation oncology picture archive communication system (RO-PACS)?*

Particularly important will be the development of accurate and efficient deformable registration tools that will allow image-guided adaptive radiation therapy to become a routine standard of practice [38–40].

Even after we gain considerable experience with photon-based image-guided IMRT and further development of it occurs, other technological advances in treatment modalities will continue to take place. Those already involved in proton beam therapy are developing image-guided intensity-modulated proton therapy. Also, there is promising work going on at the *Gesellschaft für Schwerionenforschung* in Darmstadt, Germany, where they are treating patients with carbon ions and using a PET scanner to monitor the individual patient treatments [41].

The point is that technology is going to continue to advance in radiation oncology. It is particularly exciting to contemplate the potential synergy resulting from the progress being made in image-guided planning/delivery systems and the progress being made in molecular and cancer biology. Such advances are likely to lead to optimized radiation therapy for the individual patient [42]. This will require many types of professionals – clinicians, physicists, biologists and computer scientists – all working together to develop what will eventually evolve into the next frontier of cancer therapy. This may in turn become a new standard of practice, as we repeat this cycle as advances continue, until cancer is finally eliminated or at least turned into a chronic disease in which a high quality of life can be maintained.

Radiation Oncology Informatics

The amount of digital data transferred and stored (and thus the available information) in a radiation oncology department has drastically increased with the development/implementation of IGRT treatment machines. Daily kV CBCT images or MV helical CT images are acquired during a patient's treatment course and add several dozen megabytes to gigabytes of information, which needs to be stored in a manner that permits efficient accessing when needed. At the same time, the patient's treatment planning data, which often exist only in a system-specific proprietary format, need to be similarly stored and readily accessible. In addition, cancer biology imaging techniques currently used (or those under development) generate huge digital data files that require storage. But storage is not the only issue. New software tools to effectively use the imaging data (for clinical workflow issues, outcome research, and basic research) are needed if we are to take full advantage of the new information. IGRT clearly points to the need for a new type of picture archive communication system (PACS) specifically designed for radiation oncology, i.e., RO-PACS. The development of a robust RO-PACS will be one of the most important developments for radiation oncology, as the use of information technology will be 'mission critical' in order to make radiation oncology more effective and efficient [43].

Another important informatics effort in radiation oncology is that being led by the Image-Guided Therapy QA Center (ITC) as part of the Advanced Technology QA Consortium (ATC) (http://atc.wustl.edu/) [44]. NCI-sponsored advanced technology trials in several sites are now in progress in which the patient's three-dimensional planning and verification digital data are submitted via the Internet. All target volumes and designated critical structure contours (superimposed on CT display), first-day portal films on all patients, and the three-dimensional dose distributions are all reviewed using web-based tools. The data are stored in a treatment planning verification database. This database resource is allowing researchers to mine the data so as to better understand the relationship between dose and outcomes of 3DCRT/IMRT, and ultimately to develop robust tumor control probability and normal tissue complication probability models.

Collaborative Working Groups

During the 1980s and early 1990s, the Radiation Research Program of the NCI supported several multi-institutional collaborative working groups (CWG) research contracts that focused research efforts on translating advanced technologies that were available only in a few academic institutions to the radiation oncology community as a whole. These efforts included the Photon 3D Treatment Planning CWG (1984–1987), Electron 3D Treatment Planning CWG (1986–1989), and the Radiotherapy Treatment Planning Tools CWG (1989–1994) [45]. Even IMRT benefited from a consensus paper developed using the CWG approach [46]. A parallel for university and industry collaboration can be drawn from the Elekta Research Consortium, which led to the development of the Elekta Synergy. It is now time to re-embrace the CWG concept for IGRT and address the clinical use of IGRT. This effort should combine both NCI and industry support to establish an IGRT CWG to help answer the many questions posed by IGRT.

Education and Training Requirements in the Image-Guided Radiation Therapy Era

In this new image-guided IMRT era, it should be recognized that the complexity of treatment planning and delivery is increased. The level of precision needed for planning target volume localization is amplified, as well as the requirement to preserve this geometrical precision during treatment. These requirements will impact the roles of the radiation therapy team members, and their education and training requirements to meet these new challenges. In addition to the ever-increasing needs for training in cancer medicine and cancer biology, the radiation oncologist will need to develop much more expertise in using multimodality imaging studies (e.g.

CT, CBCT, MRI, PET). Cross-sectional imaging training should be an essential component of the training programs of radiation oncologists in the IGRT era. In addition, they must be much more computer literate as the electronic medical record, RO-PACS and associated software tools become ubiquitous throughout the clinic.

The radiation oncology physicist also needs much more training in imaging physics, as four-dimensional spiral CT and multimodality imaging become the foundation of the planning process and integrated kV and/or MV imaging (including CBCT) become the foundation of the treatment verification process. Data accessibility and networking issues are extremely important to radiation oncology clinics implementing IGRT capability. Just as high-energy accelerator physicists were critical to radiation oncology in the 1970s, physicists with strong imaging and computer backgrounds, particularly with regard to networking and integration of peripheral devices, are essential for the IGRT clinic.

The medical dosimetrist also needs much more training in cross-sectional imaging anatomy. Delineating OARs continues to be too time-consuming. Dosimetrists should also become much more familiar with the inverse planning optimization approach.

The radiation therapist in the IGRT era also needs much more training in image-based anatomy, and in dealing with the very complex treatment delivery systems including the positional tracking systems likely to become standard in IGRT treatment rooms. Current IGRT systems should be thought of only as first-generation systems, as some have as many as 4 or 5 monitors and keyboards for the radiation therapist to deal with. While these cumbersome arrangements will probably continue for quite a while, eventually these components will become integrated. Ultimately, after the patient is repositioned and fixated, the treatment delivery will be highly automated using image-guided IMRT techniques without doubt. The radiation therapist will continue to play a key role in monitoring patient position and system operation in the IGRT era.

Implementing Image-Guided Radiation Therapy in the Clinic

This section is intended to briefly review lessons learned over my career in implementing advanced technologies such as IGRT. These remarks are based on my experience in implementing multimodality medical linacs in the 1970s; three-dimensional treatment planning and conformal therapy in the 1980s to early 1990s; IMRT in the 1990s to 2000s, and IGRT in the mid 2000s to the present day.

When first considering implementing an IGRT program, the department leadership must do adequate homework to fully understand the resources needed. Complex new technology places increased demands on the radiation therapy team; all members are typically affected to some degree whether it is increased contour-

ing effort, new and more detailed plan prescriptions, more complex treatment planning, change in workflow, i.e., daily image registration, and/or new QA efforts. It is prudent to assign key physician and physicist teams as the initial clinical users who will eventually become the teachers/mentors of the other new users in the department. The initial team should visit and learn from clinical groups already expert in use of the new technology, and also attend vendor training in use of the technology, particularly the planning system and the treatment delivery system.

Once the technology is in place and the team leaders have acquired initial training, the focus should be on building a strong clinical foundation. This is best accomplished by starting with disease sites in which there is already published experience, or in which there is local disease site expertise that fits well with the use of the new technology. Typically, these include such sites as prostate, head and neck, and brain. During the initial use period, try to limit weekly starts (2–3 a week) in order for all members of the team to gain experience and coordinate workflow, technology use, and QA issues. The initial team should build up a large number of clinical cases before training other new users. Also, they should provide an ample number of in-service training sessions to the various groups involved.

It is extremely important to establish strong QA and preventive maintenance inspection programs for the use of the new technology. Utmost importance is making sure that appropriate physics staffing and appropriate QA instrumentation and phantoms are provided. The QA program should incorporate redundant checks and involve all members of the team. It is essential to have written use and QA procedures. The preventive maintenance program should include vendor training classes and adequate support to maintain spare parts and appropriate test instrumentation. These points are often missed by administrators as they focus only on the purchase and not the support needed for the new technology. The bottom line is this: when implementing advanced technologies, there must be a strong commitment from the hospital administration with no shortcuts taken.

Once the new technology is in place, the goal should be to develop efficient use, i.e., class solutions. This is best accomplished by establishing weekly conferences to discuss plans and develop written procedures, review pertinent literature, and surface issues for discussion with the entire group. These weekly conferences will help establish disease site consistency in target volume and critical structure specifications, in dose prescription (including critical organ dose-volume constraints), and target volume doses. It is advised to start with simpler sites such as prostate.

A useful tool implemented at UC Davis is the use of benchmark dose-volume histograms (DVHs) for making treatment decisions in prostate cancer therapy [47]. These benchmark DVHs (for the rectum and bladder) were developed by creating both 3DCRT and IMRT plans for a certain number of patients during our initial implementation of IMRT and treating with IMRT only if its DVH profile was judged better than 3DCRT.

Finally, when implementing advanced technologies, it is essential to monitor progress in the program. This is done by establishing a quality improvement program for the new technology: (1) define and record treatment planning metrics (e.g. number plans, time required for planning per site); (2) monitor changes in volumes/prescriptions; (3) track outcomes, and (4) and most importantly, record monthly treatment planning/treatment machine uptime as reliability is key in the clinic.

Summary and Conclusion

I am going to conclude this paper with some comments that I wrote for an editorial that was published in the year 2000 in the journal *International Journal of Radiation Oncology Biology Physics* [48]. At the time, I had been invited to envisage (from a physics perspective) where radiation oncology would be in the year 2035. Today it is clear that in some areas things are developing at an even faster pace than I predicted, while other areas remain problematic.

IGRT systems are providing an integrated approach to radiation oncology treatment planning, dose delivery, and treatment verification. However, these are first-generation systems and most of the tasks in the IGRT process are not fully automated.

The ability to more accurately define the volumes containing the gross disease is improving with the use of advanced multimodality imaging. However, little progress has been made in providing a solution for accurately defining subclinical disease, i.e., the CTV.

Significant progress has been made in technologies that account for or minimize patient setup error and organ motion. However, caution is urged when reducing the PTV margins as it is essential to fully appreciate the still large uncertainty associated with the CTV specification in most disease sites.

Physicists are currently struggling with the planning and QA challenges posed by image-guided IMRT. New instrumentation and methodology that minimizes the human steps needed to plan, treat, and verify a cancer patient's radiation therapy are still needed.

In summary, these first-generation IGRT systems are truly exciting, but improvements in image quality, data storage, data import/export, and software tools (for specific workflow tasks and for data mining) are needed. Most importantly, IGRT machine reliability (i.e., 99% uptime) is absolutely critical.

While there is considerably more research and developmental work to do, as we move from these new frontiers to new standards of practice, I repeat exactly what I said in the year 2000: 'I strongly believe that this next generation of radiation oncology clinicians and scientists have a unique opportunity to significantly improve treatment outcomes and lower costs thus making high quality radiation therapy available the world over.'

References

1 Meyer JL, Purdy JA (eds): 3-D Conformal Radiotherapy: A New Era in the Irradiation of Cancer. Front Radiat Ther Oncol. Basel, Karger, 1996, vol 29.

2 International Commission on Radiation Units and Measurements: ICRU Report 50: Prescribing, Recording, and Reporting Photon Beam Therapy. Bethesda, International Commission on Radiation Units and Measurements, 1993.

3 International Commission on Radiation Units and Measurements: ICRU Report 62: Prescribing, Recording, and Reporting Photon Beam Therapy (Supplement to ICRU Report 50). Bethesda, International Commission on Radiation Units and Measurements, 1999.

4 Webb S: The physical basis of IMRT and inverse planning. Br J Radiol 2003;76:678–689.

5 Jaffray DA, Siewerdsen JH, Wong JW, et al: Flat-panel cone-beam computed tomography for image-guided radiation therapy. Int J Radiat Oncol Biol Phys 2002;53:1337–1349.

6 Ling CC, Yorke E, Fuks Z: From IMRT to IGRT: frontierland or neverland? Radiother Oncol 2006;78:119–122.

7 Kavanagh BD, Timmerman RD (eds): Stereotactic Body Radiation Therapy. Philadelphia, Lippincott Williams & Wilkins, 2005, pp 1–159.

8 Fuks Z, Kolesnick R: Engaging the vascular component of the tumor response. Cancer Cell 2005; 8:89–91.

9 Coia LR, Schultheiss TE, Hanks G (eds): A Practical Guide to CT Simulation. Madison, Advanced Medical Publishing, 1995, p 209.

10 Mutic S, Palta JR, Butker EK, et al: Quality assurance for computed-tomography simulators and the computed-tomography-simulation process: report of the AAPM Radiation Therapy Committee Task Group No 68. Med Phys 2003;30:2762–2792.

11 Purdy JA: 3-D radiation treatment planning: a new era; in Meyer JL, Purdy JA (eds): 3-D Conformal Radiotherapy: A New Era in the Irradiation of Cancer. Front Radiat Ther Oncol. Basel, Karger, 1996, pp 1–16.

12 Caldwell CB, Mah K, Skinner M, et al: Can PET provide the 3D extent of tumor motion for individualized internal target volumes? A phantom study of the limitations of CT and the promise of PET. Int J Radiat Oncol Biol Phys 2003;55:1381–1393.

13 Chen GTY, Kung JH, Beaudette KP: Artifacts in computed tomography scanning of moving objects. Semin Radiat Oncol 2004;14:19–26.

14 Rietzel E, Chen GTY, Choi NC, et al: Four-dimensional image-based treatment planning: target volume segmentation and dose calculation in the presence of respiratory motion. Int J Radiat Oncol Biol Phys 2005;61:1535–1550.

15 Rietzel E, Pan T, Chen GT: Four-dimensional computed tomography: image formation and clinical protocol. Med Phys 2005;32:874–889.

16 Bortfeld TR, Chen GTY: High-precision radiation therapy of moving targets. Semin Radiat Oncol 2004;14:1–100.

17 Mah D, Steckner MC, Palacio E, et al: Characteristics and quality assurance of a dedicated open 0.23 T MRI for radiation therapy simulation. Med Phys 2002;29:2541–2547.

18 Chapman JD, Bradley JD, Eary JF, et al: Molecular (functional) imaging for radiotherapy applications: an RTOG symposium. Int J Radiat Oncol Biol Phys 2003;55:294–301.

19 Ling CC, Humm J, Larson S, et al: Towards multidimensional radiotherapy (MD-CRT): biological imaging and biological conformality. Int J Radiat Oncol Biol Phys 2000;47:551–560.

20 Munley MT, Marks LB, Hardenbergh PH, et al: Functional imaging of normal tissues with nuclear medicine: applications in radiotherapy. Semin Radiat Oncol 2001;11:28–36.

21 Caldwell CB, Mah K, Ung YC, et al: Observer variation in contouring gross tumor volume in patients with poorly defined non-small-cell lung tumors on CT: the impact of ^{18}FDG-hybrid PET fusion. Int J Radiat Oncol Biol Phys 2001;51:923–931.

22 Gregoire V, Coche E, Cosnard G, et al: Selection and delineation of lymph node target volumes in head and neck conformal radiotherapy. Proposal for standardizing terminology and procedure based on the surgical experience. Radiother Oncol 2000;56:135–150.

23 Martinez-Monge R, Fernades PS, Gupta N, et al: Cross-sectional nodal atlas: a tool for the definition of clinical target volumes in three-dimensional radiation therapy planning. Radiology 1999;211:815–828.

24 Alinesjö A, Aspradakis MM: Dose calculations for external photon beams in radiotherapy. Phys Med Biol 1999;44:R99–R155.

25 Frank SJ, Forster KM, Stevens CW, et al: Treatment planning for lung cancer: traditional homogeneous point-dose prescription compared with heterogeneity-corrected dose-volume prescription. Int J Radiat Oncol Biol Phys 2003;56: 1308–1318.

26 Verhaegen F, Seuntjens J: Monte Carlo modeling of external radiotherapy photon beams (topical review). Phys Med Biol 2003;48:R107–R164.

27 Fraass BA, Smathers J, Deye JA: Summary and recommendations of a National Cancer Institute workshop on issues limiting the clinical use of Monte Carlo dose calculation algorithms for megavoltage external beam radiation therapy. Med Phys 2003;30:3206–3216.
28 Cygler JE, Daskalov GM, Chan GH, et al: Evaluation of the first commercial Monte Carlo dose calculation engine for electron beam treatment planning. Med Phys 2004;31:142–153.
29 Brahme A: Optimized radiation therapy based on radiobiological objectives. Semin Radiat Oncol 1999;9:35–47.
30 Niemierko A: A generalized concept of equivalent uniform dose (EUD) (abstract). Med Phys 1999;26:1100.
31 Wu Q, Mohan R, Niemierko A, et al: Optimization of intensity-modulated radiotherapy plans based on the equivalent uniform dose. Int J Radiat Oncol Biol Phys 2002;52:224–235.
32 Jaffray DA, Drake DG, Moreau M, et al: A radiographic and tomographic imaging system integrated into a medical linear accelerator for localization of bone and soft-tissue targets. Int J Radiat Oncol Biol Phys 1999;45:773–789.
33 Jeraj R, Mackie TR, Balog J, et al: Radiation characteristics of helical tomotherapy. Med Phys 2004;31:396–404.
34 Mackie TR, Holmes T, Swerdloff S, et al: Tomotherapy: a new concept for the delivery of dynamic conformal radiotherapy. Med Phys 1993;20: 1709–1719.
35 Mackie TR, Kapatoes J, Ruchala K, et al: Image guidance for precise conformal radiotherapy. Int J Radiat Oncol Biol Phys 2003;56:89–105.
36 Welsh JS, Patel RR, Ritter MA, et al: Helical tomotherapy: an innovative technology and approach to radiation therapy. Technol Cancer Res Treat 2002;1:311–316.
37 Adler JR, Chang SD, Murphy MJ, et al: The CyberKnife: a frameless robotic system for radiosurgery. Stereotact Funct Neurosurg 1997;69: 124–128.
38 Martinez AA, Yan D, Lockman D, et al: Improvement in dose escalation using the process of adaptive radiotherapy combined with three-dimensional conformal or intensity-modulated beams for prostate cancer. Int J Radiat Oncol Biol Phys 2001;50:1226–1234.
39 Yan D, Ziaga E, Jaffray D: The use of adaptive radiation therapy to reduce setup error: a prospective clinical study. Int J Radiat Oncol Biol Phys 1998;41:715–720.
40 Yan D, Lockman D: Organ/patient geometric variation in external beam radiotherapy and its effects. Med Phys 2001;28:593–602.
41 Jakel O, Kramer M, Schulz-Ertner D, et al: Treatment planning for carbon ion radiotherapy in Germany: review of clinical trials and treatment planning studies. Radiother Oncol 2004;73(suppl 2):S86–S91.
42 Coleman CN: Linking radiation oncology and imaging through molecular biology (or now that therapy and diagnosis have separated, it's time to get together again!). Radiology 2003;228:29–35.
43 Purdy JA: Data management in radiation oncology. Semin Radiat Oncol 1997;7:1–94.
44 Purdy JA, Harms WB, Michalski JM, Bosch WR: Initial experience with quality assurance of multi-institutional 3D radiotherapy clinical trials. Strahlenther Onkol 1998;174(suppl II):40–42.
45 Zink S: 3D radiation treatment planning: NCI perspective; in Purdy JA, Emami B (eds): 3D Radiation Treatment Planning and Conformal Therapy. Madison, Medical Physics Publishing, 1995, pp 1–10.
46 Intensity Modulated Radiation Therapy Collaborative Working Group: Intensity-modulated radiation therapy: current status and issues of interest. Int J Radiat Oncol Biol Phys 2001;51: 880–914.
47 Vijayakumar S, Narayan S, Yang C, et al: Use of benchmark dose-volume histograms in radiotherapy treatment planning for prostate cancer; in Meyer JL (ed): Advances in the Treatment Planning and Delivery of Radiotherapy. Front Radiat Ther Oncol. Basel, Karger, 2006, vol 40, pp 180–192.
48 Purdy JA: Future directions in 3-D treatment planning and delivery: a physicist's perspective. Int J Radiat Oncol Biol Phys 2000;46:3–6.

Prof. James A. Purdy, PhD
Department of Radiation Oncology, UC Davis Medical Center
4501 X Street, Suite G140
Sacramento, CA 95816 (USA)
Tel. +1 916 734 3932, Fax +1 916 454 4614
E-Mail james.purdy@ucdmc.ucdavis.edu

The British Journal of Radiology, 79 (2006), S36–S49

Localization: conventional and CT simulation

G R BAKER, BSc, MSc, MIPEM

Kent Oncology Centre, Maidstone Hospital, Maidstone, Kent ME16 9QQ, UK

ABSTRACT. Recent developments in imaging and computer power have led to the ability to acquire large three dimensional data sets for target localization and complex treatment planning for radiation therapy. Conventional simulation implies the use of a machine capable of the same mechanical movements as treatment units. Images obtained from these machines are essentially two dimensional with the facility to acquire a limited number of axial slices to provide patient contours and tissue density information. The recent implementation of cone beam imaging on simulators has transformed them into three dimensional imaging devices able to produce the data required for complex treatment planning. The introduction of computed axial tomography (CT) in the 1970s was a step-change in imaging and its potential use in radiotherapy was quickly realised. However, it remained a predominantly diagnostic tool until modifications were introduced to meet the needs of radiotherapy and software was developed to perform the simulation function. The comparability of conventional and virtual simulation has been the subject of a number of studies at different disease sites. The development of different cross sectional imaging modalities such as MRI and positron emission tomography has provided additional information that can be incorporated into the simulation software by image fusion and has been shown to aid in the delineation of tumours. Challenges still remain, particularly in localizing moving structures. Fast multislice scanning protocols freeze patient and organ motion in time and space, which may lead to inaccuracy in both target delineation and the choice of margins in three dimensions. Breath holding and gated respiration techniques have been demonstrated to produce four-dimensional data sets that can be used to reduce margins or to minimize dose to normal tissue or organs at risk. Image guided radiotherapy is being developed to address the interfraction movement of both target volumes and critical normal structures. Whichever method of localization and simulation is adopted, the role of quality control is important for the overall accuracy of the patient's treatment and must be adapted to reflect the networked nature of the process.

Received 30 June 2005
Revised 28 February 2006
Accepted 1 March 2006

DOI: 10.1259/bjr/17748030

The development of the delivery of radiation therapy is closely related to the accuracy with which the target tumour can be located with respect to surrounding anatomical structures. In recent years, the increase in computing power and the development of refined computer graphics have resulted in the ability to perform complex treatment planning in three dimensions and to manipulate images in real time. Early simulators were machines capable of the same mechanical movements as treatment units and were used to confirm treatment set up rather than for localization [1, 2]. Simulators that were developed commercially in the 1960s had the addition of fluoroscopy that was used to set the isocentre with the aid of remotely controlled movements of the couch. Field portals adequate to encompass the target volume to be treated could also be set by remote adjustments to the field defining wires. The introduction of computed axial tomography (CT) scanning in the 1970s was a step change in the ability to define tumours in relation to normal anatomy, and over the ensuing years has been widely adopted in tumour localization. Today it may be used in conjunction with complex graphics software as a virtual simulator. However, the conventional simulator still retains its place in many radiotherapy departments for localization of some tumour sites, either as a result of lack of sufficient access to a CT scanner or for relatively simple techniques not requiring the production of a dose plan. The conventional simulator is also frequently used to verify the more complex treatment plans, producing an image corresponding to a beam's eye view (BEV) from the treatment planning system (TPS) or by verifying the isocentre location from orthogonal films.

Brief history

Mould [3] describes the development of simulation, from the use of diagnostic radiographs and skin marks in the 1950s to the introduction of virtual simulation in the 1980s. In 1973, Hounsfield and Ambrose [4, 5] published their work on computerized transverse axial tomography and the potential uses of CT in radiotherapy were quickly recognized [6]. However, access to a CT scanner was often very limited, and in many cases the scanner was not even in the same hospital as the treatment facilities. In addition, a CT scanner was principally a diagnostic tool with limitations for treatment planning imposed by the small aperture and the design of the

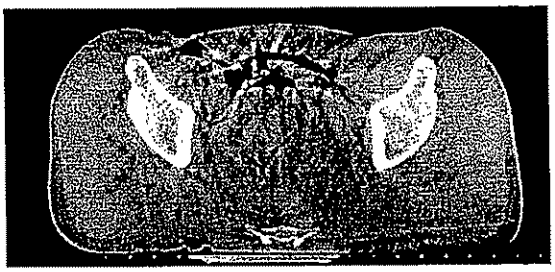
couch, which frequently prevented the patient from being scanned in the treatment position. Harrison and Farmer [7] recognized the usefulness of being able to acquire a cross-sectional image of the patient in the treatment position using a simulator as a CT scanner and went on to describe the implementation of their idea using a fluorescent screen and an Isocon camera [8]. A number of other adaptations of the simulator to produce cross-sectional images were also proposed at this time [9–12]. This functionality was called Sim-CT and became standard on simulators in the 1990s, but the system had its limitations:

1. The heat capacity of the X-ray tube generally meant that only a few slices could be scanned;
2. The time taken to scan was limited to approximately one revolution per minute, which introduced motion artefacts resulting in images that were of a poorer quality than those produced on a diagnostic scanner;
3. The uncertainty in the Hounsfield units (HU), which depends on the field of view and the phantom/patient size, a result of the beam hardening in the unfiltered X-ray beam from the simulator CT. However, the uncertainty in HU is translated into dose variation not exceeding 3% for photon beams in the range 6–18 MV [13];
4. The relatively high dose to the patient which was shown to be approximately 10 times that delivered with a diagnostic scanner under similar conditions [14].

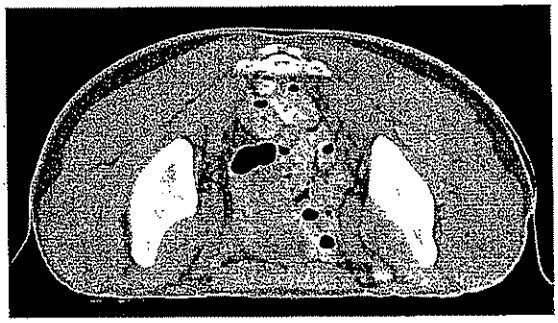
In spite of its limitations, the Sim-CT was a useful tool for planning in a department with limited access to a diagnostic scanner. It was a more accurate way of producing a patient outline than manual methods using callipers and flexicurves and enabled CT numbers to be converted to relative electron densities for tissue inhomogeneity corrections to be applied to a single CT slice in dose calculations. The dose distributions and monitor unit calculations showed good agreement with those obtained with diagnostic scan data [14].

In 1998, Cho et al [15] described the application of digital technology to a radiotherapy simulator in which the imaging system was replaced by a digital spot imager (DSI). The DSI consisted of an image intensifier, digital image processing, display and data transfer facilities. The images were stored during acquisition for later archiving or transfer to workstations. Simulator manufacturers now offer digital capabilities on their machines and conventional image intensifiers have been replaced by flat panel amorphous silicon (aSi) detectors. Their longevity in this application has to be proved and it is possible that the need for regular replacement may have significant revenue consequences. The most recent simulators include anatomical protocol selection, automatic correction for image distortion, last image hold, multileaf collimator (MLC) verification, a variety of image viewing and manipulation tools with annotation, image printing to film or paper, Digital Image Communications in Medicine (DICOM) export to TPS, electronic portal imaging device (EPID), record and verify, and patient management systems. The image manipulation tools enable adjustments to be made to field parameters and image quality on the last-held image, which reduces the screening time and hence patient dose compared with non-digital systems. A wide aperture (typically 90 cm) CT option is available. However, because of the restriction on gantry rotation speed, acquisition times are still slow and reconstruction time does not match that of a diagnostic scanner. In an attempt to overcome this, volume or cone beam CT (CBCT) has been developed. A number of authors describe cone beam reconstructions, based on Feldkamp's original back projection algorithm [16], for the acquisition of volumetric data [17–19].

When first proposed, the size of the detector was a severe limitation on the reconstruction volume and, although promising results were obtained, its use in treatment planning was not realised until aSi flat panel detectors of a reasonable size became available. Commercial systems are now available. For example, the Acuity (Varian, Palo Alto, CA) with cone beam option gives a cone of 17 cm at the isocentre but with added penumbra of 1.9 cm at either end regardless of the scan length. It is therefore not appropriate to acquire a single narrow slice. A single slice takes 45 s and 675 images are acquired per rotation. Early reports (private communications, A Vinall, K Venables, 2005) suggest that the geometric performance and image quality are adequate for radiotherapy planning purposes although the images are not of diagnostic quality. The rotation time of 45 s does, however, result in significant movement artefacts. Figure 1a shows the streaking that results from the movement of bowel gas during the acquisition of a CBCT scan compared with a CT planning scan.



(a)



(b)

Figure 1. (a) Movement artefacts on an axial slice of a CBCT scan as a result of movement of bowel gas. (b) An axial slice from a planning CT of the pelvis for comparison. (Courtesy of Varian Medical Systems, Palo Alto, CA and Memorial Sloan-Kettering Cancer Centre).

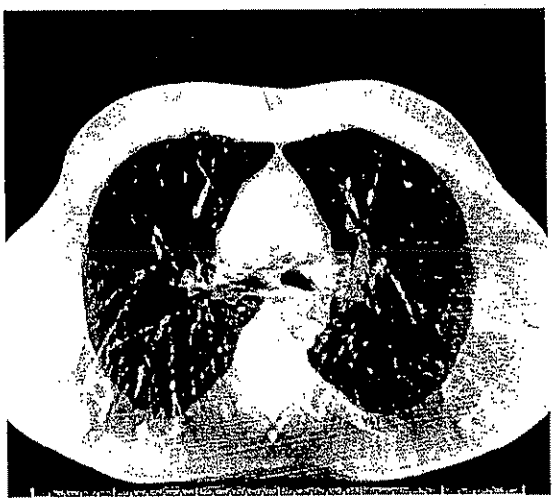


Figure 2. Movement artefacts on an axial slice from a CBCT acquired during normal breathing. (Courtesy of Varian Medical Systems and Hirslanden Klinik, Aarau).

Figure 2 shows similar streaking in the soft tissue around lungs in a CBCT taken during normal breathing. As with the single slice option on the simulator, there seem to be problems with the HU values both in accuracy compared with the calibration and reproducibility on a day-to-day basis. Slice thicknesses of 1–5 mm are available. Reconstruction times vary with the slice thickness and are in the order of 90 s. There is no standard way of quoting doses for these scans. Computed tomography dose index ($CTDI_w$) is a measure of the dose from a CT scan, weighted between the centre and the surface to give an average value across the section. A $CTDI_w$/810 mAs value of 15 mGy has been measured for a 10 cm scan length collimated to 13.8 cm (15 pulse s^{-1}, pulse length 15 ms, 80 mA, 125 kV, 45 s rotation). Setting the scan length to 1 cm in clinical mode gave 54 mGy/810 mAs with the same exposure factors. This compares with the national reference dose of 20 mGy for a multislice scanner [20].

CT simulation

The alternative to using the simulator and CBCT to acquire a volume data set of the patient in the treatment position was to modify CT scanners to meet the needs of radiotherapy and add software to perform the simulation function.

With the rapid development of computer technology, enabling fast reconstruction of images in three dimensions, the true value of the enormous quantity of data acquired by a CT scanner and its use in radiotherapy planning was recognized.

The development of the concept of the beam's eye view (BEV) into the transmission image from CT scans that would result from any beam orientation paved the way to producing images from CT data that correspond to conventional simulator films [21–23]. These digitally reconstructed radiographs (DRRs) could be overlaid with the outlines of anatomic structures, field shapes and cross wires, and hence could display images similar to simulator radiographs. However, the spatial resolution of DRRs is limited by the voxel size of the CT scans and cannot match that of a simulator radiograph taken with a small focal spot and a short exposure. Even in the early implementation of this process the reconstruction time of the DRRs was reasonable, being in the region of 10 s for a 50 slice study. However, studies were limited by the specification of the CT scanner. The acquisition of a single slice might take 2–3 s with a delay between scans required for repositioning of the scanner and tubes with low heat capacity needed cooling time during the scan [24].

Early critical analysis of the CT simulation process highlighted the areas for improvement [25]. These included the limitations imposed on both treatment technique and the size of the patient by the aperture of the scanner (normally 70 cm), the time required for CT data acquisition and transfer from the scanner to the planning system, time required for outlining and contouring target volume and critical structures and the inconsistent accuracy of portal marking on the patient's skin. Complete field ports were marked on the patient's skin in most cases and novel devices for doing this constituted an important part of the virtual simulation process reported. [26, 27]. These drawbacks have now largely been overcome.

Multislice helical scanning, with high heat capacity CT tubes, has reduced the time required to acquire a CT data set of 100 slices to a matter of seconds. Wide bore scanners have removed most of the constraints of patient size and technique. Increased computing capacity and speed allows for real time reconstruction of the slice images at the scanner and real time manipulation of images in the virtual simulation software. In addition, the DICOM protocol facilitates fast transfer of image data between systems.

Current practice

Conformal radiotherapy (CRT) is now accepted best practice for a number of treatment sites, having the advantages of sparing normal tissue and providing the opportunity for dose escalation. Intensity-modulated radiotherapy (IMRT) is the ultimate expression of this, but successful implementation of CRT and IMRT cannot be achieved without three-dimensional information on the location and extent of the target volume and the position of adjacent organs at risk (OAR). The three-dimensionality of virtual simulation is essential to visualize the coverage of the target volume and the avoidance of OARs in the highly complex treatment plans required for CRT and IMRT. For some sites, such as the lung where the relative position of the target and OARs varies with time, this fourth dimension needs to be taken into account.

Sherouse et al [28] introduced the term virtual simulation in 1987 to describe the process of using computer aided design and digitally reconstructed radiographs to replace the process of physical simulation. The process of virtual simulation has been described in detail by Aird and Conway [29] who also gave examples of its application to a number of different sites.

The specification of a CT simulator

The fundamental requirements of a CT simulator are a CT scanner with a flat couch, positioning lasers and virtual simulation software.

CT scanner

Advances in the design and capabilities of CT scanners have modified the specifications given by Aird and Conway [29]. Multislice scanners enable very fast scanning times, even for the large studies, with narrow slice thicknesses required for the production of good DRRs. High heat capacity anodes are required for the large datasets that are frequently required for treatment planning applications. One manufacturer (Siemens Medical, Erlangen, Germany) has introduced a new design of directly cooled anode that should eliminate delays due to anode heating and enable fast acquisition of scans with the large number of narrow slices required for good DRRs.

Three manufacturers now produce wide aperture (85 cm) scanners designed for radiotherapy applications. In two, the scanned field of view (SFOV) is 60 cm with an extended reconstructed FOV of 85 cm. It should be noted that in the extended reconstructed FOV the HU numbers may not be consistent with the SFOV. In reality, it is unlikely that the uncertainty in HU translates into a dose discrepancy of more that 1–2% in the target. The third manufacturer claims a true SFOV of 85 cm.

Positioning lasers

A system of three lasers for the accurate positioning and alignment of the patient is required. The lateral lasers may be wall or frame mounted, and may be either fixed or move in a vertical plane. The sagittal laser must be able to move laterally to account for lack of lateral movement on the CT couch. These lasers move under computer control to define the isocentre for the treatment plan in terms of shifts from the reference marks.

Virtual simulation software

The virtual simulation software may either be part of a treatment planning system or may be a stand-alone system. If the latter is chosen, it is essential that connectivity is easily established with the treatment planning system for dose calculation. Since the introduction of DICOM-RT this connectivity is more readily achievable, but the user must be aware that not all manufacturers interpret the standard in the same way and there are frequently hidden licensing issues associated with the connectivity. Essential features of virtual simulation software include automatic contouring of body outlines and semi-automatic contouring of other structures and critical organs such as spinal cord, kidneys and lungs. Particular attention should be paid to treatment of bifurcating structures. Contouring tools should be simple to use and interpolation between non-adjacent slices, with correction as necessary, should be provided to speed the contouring process. The ability to contour in three dimensions, *i.e.* in sagittal and coronal as well as axial sections, is particularly helpful. Figure 3 shows how three single contours in orthogonal planes produce a three dimensional structure. This functionality can considerably reduce the time taken to outline structures. The shape of the contours can be modified on any slice as necessary. Similar interpolation tools should be available for target volume delineation and true three-dimensional volume margin growth with different margin widths in different directions. Three-dimensional display systems are an essential feature of

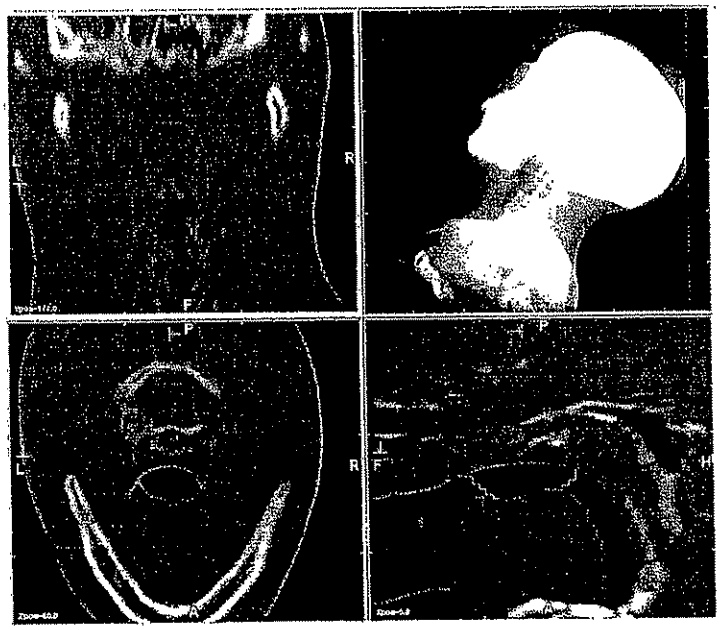


Figure 3. A single contour in axial sagittal and coronal planes defines a three dimensional target in Prosoma. (Courtesy of Oncology Systems Limited, Shrewsbury, UK and Medcom, Darmstadt, Germany).

any virtual simulation software. It should be possible to display axial, sagittal and coronal sections on the same screen and relate each section to the others, and to visualize the DRRs in the same window. An Observer's Eye View, with the patient on the couch and the floor and gantry angles depicted, is an aid to patient setup, as is a light-field displayed on the patient's skin related to skin marks or tattoos. Anti-collision software avoids planning a treatment field which it is physically impossible to reproduce in the treatment room. There are many different ways of rendering the target volume and OARs, but they should be unambiguous and should be rendered in three-dimensions so that coverage can be checked from all aspects. Optimization of MLC leaf positions and collimator angle should be available but adjustable by the planner. For treatment planning where a full dose distribution will not be calculated, a particularly useful feature is the calculation of the equivalent square of an irregular field, the parameter required for simple dose calculations. Increasingly, oncologists are using a number of other imaging modalities such as MRI (see Khoo and Joon in this issue) and positron emission tomography (PET) (see Jarritt et al in this issue) to help in determining target volumes. Most virtual simulation packages include an image fusion function enabling registration of two datasets of the same or different modalities, CT/CT, CT/MRI, CT/PET. Image registration and fusion may be achieved in a number of different ways, both manual and automatic (see Kessler in this issue). Irrespective of the algorithm, there is a variety of display modes to assist in performing and viewing the fusion, some of which are shown in Figure 4. Figure 4a shows the two data sets (MR and CT) fused with information from both sets displayed in the same window. The image can be "faded" between the two showing 100% of the primary data set (CT in this case) through to 100% of the secondary data set (MRI in this example). Figure 4b shows a split screen, with two quadrants displaying the CT data and two showing the MRI data. The point of intersection can be moved around the image to display the intersection at any position on the image. This will assist in delineating the structures using information from both data sets. Figure 4c shows a split screen with the secondary data set fused with the primary in the centre of the image and the primary image on either side. Contours outlining the target or OARs can be drawn on either data set or on the fused images in any of these display modes. These three screens show the fused images in the top three windows and the secondary data set in the lower windows. Figure 4d shows the region of discrepancy between the two fused data sets, in this case two CT studies, as areas of enhancement on the image. Improved localization of a brain tumour when CT and MRI data sets are fused compared with localization on CT alone for treatment planning is demonstrated in Figure 5.

Comparison of conventional and virtual simulation

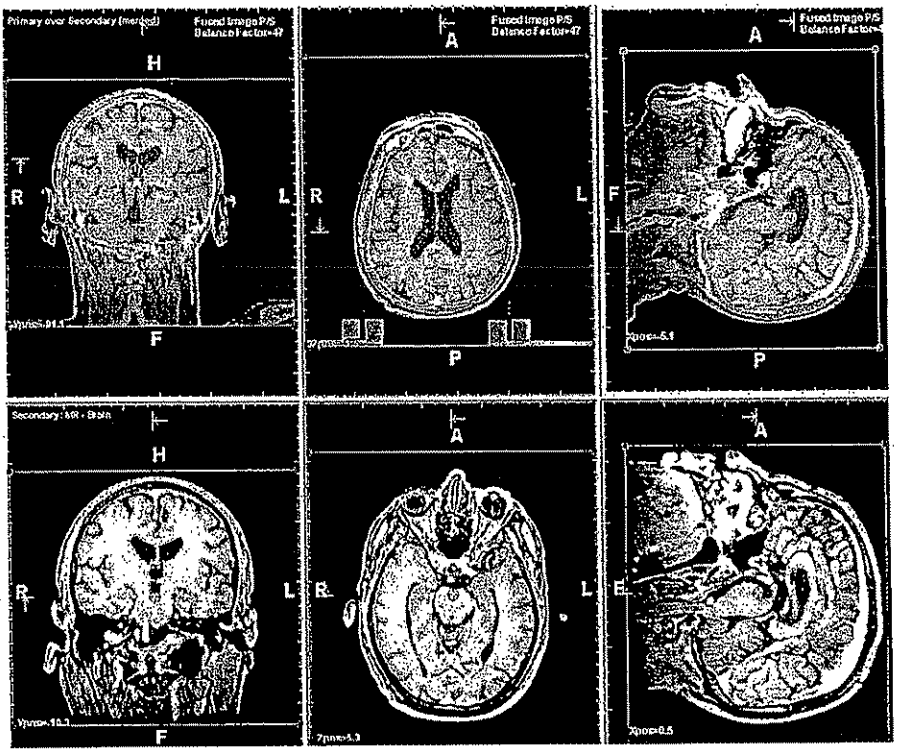
Conventional and virtual simulation approach the task of localizing the target volume for treatment planning in very different ways, which may result in significantly different treatments. Realisation of the steps performed to provide the data to a treatment planning system is compared for the two modalities in Table 1.

In comparing the two methods of simulation, the first question that arises is whether the two are comparable in terms of accuracy of the treatment set up. There are a number of studies addressing this question for different treatment sites. Bollet et al [30] showed that in a series of 20 patients who were CT scanned and had conventional simulation, the precision of set up evaluations using DRRs was similar to that using simulator films in conformal prostate treatments. They also considered whether errors were introduced at the simulation stage and found a statistically significant systematic error between DRRs and simulator, in both the craniocaudal direction and the anteroposterior direction. In another study of prostate patients Valicenti et al [31] showed that there was no statistically significant reduction in treatment setup error if patients have physical simulation following virtual simulation and concluded that physical simulation may be omitted if virtual simulation is available. In a study of 86 patients undergoing palliative radiotherapy for lung cancer using parallel opposed fields, McJury et al [32] found that setup errors were comparable between the group planned by virtual simulation and that planned using conventional simulation. Similar results are reported at different treatment sites [33–35]. In a detailed study of setup errors in 39 patients undergoing CT planned radiotherapy for lung cancer, de Boer et al [36] concluded that the setup errors introduced at simulation, which become systematic errors if the simulator film is used as the reference image, were comparable with systematic errors at the treatment unit. Hence, omission of the simulation stage would reduce systematic errors on treatment. This conclusion supported a similar result for prostate patients [37].

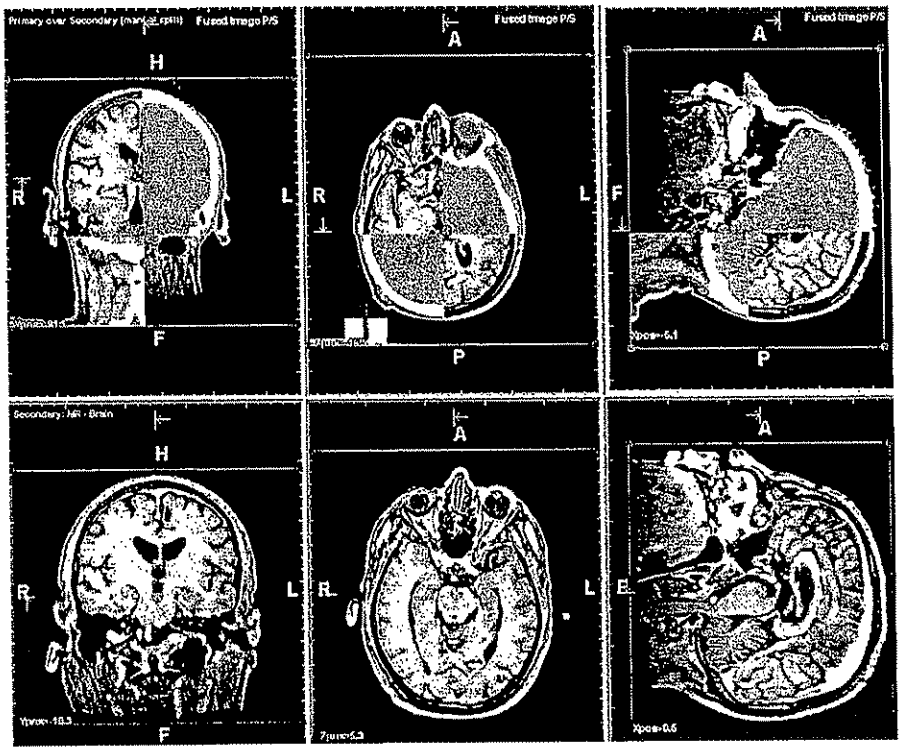
In comparing the two methods of simulation, studies have shown that the target volumes and field sizes are smaller for virtual than conventional simulation in lung cancer with the associated reduction in irradiation of normal tissue [32, 38]. Smaller field sizes have also been reported for maxillary cancer with a corresponding reduction in long-term side effects [39].

One of the perceived advantages of virtual simulation is the improved coverage of the gross tumour volume (GTV) and the avoidance of OARs as a result of better visualization of soft tissue structures on a CT scan compared with a simulator image, particularly if shielded by bone. This is aided by software functions that remove overlying structures, giving better definition of the region of interest. A study comparing conventional and virtual simulation in the treatment planning of malignant lymphoma showed incomplete coverage of the spleen and spleen hilus in 5 of 15 and 6 of 15 patients, respectively, on conventional simulation and incomplete coverage of the right and left hilus in 4 of 15 and 1 of 15 patients, respectively. In addition, the left kidney was inadequately shielded in 6 of 15 of the conventionally planned patients [40]. Similar improvements in target coverage and OAR avoidance are reported for other anatomical sites [41–44].

Improved visualization of soft tissue structures may bring to light hitherto unsuspected pathology. Mehta

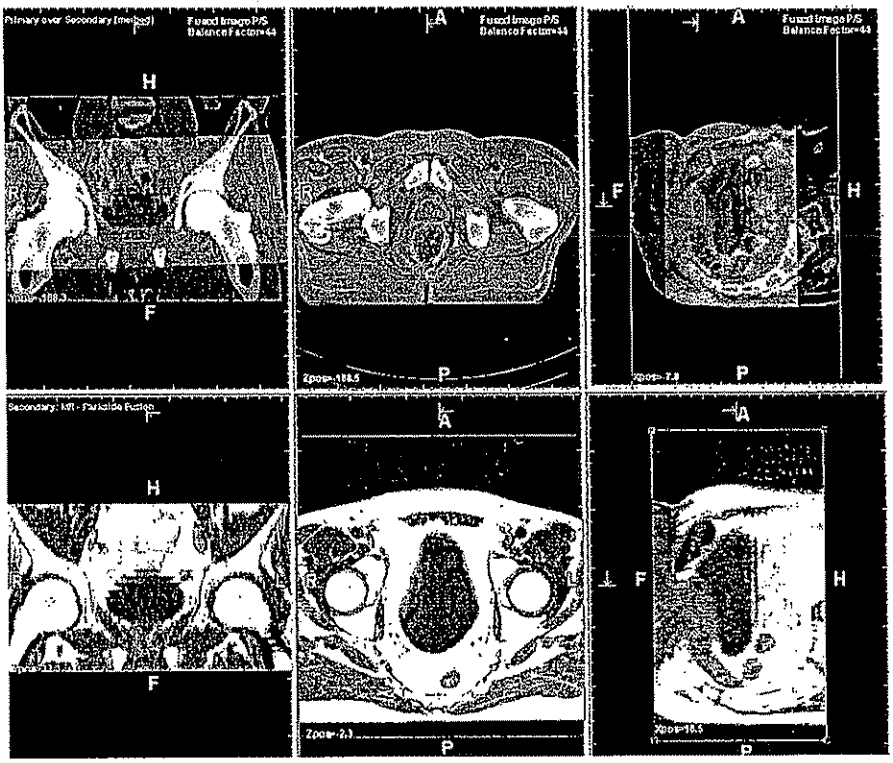


(a)

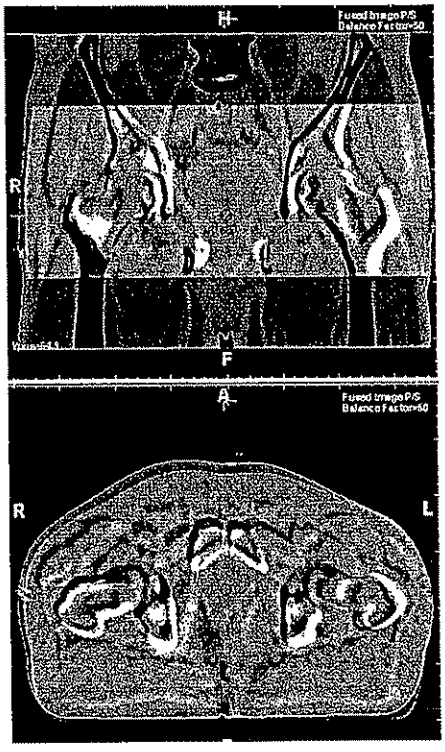


(b)

Figure 4. (a) Fusion of MRI and CT data sets, fused images in the top windows and MRI images below. (b) A split screen showing fusion between CT and MRI data sets in quadrants. (*Continued*)



(c)



(d)

Figure 4. (*Cont.*) (c) An alternative split screen representation of fusion between CT and MRI data sets. (d) Areas of mismatch between two CT data sets displayed as image enhancement. (Courtesy of OSL and Medcom).

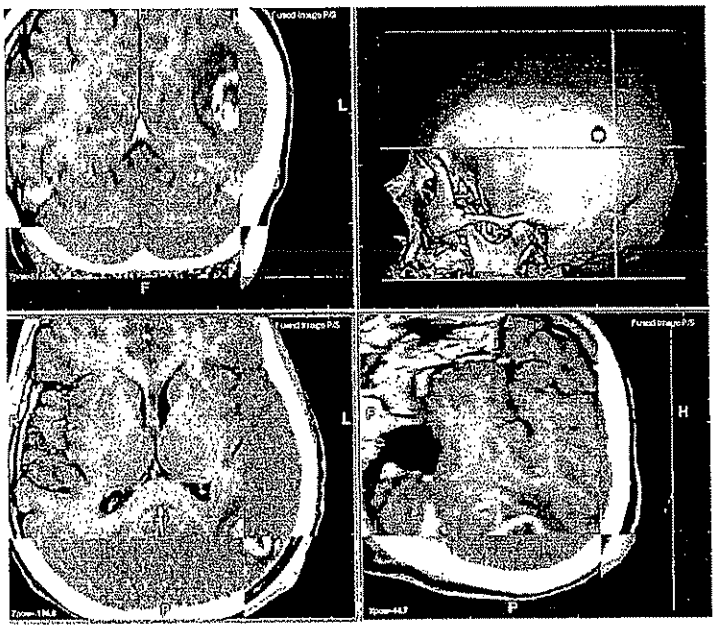


Figure 5. Improved localization of brain tumour using fused CT and MRI data sets. (Courtesy of OSL and Medcom).

and Goffinet [45] reported 17 unsuspected abnormalities in 153 scans (11%) obtained for treatment planning for patients referred for irradiation of the breast or chest wall. Of these, four represented disease that altered the treatment plan.

Working practices

The introduction of CT simulation has had a considerable impact on working practices in radiotherapy departments.

Oncologist attendance

The most notable change is that an oncologist is not required to be present during the scanning process. This releases the planning schedule from reliance on the oncologist's timetable, and the oncologists are free to undertake volume definition at a time convenient to them.

Time

A number of centres have reported on the different time allocation between conventional and virtual simulation [25, 28, 35]. Experience at the Kent Oncology Centre has shown that there is little difference in the total time needed for localization between the two modalities for the planning radiographers. With three radiographers in the scanning suite, 20 min appointments are adequate for most patients. Patients undergoing planning for breast radiotherapy are usually allocated 30 min because of the complex immobilization and positioning required with a narrow aperture scanner. These times are shorter than conventional simulation (30 min and 45 min, respectively), but more time is spent in manipulating the acquired data in the virtual simulation software. This includes the registering of reference marks and the production of DRRs for palliative patients, and outlining of target volumes and OARs for radical patients. Reduced simulation time for the patient leads to improved patient compliance, resulting in fewer problems from movement during scanning.

Table 1. Comparison of localization with CT and conventional simulation

Function	Conventional simulation	Virtual simulation
Patient alignment	Room lasers	Room lasers
Reference point definition	Skin markers	Skin markers
Localization	Fluoroscopy	CT scan
Definition of target and organs at risk	Drawing on plane films	Contouring on original or reconstructed slices
Isocentre	From simulator scales or film	DRR from CT
Field definition	From simulator scales or film	Virtual Sim
Patient outline	Manual/optical/single slice on Sim CT	Axial slice
Isocentre compared with reference point	Shifts measured on film	Calculated from Virtual Sim data
Treatment verification	Plane films	DRRs

DRR, digitally reconstructed radiograph.

Reference marks

In conventional simulation, using fluoroscopy for localization of the target volume, the isocentre can usually be established and marked at the time of simulation. In CT simulation, a reference point is chosen at the scanning session and the eventual isocentre is defined by movements of the couch from the reference point. If virtual simulation of palliative patients is undertaken with the patient remaining on the couch, the isocentre can be marked immediately from the couch movements indicated.

Verification

It has already been shown that to verify a plan on a conventional simulator after virtual simulation is not only unnecessary, but it could also be a source of systematic errors. However, treatment verification is still required and is of greater importance because of the use of reference marks. Verification takes place on the treatment unit with the electronic portal imaging system. The portal images acquired are then compared with the DRRs produced by the TPS or the virtual simulation software. For complex plans, this may require an extra treatment slot to allow time for the detailed comparison of portal images and DRRs before treatment.

Advantages and disadvantages of conventional and CT simulation

The advantages and disadvantages of conventional and CT simulation are summarized in Tables 2 and 3.

The availability of a three-dimensional dataset for all patients has some unexpected benefits. The increased information available may demonstrate previously unsuspected disease that may influence patient management. In palliative patients the extent of bone destruction from osteolytic lesions is easier to visualize on a CT scan than on a simulator film (Figure 6) and the use of software functions to remove overlying structures and display images optimized for different tissue types enables quicker localization of the disease. In breast planning, cardiac and lung volumes are more clearly demonstrated and therefore the fields can be adjusted or shielding employed accordingly.

One disadvantage of CT simulation is the increased patient dose. Doses for CT scanners are quoted as $CTDI_w$ with values in the region of 20 mGy. This dose is delivered to regions of normal healthy tissue as well as the tumour volume. Manufacturers of CT scanners provide various methods to reduce the total dose to the patient, taking account of the different dimensions of the patient at different levels and modulating the exposure in response to the detector measurements.

Some challenges still remain. Respiratory motion can affect the position of lung tumours and their relationship to OARs. Fast scanning protocols freeze patient and organ motion giving a snapshot view in time and space which may lead to inaccuracy in target delineation and choice of margins in three dimensions. Imaging techniques to overcome this drawback are an area of active investigation. The conventional method of treatment planning for lung tumours is to use fluoroscopic imaging to determine the maximum migration of the tumour during respiration and adopt large margins around the CTV to ensure that the target remains in the high dose region throughout the breathing cycle. A similar philosophy can be adopted by performing scans at deep inhale and deep exhale [46]. However, a number of other techniques have been suggested involving breath holding and respiratory gating techniques [47]. Deep inspiration breath hold (DIBH) increases the lung volume relative to normal breathing and hence the total volume of lung irradiated will be reduced using this technique [48]. In some patients, DIBH may displace the tumour away from OARs [49], which has the potential for dose escalation to the target for the same level of toxicity to OARs. Gated respiration techniques may either be active or passive. In active breathing control (ABC), the patient is prevented from breathing at a given part of the respiratory cycle during which the scan is performed and subsequent treatment takes place. By acquiring a number of scans at different parts of the breathing cycle, motion of the organ in three-dimensions can be demonstrated. Passive techniques allow the patient to breathe normally and a surrogate for the respiratory induced motion, such as the movement of the anterior chest wall, is monitored. Images obtained from CT scans are sorted according to respiratory phase to produce a 4D CT data set [50–52].

Table 2. Advantages and disadvantages of CT simulation

Advantages	Disadvantages
Three-dimensional dataset available, resulting in better visualization of tumour and nodal involvement, leads to reduction in side effects	Organ motion not visualized
Reduced simulation time leads to improved patient compliance	Repeat scan required for changes in patient set-up/shape/size during treatment
One fewer patient visit during planning	Palliative patients may spend longer in department between scanning and treatment
Oncologist not required during scanning	Transfer of verification to treatment unit may require extra treatment slot
Reduced transfer inaccuracies by omitting conventional simulator verification	Some patients/techniques may not be suitable for small aperture scanners (availability of wide aperture scanners should eliminate this problem)
Can simulate non-coplanar fields	Data storage
	Higher patient doses

Table 3. Advantages and disadvantages of conventional simulation

Advantages	Disadvantages
Fluoroscopy gives idea of organ motion	Difficult to visualize some tumours, especially if overlaid by bone (e.g. mediastinal lesions)
High spatial resolution	Limited three-dimensional information, even with CT option. Therefore cannot plan conformal or IMRT (cone beam may improve this)
Field visualization on patients skin	Two patient appointments required, localization and verification
	Difficult or impossible to simulate non-coplanar treatment fields

IMRT, intensity-modulated radiotherapy.

Breath hold and ABC techniques both require the co-operation of the patient and are therefore not appropriate for all patients. Some verbal or visual coaching helps to maintain regular breathing.

An alternative approach to the problem of organ motion is suggested by Murphy [53] who describes the real-time tracking of moving organs. Tracking respiratory motion is a complex procedure as it involves fast movement of organs relative to each other. For real-time tracking to be successful, the system must be able to locate the target, predict the motion to account for any time delays in repositioning the beam and adapt the treatment plan to allow for the change in relative positions of target and OARs. Although respiratory motion appears fairly regular, there are changes in amplitude and period from one cycle to the next which make prediction complicated. Murphy discusses two ways of predicting respiratory movement, by developing a mathematical model and by using an empirical algorithm that is based on measurements of previous breathing cycles. The technical challenges of fast response times to organ motion in continuous real time tracking are presented, but Murphy suggests that in the future it should be possible to treat lung tumours in some patients during free breathing, without needing to include movement margins in the treatment plan.

Respiratory correlation techniques developed to minimize motion artefacts in axial and helical scanning are not applicable to CBCT and different techniques have been developed for the CB application. Sonke et al [54] describe a method for sorting the projections into different phases of the breathing cycle to produce a 4D CBCT scan. Sillanpaa et al describe a method of acquiring megavoltage cone beam CT projection images at the same phase of breathing at all acquisition angles, giving a three-dimensional reconstruction at a single breathing phase [55]. It must be emphasised that gated respiration techniques must be employed at both the localization stage and during treatment.

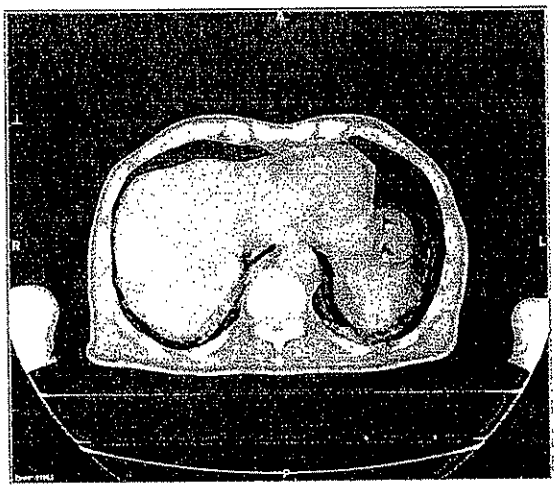


Figure 6. Osteolytic lesion of the spine.

Quality assurance

The accuracy of both conventional and CT simulation has a crucial effect on the overall accuracy of the patient's treatment. Whereas the accuracy of conventional simulation relies mainly on geometric features such as gantry and collimator angles and field defining wire positions, that of CT simulation depends on the image obtained by the scanner and the faithful transfer to the virtual simulation software. This connectivity should be part of any quality assurance (QA) programme.

A detailed description of quality control tests in conventional simulation and their recommended frequency is given by Tuohy [56].

Virtual simulation forms part of the network of the radiotherapy department, the end result of which is the treatment of the patient. The QA of this network should be seen as a process to which the various components of the hardware and software contribute. Guidance for the QA of a networked radiotherapy department is due to be published soon [57]. A QA programme should be established that reflects the importance of the contribution of each component of the system to the accuracy of the patient's treatment. Some components will be checked daily, such as the alignment of the lasers, the accuracy of positioning of any moving lasers and the HU accuracy for water. Others may be checked monthly, annually or after significant upgrades to the system. Special phantoms have been designed to assist with various aspects of QA [58, 59]. The Kent Oncology Centre has produced its own phantom that incorporates checks for a number of parameters in one scan study. These include spatial resolution, HU number, slice thickness, alignment and geometric accuracy.

Mutic et al [60] provide a comprehensive guide to the QA of CT simulators. They stress the need for audit and review of the process and flexibility in the programme as CT simulation evolves.

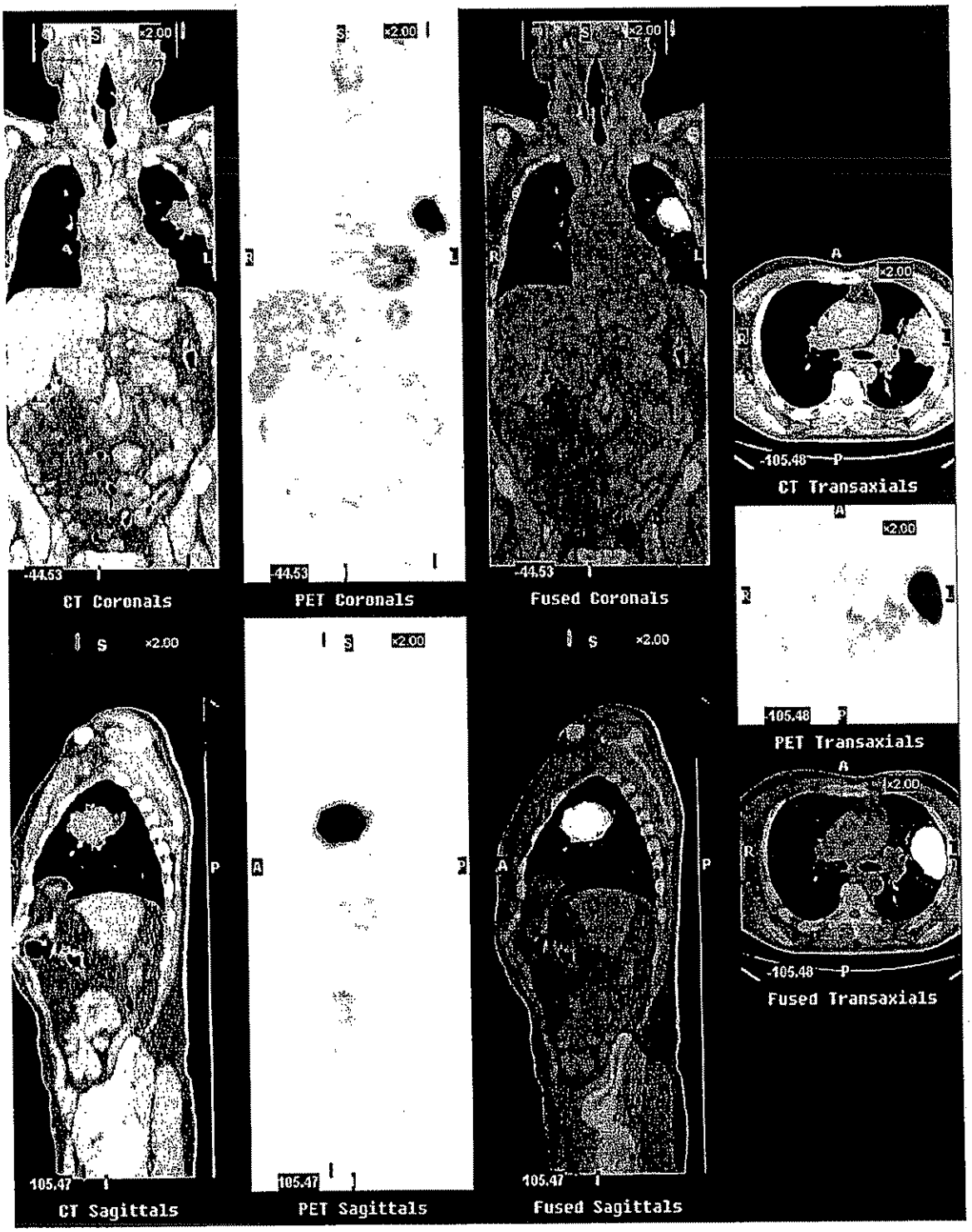


Figure 7. Fusion of positron emission tomography (PET) and CT images from a CT/PET scanner to localize a left lung tumour.

The future

The aim of radiotherapy is to deliver a tumoricidal dose of radiation to the clinical target volume (CTV) whilst sparing normal tissue and critical organs as far as possible. Localization is aimed at answering the question "where is the target?" The gross tumour volume (GTV) is neither a simple line nor an unchanging volume. It is an oncological concept and will vary according to the imaging technique or techniques used, any additional clinical data available and the judgement of the clinician. Each imaging modality displays different information about the GTV. Traditionally, delineation of the GTV has been associated with an anatomical abnormality that is imaged by plane radiography, CT or in some cases MRI. This gives structural, not functional information. However, molecular and physiological imaging techniques are now available which give an indication of the functional state of the tissues. This information can potentially be used in addition to CT and MRI to assist in defining clinically relevant targets more accurately [61]. Ling et al [62] proposed treating a biological target volume defined from anatomical, physiological and/or molecular images. For example, increased glycolysis is a function of a tumour and fluorine-18 fluorodeoxyglucose positron emission tomography (^{18}FDG-PET) studies have been used as an addition to CT for planning patients with poorly defined non-small cell lung cancer (NSCLC) [63, 64], head and neck cancers [65] and malignant gliomas [66] (see Jarritt et al in this issue). Figure 7 shows the fused images from ^{18}FDG-PET and CT acquired in a single session on a PET/CT scanner. The lesion in the left lung is clearly demonstrated in both modalities in this example. Other PET agents may be used to identify areas of hypoxia within a tumour that may benefit from higher doses of radiation such as can be delivered by IMRT. Similar inhomogeneous dose distributions may be applied to regions of the prostate demonstrating a high choline:citrate ratio, indicating a region of active tumour, as demonstrated on MR spectroscopy [67] (see Payne and Leach in this issue). Modalities such as functional MRI (fMRI) and single photon emission computed tomography (SPECT) may also be used to assist in GTV and OAR delineation. SPECT perfusion studies for NSCLC can be used in treatment planning to provide information on normal lung tissue and help to reduce the volume of normal lung irradiated [68].

Imaging techniques are continually evolving and as they are refined they will reveal more information about the disease to be treated. Collaboration between radiologists and oncologists will be essential if the information contained within these new images is to be maximized for the benefit of the patient.

No consideration of the future of radiation therapy would be complete without mention of image guided radiotherapy (IGRT). IGRT aims to address the interfraction movement of tumours and their relationship to OARs. Of the linear accelerator manufacturers, both Elekta (Crawley, Sussex, UK) and Varian (Palo Alto, CA) provide kilovoltage cone beam CT (CBCT) on the gantry and Siemens (Erlangen, Germany) have installed a CT scanner on rails in the treatment room (see Moore et al and Thieke et al, respectively, in this issue).

These imaging devices provide the ability to localize the tumour immediately prior to treatment and to reposition the patient to correct for interfraction variation in tumour position. Wong et al [69] describe the use of daily scans in the treatment room to reposition prostate patients for the final phase of their treatment. 46% required no isocentre adjustment in the anterior–posterior direction, but 44% required a shift of greater than 5 mm. In the superoinferior direction, 25% required a shift greater than 5 mm and in left-right direction 24% required a shift greater than 5 mm. The shifts were associated with significant changes in the dosimetry. Other authors describe the implementation of CBCT for IGRT [54, 70, 71].

IGRT is a rapidly evolving field and will undoubtedly have implications for treatment planning.

Conclusion

Both conventional and virtual simulation have developed in line with the changes in imaging techniques over recent years. The anticipated advantages of virtual simulation have been realised to a great extent and have changed the work flow in treatment planning. The availability of wide bore scanners enables most treatment techniques to be imaged. Fast computer graphics that have reduced image reconstruction times enable the acquisition of large data sets that can be manipulated for respiratory correlated techniques. The rapid development of biological imaging holds the prospect of multimodality localization, which is already being realised for some disease sites such as lung and prostate. The addition of cone beam CT to conventional simulators may add flexibility to departments with both a scanner and a simulator. However localization is achieved, it must be considered as part of the overall process that leads to treatment. The accuracy of the data acquisition and transfer is vital to this process and a comprehensive QA programme is essential.

I would like to thank Dr Ruth Beddows for the design of the Kent Oncology Centre phantom, Ms Alison Vinall and Ms Karen Venables for reports on cone beam CT, David Hill for assistance with image processing and colleagues for discussions during the preparation of this manuscript.

References

1. Farmer F, Fowler J, Haggith J. Megavoltage treatment planning and the use of xerography. Br J Radiol 1963;36:426–35.
2. Greene D, Nelson K, Gibb R. The use of a linear accelerator in radiotherapy. Br J Radiol 1964;37:394–7.
3. Mould R. From conventional to virtual simulation: a historical vignette. In: Mould RF, editor. Progress in CT-3D simulation. Bochum, Germany: Medintec, 2003:156–62.
4. Hounsfield G. Computerised transverse axial scanning (tomography) Part 1. Description of the system. Br J Radiol 1973;46:1016–22.
5. Ambrose J. Computerised transverse axial scanning (tomography) Part 2. Clinical application. Br J Radiol 1973;46:1023–47.
6. Dobbs H, Parker R. The respective roles of the simulator & CT in RT planning: a review. Clin Radiol 1984;35:433–9.

7. Harrison R, Farmer F. Possible application of a radiotherapy simulator for imaging of body cross sections. Br J Radiol 1976;49:813.
8. Harrison R, Farmer F. The determination of anatomical cross sections using a radiotherapy simulator. Br J Radiol 1978;51:448–53.
9. Webb S, Lillicrap S, Steere H, Speller R. Application of a radiotherapy simulator for imaging of body cross sections. Br J Radiol 1977;50:150–3.
10. Kotre C, Harrison R, Ross W. A simulator based CT system for radiotherapy treatment planning. Br J Radiol 1984;57:631–5.
11. Redpath A, Wright D. The use of an image processing system in radiotherapy simulation. Br J Radiol 1985;58:1081–9.
12. Arnot R, Willets R, Batten J, Orr J. Investigations using an x-ray image intensifier and a TV camera for imaging transverse sections in humans. Br J Radiol 1984;57:47–55.
13. Chu J, Ni B, Kriz R, Saxena A. Applications of simulator computed tomography number for photon dose calculations during radiotherapy treatment planning. Radiother Oncol 2000;55:65–73.
14. Verellen D, Vinh-Hung V, Bijdekerke P, Nijs F, Linthout N, Bel A, et al. Characteristics and clinical application of a treatment simulator with CT-option. Radiother Oncol 1999;50:355–66.
15. Cho P, Lindsley K, Douglas J, Stelzer K, Griffin T. Digital radiotherapy simulator. Comput Med Imag Graph 1998;22:1–7.
16. Feldkamp L, Davis L, Kress J. Practical cone beam algorithm. J Opt Soc Am 1984;1:612–9.
17. Cho P, Griffin T. Single scan volume CT with a radiotherapy simulator. Med Phys 1993;20:1292.
18. Mosleh-Shirazi M, Evans P, Swindell P, Webb S, Partridge M. A cone beam megavoltage CT scanner for treatment verification in conformal radiotherapy. Radiother Oncol 1998;48:319–28.
19. Midgley S, Millar R, Dudson J. A feasibility study for megavoltage cone beam CT using a commercial EPID. Phys Med Biol 1998;43:155–69.
20. Shrimpton P, Hillier M, Lewis M, Dunn M. Doses from computed tomography (CT) examinations in the UK – 2003 Review. Didcot, UK: National Radiological Protection Board, 2005.
21. McShan D, Fraass B, Lichter A. Full integration of the beam's eye view concept into computerised treatment planning. Int J Radiat Oncol Biol Phys 1990;18:1485–94.
22. Sherouse G, Novins K, Chaney E. Computation of digitally reconstructed radiographs for use in radiotherapy treatment design. Int J Radiat Oncol Biol Phys 1990;18:651–8.
23. Goitein M, Abrams M, Rowell D, Pollari H, Wiles J. Multi-dimensional treatment planning II. Beam's eye view back projection and projection through CT sections. Int J Radiat Oncol Biol Phys 1983;9:789–97.
24. Galvin J, Sims C, Dominiak G, Cooper J. The use of DRRs for three dimensional treatment planning and CT simulation. Int J Radiat Oncol Biol Phys 1995;31:935–42.
25. Perez C, Purdy JA, Harms W, Gerber R, Matthews J, Grigsby P, et al. Design of a fully integrated 3 dimensional computed tomography simulator and prelimary clinical evaluation. Int J Radiat Oncol Biol Phys 1994;30:887–97.
26. Nishidai T, Nagata Y, Takahashi M, Abe M, Yamaoka N, Ishihara H, et al. CT simulator: a new 3-D planning and simulation system for radiotherapy. 1. Description of system. Int J Radiat Oncol Biol Phys 1990;18:499–504.
27. Ragan D, Forman J, He T, Mesina C. Clinical results of computerised tomography based simulation with laser patient marking. Int J Radiat Oncol Biol Phys 1996;34:691–5.
28. Sherouse G, Mosher C, Novins K, Rosenman J, Chaney E. Virtual simulation: concept and implementation. In: Bruinvis IAD, Van der Geissen PH, Van Kleffens HJ, Wittkamper FW, editors. Proceedings of the Ninth International Conference on the use of computers in Radiation Therapy, Amsterdam, The Netherlands. North Holland Publishing Co. 1987:433–6.
29. Aird E, Conway J. CT Simulation for radiotherapy treatment planning. Br J Radiol 2002;75:937–49.
30. Bollet M, McNair H, Hansen V, Norman A, O'Doherty V, Taylor H, et al. Can digitally reconstructed radiographs replace simulation films in prostate cancer conformal radiotherapy? Int J Radiat Oncol Biol Phys 2003;57:1122–30.
31. Valicenti R, Waterman F, Corn B, Curran W. A prospective, randomised study addressing the need for physical simulation following virtual simulation. Int J Radiat Oncol Biol Phys 1997;39:1131–5.
32. McJury M, Fisher P, Pledge S, Brown G, Anthony C, Hatton M, et al. The impact of virtual simulation in palliative radiotherapy for non-small cell lung cancer. Radiother Oncol 2001;59:311–8.
33. Horst E, Schuck A, Moustakis C, Shaefer V, Micke O, Kronholz H, et al. CT simulation in nodal positive breast cancer. Strahlenth und Onkol 2001;177:511–6.
34. Schiebe M, Hoffman W. CT based virtual simulation using the advantage Sim 4.1 system. Description of reliability and accuracy. Strahlenth und Onkol 2000;176:377–80.
35. Buchali A, Geismar D, Hinkelbein M, Shlenger L, Zinner K, Budach V. Virtual simulation in patients with breast cancer. Radiother Oncol 2001;59:267–72.
36. de Boer HJ, Van Sorensen de Koste J, Senan S, Vissier AG, Heijmen B. Analysis and reduction of 3D systematic and random setup errors during the simulation and treatment of lung cancer patients with CT based external beam radiotherapy dose planning. Int J Radiat Oncol Biol Phys 2001;49:857–68.
37. Bel A, Bartelink H, Vijlbrief R, Lebesque J. Transfer errors of planning CT to simulator: a possible source of setup inaccuracies? Radiother Oncol 1994;31:176–80.
38. Senan S, Van Sorensen de Koste J, de Boer J, et al. The use of CT simulation in digitally reconstructed radiographs (DRRs) in setup verification allows for smaller planning target volumes in lung cancer. Lung Cancer 2000;20 (Suppl. 1):162.
39. Nagata Y, Okajima K, Murata R, Mitsumori M, Mizowaki T, Tsutsui K, et al. Three-dimensional treatment planning for maxillary cancer using a CT simulator. Int J Radiat Oncol Biol Phys 1994;30:979–83.
40. Dinges S, Koswig S, Buchali A, Wurm R, Schlenger L, Bohmer D, et al. Comparison of conventional and virtual simulation for radiation treatment planning of malignant lymphoma. Strahlenth und Onkol 1998;174(Suppl. II):28–30.
41. Nishioka T, Shirato H, Arimoto T, Kaneko M, Kitahara T, Oomori K, et al. Reduction of radiation induced xerostomia in nasopharyngeal carcinoma using CT simulation with laser patient marking and three field irradiation technique. Int J Radiat Oncol Biol Phys 1997;38:705–12.
42. Gripp S, Doeker R, Glag M, Vogelsang P, Bannach B, Doll T, et al. The role of CT simulation in whole brain irradiation. Int J Radiat Oncol Biol Phys 1999;45:1081–8.
43. Driver D, Drzymala M, Dobbs H, Faulkner S, Harris S. Virtual simulation in palliative lung radiotherapy. Clin Oncol 2004;16:461–6.
44. Chao M, Gibbs P, Tjandra J, Darben P, Lim-Joon D, Jones IT. Evaluation of the use of computed tomography versus conventional orthogonal x-ray simulation in the treatment of rectal cancer. Australas Radiol 2005;49:122.
45. Mehta V, Goffinet D. Unsuspected abnormalities noted on CT treatment planning scans obtained for breast and chest wall irradiation. Int J Radiat Oncol Biol Phys 2001;49:723–5.
46. Shih H, Jiang S, Aljarrah K, Doppke K, Choi N. Internal target volume determined with expansion margins beyond

composite gross tumor volume in three dimensional conformal radiotherapy for lung cancer. Int J Radiat Oncol Biol Phys 2004;60:613–22.
47. Mageras G, Yorke E Deep inspiration breath hold and respiratory gating strategies for reducing organ motion in radiation treatment. Semin Radiat Oncol 2004;14:65–75.
48. Rosenzweig K, Hanley J, Mah D. The deep inspiration breath hold technique in the treatment of inoperable non small cell lung cancer. Int J Radiat Oncol Biol Phys 2000;48:81–7.
49. Stromberg J, Sharpe M, Leonard H. Active breathing control (ABC) for Hodgkin's disease: reduction in normal tissue irradiation with deep inspiration and implications for treatment. Int J Radiat Oncol Biol Phys 2000;48:797–806.
50. Ford E, Mageras G, Yorke E, Ling C. Respiration correlated spiral CT: a method of measuring respiratory induced anatomic motion for radiation treatment planning. Med Phys 2003;30:88–97.
51. Pan T, Lee T, Rietzel E, Chen G. 4D-CT imaging of a volume influenced by respiratory motion on multi-slice CT. Med Phys 2004;31:333–40.
52. Vedam S, Keall P, Kini V, Mostafavi H, Shukla H, Mohan R. Acquiring a four dimensional computed tomography dataset using an external respiratory signal. Phys Med Biol 2003;48:45–62.
53. Murphy M. Tracking moving organs in real time. Semin Radiat Oncol 2004;14:91–100.
54. Sonke J, Zijp L, Remeijer P, van Herk M. Respiratory correlated cone beam CT. Med Phys 2005;32:1176–86.
55. Sillanpaa J, Chang J, Mageras G, Riem H, Ford E, Todor D. Developments in megavoltage cone beam CT with an amorphous silicon EPID: reduction of exposure and synchronisation with respiratory gating. Med Phys 2005;32:819–29.
56. Tuohy JB. Radiotherapy imaging devices: treatment simulators. In: Mayles WPM, Lake R, McKenzie A, Macaulay EM, Morgan HM, Jordan TJ, et al. Physics aspects of quality control in radiotherapy. York, UK: Institute of Physics and Engineering in Medicine, 1999:34–43.
57. Kirby M, Carpenter D, Lawrence G, Poynter A, Studdart P. Guidance for the commissioning and quality assurance of a networked radiotherapy department. A report produced by the Institute of Physics and Engineering in Medicine working party. In Press.
58. McGee K, Das I, Sims C. Evaluation of digitally reconstructed radiographs (DRRs) used for clinical radiotherapy: a phantom study. Med Phys 1995;22:1815–27.
59. Craig T, Brochu D, Van Dyke J. A quality assurance phantom for three dimensional radiation treatment planning. Int J Radiol Oncol Biol Phys 1999;44:955–66.
60. Mutic S, Palta JR, Butker E, Das I, Huq M, Loo LD, et al. Quality assurance for computed-tomography simulators and the computed-tomography-simulation process: Report of the AAPM Radiation Therapy Committee Task Group No.66. Med Phys 2003;30:2762–92.
61. Apisarnthanarax S, Chao K. Current imaging paradigms in radiation oncology. Radiat Res 2005;163:1–25.
62. Ling C, Humm J, Larsan S, Amols H, Fuks Z, Liebel S, et al. Towards multidimensional radiotherapy (MD-CRT) biological imaging and biological conformality. Int J Radiat Oncol Biol Phys 2000;47:551–60.
63. Mah K, Caldwell C, Ung Y, Danjoux C, Balogh J, Ganguli N, et al. The impact of ^{18}FDG-PET on target and critical organs in CT based treatment planning of patients with poorly defined non small cell lung cancer: a prospective study. Int J Radiat Oncol Biol Phys 2002;52:339–50.
64. Bradley J, Thorstad W, Mutic S, Miller T, Dehdashti F, Siegel B, et al. Impact of ^{18}FDG-PET on radiation therapy volume delineation in non-small-cell lung cancer. Int J Radiat Oncol Biol Phys 2004;59:78–86.
65. Heron D, Andrade R, Flickinger J, Johnson J, Agarwala S, Wu A, et al. Hybrid PET-CT simulation for radiation treatment planning in head and neck cancers. A brief technical report. Int J Radiat Oncol Biol Phys 2004;60:1419–24.
66. Gross M, Weber W, Feldman H, Bartenstein P, Schwaiger M, Molls M. The value of ^{18}FDG-PET for the 3-D radiation treatment planning of malignant gliomas. Int J Radiat Oncol Biol Phys 1998;41:989–95.
67. Beasley M, Driver D, Dobbs H. Complications of radiotherapy: improving the therapeutic index. Cancer Imaging 2005;5:78–84.
68. Munley M, Marks L, Scarfone C, Sibley G, Patz E, Turkington T, et al. Multimodality nuclear medicine imaging in three dimensional radiation treatment planning for lung cancer: challenges and prospects. Lung Cancer 1999;23:105–14.
69. Wong J, Grimm L, Uematsu M, Oren R, Cheng C, Merrick S, et al. Image guided radiotherapy for prostate cancer by CT linear accelerator combination: prostate movements and dosimetric considerations. Int J Radiat Oncol Biol Phys 2005;61:561–9.
70. Sykes J, Amer A, Czajka J, Moore C. A feasibility study for image guided radiotherapy using low dose, high speed cone beam x-ray volumetric imaging. Radiother Oncol 2005;77:45–52.
71. Jaffray D, Siewerdsen J, Wong J, Martinez A. Flat panel cone beam computed tomography for image guided radiation therapy. Int J Radiat Oncol Biol Phys 2002;53:1337–49.

Int. J. Radiation Oncology Biol. Phys., Vol. 64, No. 1, pp. 205–209, 2006

0360-3016/06/$–see front matter

ELSEVIER

doi:10.1016/j.ijrobp.2005.06.025

CLINICAL INVESTIGATION **Cervix**

USE OF CT SIMULATION FOR TREATMENT OF CERVICAL CANCER TO ASSESS THE ADEQUACY OF LYMPH NODE COVERAGE OF CONVENTIONAL PELVIC FIELDS BASED ON BONY LANDMARKS

MARISA H. FINLAY, M.D.,* IDA ACKERMAN, M.D.,* ROMEO G. TIRONA, B.SC.,† PAUL HAMILTON, M.D.,‡ LISA BARBERA, M.D.,* AND GILLIAN THOMAS, M.D.*

Departments of *Radiation Oncology, †Medical Physics, and ‡Radiology, Toronto Sunnybrook Regional Cancer Centre, Sunnybrook and Women's College Health Sciences Centre, University of Toronto, Toronto, Ontario, Canada

Purpose: To assess the adequacy of nodal coverage of "conventional" pelvic radiation fields for carcinoma of the cervix, with contoured pelvic vessels on simulation computed tomography (CT) as surrogates for lymph node location.

Methods and Materials: Pelvic arteries were contoured on non–contrast-enhanced CT simulation images of 43 patients with cervix cancer, FIGO Stages I–III. Vessel contours were hidden, and conventional pelvic fields were outlined: (*1*) anterior/posterior fields (AP): superior border, L5–S1 interspace; inferior border, obturator foramina; lateral border, 2 centimeters lateral to pelvic brim. (*2*) Lateral fields (LAT): Anterior border, symphysis pubis; posterior border, S2–S3 interspace. Distances were measured between the following: (*1*) bifurcation of the common iliac artery and superior border, (*2*) external iliac artery and lateral border of the AP field, and (*3*) external iliac artery and anterior border of the LAT field. The distances were considered as "inadequate" if <15 mm, "adequate" if 15–20 mm, and "generous" if >20 mm.

Results: Superiorly, 34 patients (79.1%) had inadequate coverage. On the AP, margins were generous in 19 (44.2%), but inadequate in 9 (20.9%). On the LAT, margins were inadequate in 30 (69.8%) patients. Overall, 41 (95.4%, CI, 84.2%–99.4%) patients had at least 1 inadequate margin, the majority located superiorly. Twenty-four (55.8%; CI, 39.9%–70.9%) patients had at least 1 generous margin, the majority located laterally on the AP field.

Conclusion: Conventional pelvic fields based on bony landmarks do not provide optimal lymph node coverage in a substantial proportion of patients and may include excess normal tissue in some. CT simulation with vessel contouring as a surrogate for lymph node localization provides more precise and individualized field delineation.

Cervix cancer, Lymph nodes, CT simulation, Radiation planning, Radiation therapy.

INTRODUCTION

External beam radiation therapy to the pelvis with adequate volumetric coverage of the tissues at risk for dissemination of disease is an essential component of the curative treatment for locally advanced cervix cancer. This includes both the primary tumor and the draining lymph nodes. For microscopic disease in pelvic lymph nodes, a dose of 50 Gy is necessary for 90% probability for local control (1). To date, conventional pelvic field parameters have used bony landmarks to plan pelvic treatment volumes, rather than techniques that may more precisely delineate the relevant pelvic nodes.

It has already been shown that recommended conventional fields provide inadequate margins for the gross primary tumor volume in a significant proportion of patients. Magnetic resonance imaging (MRI) studies have demonstrated that the primary cervical tumor and uterine fundus may be missed nearly half the time (2). Moreover, the study by Kim *et al.* demonstrated that inadequate margins around the computed tomography (CT)-defined gross tumor volume resulted in decreased local control (3).

Data exist showing that margins around the pelvic lymph nodes may also be inadequate or conversely may encompass excess volume of normal tissue. Several authors have used data from lymphangiograms, intraoperative measurements, or placement of surgical clips to assess the coverage of lymph nodes while employing conventional pelvic fields (2, 4–7). All found areas of suboptimal coverage. For practical reasons, the generalized implementation of these techniques to improve treatment planning and nodal coverage is unlikely.

With the advent of CT simulation, individualized nodal

Reprint requests to: Ida Ackerman, M.D., Department of Radiation Oncology, Toronto-Sunnybrook Regional Cancer Centre, 2075 Bayview Avenue, Toronto, Ontario, Canada M4N 3M5. Tel: (416) 480-6128; Fax: (416) 480-6002; E-mail: Ida.Ackerman@sw.ca

Received Mar 1, 2005, and in revised form June 3, 2005. Accepted for publication June 14, 2005.

locations can be obtained and incorporated into treatment planning. More accurate identification of the appropriate treatment volume for the individual patient is now possible. The pelvic blood vessels can be identified and contoured on CT simulation images. Contoured vessels can then be used as surrogate markers for the location of the corresponding lymphatic vessels and lymph nodes. Information about the relative location of pelvic lymph nodes to the vessels is just emerging. Chao and Lin (8) used bipedal lymphangiograms to establish the relationship or distance between pelvic nodes and the corresponding vessels. To ensure adequate volumetric coverage of the majority (82.3%) of normal-size lymph nodes, they recommended a distance of 15 mm and 20 mm around the common iliac and external iliac vessels, respectively. They also suggested the importance of individualized treatment fields and generated some preliminary information regarding the location of nodes in relationship to vessels.

We hypothesized that CT simulation would allow a noninvasive method for more precise radiotherapy treatment planning than conventional pelvic fields for cervix cancer. The purpose of this study was to assess the adequacy of conventional pelvic fields with regard to coverage of the pelvic nodes in relation to individual patient anatomic node location using vessels contoured on CT simulation as a surrogate for lymph node location. In this study, coverage of the primary cervical tumor was not addressed.

METHODS AND MATERIALS

The CT simulation images made, using the AcQSim Oncodiagnostic Simulation/Localization System (Philips, Cleveland, OH), were retrospectively obtained from 43 patients with FIGO Stage I–III cervix cancer treated at the Toronto Sunnybrook Regional Cancer Centre between March of 2002 and January of 2004. Sixteen patients had FIGO Stage I and II disease, respectively, and the remainder had Stage III. The images were obtained every 5 mm. No i.v. or bowel contrast was used, because that was not the policy of the institution during that time. The pelvic vessels were contoured on AcQSim by the author and verified by a diagnostic radiologist who specializes in abdominal/pelvic imaging. The aorta and common, external, and internal iliac arteries were contoured on each image with no interpolation done. The contours were then hidden from view. Conventional pelvic fields were outlined (9). For the anterior/posterior (AP) field, the superior border was placed at the L5–S1 interspace; the inferior border was placed at the inferior aspect of the obturator foramen, and the lateral border was placed 2.0 cm beyond the widest part of the pelvic brim. For the lateral field (LAT), the anterior border was placed at the most anterior part of the symphysis pubis, and the posterior border was defined at the S2–S3 interspace. The superior and inferior borders were identical to those on the AP/PA fields. These borders were outlined on coronal and sagittal digitally reconstructed radiograph images on ACQSim and verified by a radiation oncologist.

To assess the adequacy of coverage of the common and external iliac nodes delineated previously, the following was done. The vessel contours were reinstated on the digitally reconstructed radiograph images, and 3 sets of measurements were taken: (*1*) the distance from the bifurcation of the common iliac artery to the superior border of the AP field, (*2*) the distance from the external iliac artery to the lateral border of the AP field, and (*3*) the distance between the nearest external iliac artery vessel edge and the anterior border of the LAT field (Fig 1). The inguinal nodes were not specifically intended to be in the treatment volume. The acetabulum approximates the level of the inguinal ligament, which divides the external iliac artery from the femoral artery, and the pelvic from the inguinal lymph nodes. Because the inguinal ligament is difficult to identify on axial CT slices, the acetabulum was used as the inguinal demarcation point. The second and third measurements were taken at a level 1.0 cm superior to the acetabulum.

Because microscopic and small-volume nodal disease cannot be visualized on CT, the vessel location was used to define the clinical target volume. A distance of 15–20 mm from vessel edge to field edge would provide adequate coverage (95% of dose prescribed to isocenter) for any microscopic nodal disease within 5 mm of the vessel edge. Accordingly, a margin of 15–20 mm from vessel edge to field edge was defined as "adequate." Margins less than 15 mm were deemed "inadequate," and margins >20 mm were considered "generous."

RESULTS

At the superior field border, 11 patients (25.6%) had 1 or both common iliac bifurcations entirely outside the conventional pelvic field. Twenty-three patients (53.5%) had inadequate margins. Nine patients (20.9%) had adequate coverage (15–20 mm) of the common iliac artery bifurcation, whereas 4 (9.3%) had generous margins (>20 mm). The median distance from vessel edge to the field edge of those common iliac bifurcations located within the field was 11 mm with a range of 0–38 mm.

The lateral border of the AP field provided inadequate coverage of the external iliac nodes in 9 patients (20.9%). Fifteen patients (34.9%) had adequate margins, and 19 (44.2%) had generous margins bilaterally by our definition. The median distance of the external iliac artery location to the field edge was 22.5 mm with a range of 0–37 mm. For the anterior border of the LAT field, 2 patients had vessels outside the field, and nearly two-thirds (65.1%) had inadequate margins. Six (14.0%) patients had generous margins bilaterally. The median distance of external iliac arteries located within the field to the anterior border was 13 mm with a range of 6–37 mm (Table 1).

Overall, 41 (95.4%, CI, 84.2%–99.4%) patients had at least 1 inadequate margin, the majority located superiorly. However, 24 (55.8%; CI, 39.9%–70.9%) patients had at least 1 generous margin, the majority located at the lateral borders of the AP field.

DISCUSSION

This study demonstrates that contouring of vessels with CT simulation is feasible even without the presence of contrast enhancement. It also confirms that a significant proportion of patients do not have optimal pelvic lymph

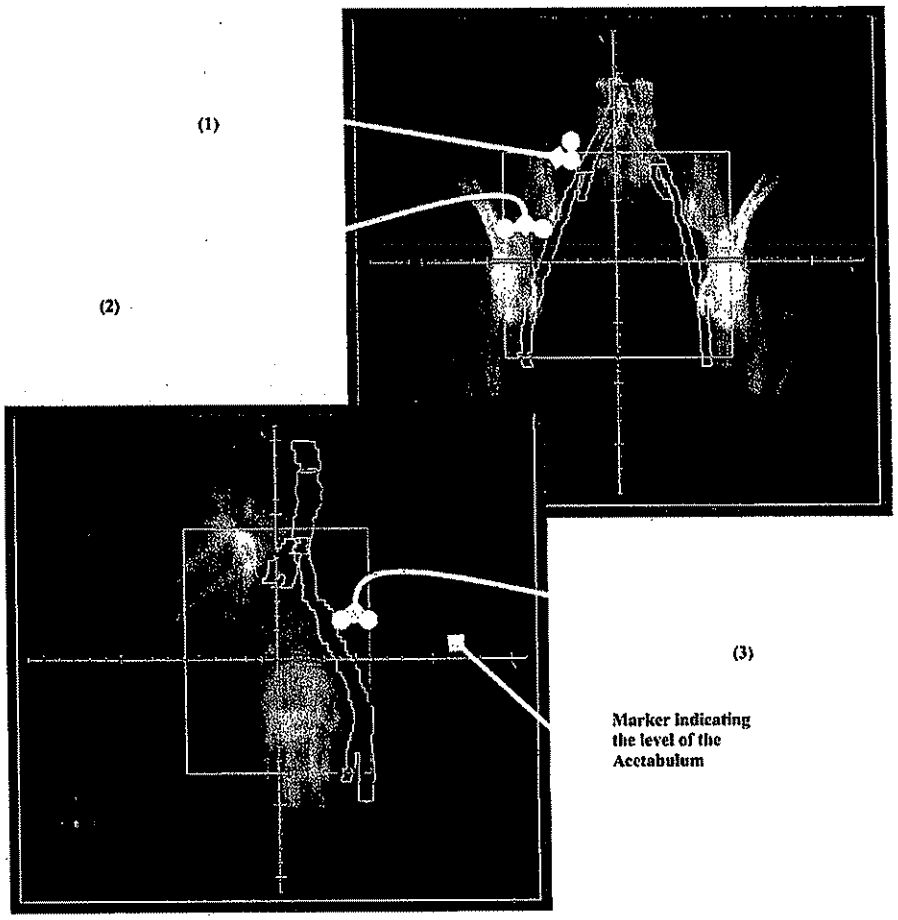


Fig. 1. Location of measurements taken with contoured vessels and pelvic fields in place.

node coverage when conventional pelvic fields are planned based on bony landmarks.

Optimization of locoregional treatment in the radical radiotherapeutic management of locally advanced cervix cancer is crucial for cure. Although the addition of chemotherapy to radical radiation has improved outcome, locoregional relapse rates remain high (9, 10). Adequate nodal coverage must be ensured while normal-tissue irradiation is minimized, so toxicity is avoided. More precise localization of the critical target volume remains an important therapeutic objective.

Previous attempts to more precisely identify the adequacy of pelvic lymph node coverage include intraoperative measurements, placement of surgical clips, and lymphangiograms.

Greer *et al.* quantified the relationships between pelvic vessels and bony landmarks using intraoperative measurements in 100 patients (4). They found that both common iliac bifurcations were located proximally to the L5–S1 interspace in 87% of the patients. The authors therefore recommended that the superior border be placed at L4–L5 to encompass the mid common iliac nodes consistently, if inclusion of common iliac nodes is desirable and of therapeutic benefit.

In a study of 100 patients, McAlpine *et al.* (5) placed surgical clips intraoperatively at the bifurcation of the common iliac arteries, and at the insertion of the deep circumflex vein into the external iliac vein. Comparison of the position of these clips with bony landmarks on radiographs showed that 26% of the patients had inadequate coverage at 1 or both lateral borders, with less than 1.0 cm distance between the clips and the field edge. In this study, the superior border would have to be as high as the L3–L4 interspace to consistently cover all patients' common iliac nodes. Like Greer *et al.* (4), McAlpine *et al.* (5) suggested using surgical techniques to assist in the design of the radiation therapy field if CT or MRI is unavailable.

Lymphangiograms have also been used to assess pelvic node coverage of conventional fields. Using lymphangiograms, Zunino *et al.* (2) and Bonin *et al.* (7) demonstrated that the lateral borders of conventional AP fields provided insufficient margins. To adequately cover all the external iliac lymph nodes, they recommended a margin beyond the pelvic brim of 2.5 and 2.6 cm, respectively. Pendlebury *et*

Table 1. Adequacy of field borders (n = 43)

	Superior border n (%)	Lateral border anterior/posterior field n (%)	Anterior border lateral field n (%)
Out of field	11 (25.6)	0 (0.0)	2 (4.6)
Inadequate margin (<15 mm)	23 (53.5)	9 (20.9)	28 (65.1)
Adequate margin (15–20 mm)	5 (11.6)	15 (34.9)	7 (16.3)
Generous margin (>20 mm)	4 (9.3)	19 (44.2)	6 (14.0)

al. (6), in a study on the role of bipedal lymphangiogram in radiation treatment planning for cervix cancer, reported on the nodal coverage of 87 patients, of whom only 50 had bilateral uptake of dye. Nearly two-thirds of the 50 patients (62%) required alteration of the conventional pelvic fields. In this authors' study, the inadequate margins involved most commonly the lateral borders on the AP field and the anterior margin on the lateral field. Again, a lateral border 2.5 cm beyond the pelvic brim was recommended, and additionally an anterior border 0.5 cm anterior to the pubic symphysis was advised to cover the pelvic lymph nodes in 90% of their patients. Although most adjustments required enlargement of the standard pelvic fields, 20% permitted smaller fields, resulting in the reduction of normal tissue volume irradiated.

Given the significant interpatient variability in lymph node location, the recommendations from the studies reported above have been to either enlarge treatment fields or, for more precision, undertake preoperative assessment or lymphography, neither of which is practical or feasible today.

Our study confirms the fallibility of conventional pelvic fields with respect to maximizing nodal coverage while minimizing normal tissue irradiated in a significant proportion of patients. CT simulation with contouring of vessels can identify the approximate nodal location for the individual patient, and field enlargement or routine field descriptions for all patients would no longer be necessary. CT simulation is noninvasive and can ensure appropriate gross tumor and nodal volume coverage allowing individualized placement of pelvic fields. Like the study by Pendlebury *et al.* (6), our study demonstrated also that a significant proportion of patients had generous field borders and simply enlarging treatment fields is not appropriate for many patients. In our study, field reductions of 1.0 to 2.0 cm were possible without compromise in nodal coverage at the superior, lateral, and anterior borders in 9.3%, 14%, and 44.2% of the patients, respectively. Reduction in field size and volume of normal tissue irradiated is desirable, and hopefully could lead to reduced toxicity. This study is the first to show that a CT-based treatment planning process now being adopted by many institutions may tailor radiation treatment volumes more specifically.

Based on some preliminary information, the definition of "adequate," "inadequate," and "generous" margins used for this study seemed reasonable (8). More information continues to emerge about the exact location of pelvic lymph nodes with respect to the vessels. Recently, the novel MRI contrast agent USPIO, or ultra-small superparamagnetic iron oxide particles, has been introduced to determine the relationship between lymph nodes and pelvic vessels. USPIO localizes in macrophages, allowing normal-size lymph nodes to be visualized, because they appear black on MRI. Taylor *et al.* (11) used USPIO MRI scans of 15 patients to determine the necessary volumetric expansions around pelvic vessels for adequate nodal coverage. For the first 10 patients assessed, volumetric expansions of 15 mm covered 99% of the nodes, with a significant amount of small bowel in the irradiated volume. Expansions of 10 and 7.0 mm gave 96% and 90% coverage, respectively. Using the same expansions for the next 5 patients, the authors found that the 7-mm volumetric expansion gave coverage of 97% of the lymph nodes, with a 22% reduction in the amount of small bowel treated.

These preliminary data suggest that our definition of an adequate margin of 15–20 mm from vessel to field edge for coverage of microscopic nodal disease within 5 mm of the vessel edge is reasonable, although possibly too conservative. Further studies will greatly aid our quantification of nodal relationships to vessels and facilitate the more precise delineation of the target volume using CT simulation with vessel contouring.

Some limitations of our study exist. First, i.v. contrast was not used, and this would have greatly aided visualization of the vessels. This limited the ability to identify and contour the internal iliac vessels reliably. Therefore, assessment of the adequacy of coverage of the presacral and lateral sacral nodes by the placement of the posterior border of the lateral fields was not possible. We recommend the use of i.v. contrast in the future.

Second, no attempt has been made to correlate sites of pelvic failure with our pelvic volumes, to determine whether inadequate coverage resulted in geographic failures. The follow-up of this cohort is not long enough to make such a correlation, and identification of the precise sites of failure within the pelvis can be difficult. However, this correlation would clearly be desirable.

Finally, this study focused on the technique of pelvic vessel contouring and the adequacy of nodal coverage by what is considered to be "conventional pelvic fields." However, it is not yet known which of these potential pelvic nodes are crucial for inclusion in treatment volumes and which nodes are rarely involved and could therefore be excluded. Emerging information from the sentinel node studies may provide some insights into these important questions (12).

CONCLUSION

In summary, we have confirmed that conventional fields planned based on bony landmarks may not provide optimal pelvic nodal coverage. Contouring the pelvic vessels using noncontrast CT simulation images more precisely defined the clinical target volume. This more accurate definition of the target volume and individualization of field delineation may potentially lead to an improved therapeutic ratio, especially as investigators are beginning to use more conformal radiotherapy techniques such as intensity-modulated radiotherapy.

REFERENCES

1. Withers HR, Peters LJ, Taylor JMG. Dose-response relationship for radiation therapy of subclinical disease. *Int J Radiat Oncol Biol Phys* 1995;31:353–359.
2. Zunino S, Rosato O, Lucino S, *et al.* Anatomic study of the pelvis in carcinoma of the uterine cervix as related to the box technique. *Int J Radiat Oncol Biol Phys* 1999;44:53–59.
3. Kim RY, McGinnis S, Spencer SA, *et al.* Conventional four-field pelvic radiotherapy technique without computer tomography-treatment planning in cancer of the cervix: Potential geographic miss and its impact on pelvic control. *Int J Radiat Oncol Biol Phys* 1995;31:109–112.
4. Greer BE, Wui-Jin K, Figge DC, *et al.* Gynecologic radiotherapy fields defined by intra-operative measurements. *Gynecol Oncol* 1990;38:421–424.
5. McAlpine A, Schlaerth JB, Lim P, *et al.* Radiation fields in gynecologic oncology: Correlation of soft tissue (surgical) to radiologic landmarks. *Gynecol Oncol* 2004;92:25–30.
6. Pendlebury SC, Cahill S, Crandon AJ, *et al.* Role of bipedal lymphangiogram in radiation treatment planning for cervix cancer. *Int J Radiat Oncol Biol Phys* 1993;27:959–962.
7. Bonin SR, Lanciano RM, Corn BW, *et al.* Bony landmarks are not an adequate substitute for lymphangiography in defining pelvic lymph node location for the treatment of cervical cancer with radiotherapy. *Int J Radiat Oncol Biol Phys* 1996;34:167–172.
8. Chao KSC, Lin BS. Lymphangiogram-assisted lymph node target delineation for patients with gynecologic malignancies. *Int J Radiat Oncol Biol Phys* 2002;54:1147–1152.
9. Pearcey R, Brundage M, Droulin P, *et al.* Phase III trial comparing radical radiotherapy with and without cisplatin chemotherapy in patients with advanced squamous cell cancer of the cervix. *J Clin Oncol* 2002;20:966–972.
10. Eifel PJ, Winter K, Morris M, *et al.* Pelvic irradiation with concurrent chemotherapy versus pelvic and para-aortic irradiation for high-risk cervical cancer: An update of Radiation Therapy Oncology Group trial (RTOG) 90–01. *J Clin Oncol* 2004;22:872–880.
11. Taylor A, Rockall AG, Powell MEB. Magnetic resonance lymphography to localize pelvic lymph nodes for intensity-modulated radiotherapy in gynecological cancer. *Proc Am Soc Clin Oncol* 2004;22:7–15.
12. Levenback C, Coleman RL, Burke TW, *et al.* Lymphatic mapping and sentinel node identification in patients with cervix cancer undergoing radical hysterectomy and pelvic lymphadenectomy. *J Clin Oncol* 2002;20:688–693.

Attachment C

Curriculum Vitae of Key Personnel Related to Proposal

ELLIOT JOSEPH
3 Sunningdale
Farmington, CT 06032

CAREER SUMMARY

Fifteen years of health care CEO experience, with special emphasis on large integrated delivery systems. Proven track record in visionary strategic leadership, organizational culture building, and operating performance improvement.

PROFESSIONAL EXPERIENCE

April 2008 – Present
President and CEO
Hartford Hospital and Hartford Health Care

June 1998 – March 2008
Ascension Health
Ascension Health, the largest not-for-profit health system in America, is a Catholic sponsored, mission focused organization with over $11 billion in net revenue, 78 hospitals, and over 100,000 associates.

February 2001 – March 2008
President & CEO
St. John Health (Ascension Health)
Warren, Michigan

St. John Health, the largest local health ministry within Ascension Health, operates seven hospitals with approximately $2 billion in annual net revenue, 18,000 associates, 3,200 physicians and 470 residents and fellows in 61 training programs. St. John Health is the largest provider of hospital services in Southeast Michigan, serving the entire five county area.

Significant accomplishments:

- Improved annual operating margin from 0.9% (FY 01) to 2.5% (FY 07), while increasing "care of the poor" from $95 million (FY 01) to $155 million (FY 07).
- Increased days cash on hand from $137 million (FY 01) to $171 million (FY 07) while investing over $500 million in major capital projects.
- Decreased mortality rates from 12% (FY 02) favorability over Michigan norms to 23% favorability (FY 07).
- Outperformed market with impatient growth of +1.1% over past two years against average market growth of -0.5%.
- Decreased RN turnover by 26% between FY 06 and FY 07.
- Increased employee "top box" satisfaction from 25.2% (FY 03) to

42.2% (FY 07).

June, 1998 – January, 2001
President & CEO
Genesys Health System (Ascension Health)
Grand Blanc, Michigan
With annual net revenue of $330 million, Genesys is a regionally integrated health care system resulting from the merger and consolidation of four hospitals into one new 379-bed tertiary medical center campus.

Significant accomplishments:

- Improved operational margin from loss of 0.9% in FY 98 to +1.2% in FY 01 while addressing post-merger dysfunction.
- Results achieved:

	FY 98	FY 01
Operating revenue (million)	$295,972	$330,611
Inpatient discharges	24,142	24,897
Surgical cases	19,707	21,798
FTE's per AOB	6.16	5.44

- Turned around cardiac surgery program with resulting volume increase from 459 (FY 98) to 615(FY 01).
- Developed and implemented a successful cultural "turn around" plan addressing both internal and external (community) elements. Achieved dramatic improvements in community awareness and perception.
- Integrated medical staffs and medical education functions of four hospitals, including osteopathic and allopathic teaching facilities.

June, 1993 – May, 1998
The Detroit Medical Center (DMC)
Detroit, Michigan
The Detroit Medical Center is an eight hospital, $1.6 billion, integrated academic health system with over 2,500 physicians and 100 ambulatory sites. This system is affiliated with Wayne State University School of Medicine.

November, 1995 - May, 1998
Senior Vice President/Oakland Region

June, 1993 - November, 1995
President
Huron Valley Hospital

Significant accomplishments:

- Instituted strategic planning process resulting in $41 million expansion project, including an outpatient regional specialty center, integrating academic faculty practices and local community specialists.
- Inpatient admissions increased from 6,976 (FY 93) to 8,471 (FY 98) while operating margin increased from -4.2%(FY93) to +6.4% (FY 98)

August, 1985 – May, 1993
Mercy Hospital and Medical Center (MHMC)
Chicago, Illinois
A 485- bed community-based teaching hospital affiliated with the University of Illinois. Approximately $350 million revenue base.

February, 1991 – May, 1993
Senior Vice President

August, 1985 – January, 1991
Vice President

October, 1981 – August, 1985
Edward Hospital
Naperville, Illinois
A 162-bed community hospital serving west suburban Chicago.

November, 1982 – August, 1985
Vice President/ Marketing and Planning

October, 1981 – November, 1982

Director/ Planning

EDUCATION

University of Pennsylvania
Wharton CEO Program for Health Care Leadership (2006)

University of Michigan/Ann Arbor, Michigan
Master of Health Services Administration (1979)

State University of New York
Binghamton – Binghamton, New York
Bachelor of Science in Business Administration and Psychology (1976)

ACTIVITIES/APPOINTMENTS

- American Hospital Association Regional Policy Board 5 (2005-present)
- American Heart Association Ball co-Chair (2004)
- Caymich Insurance Company, LTD Board of Directors (1998-2003)
- Citizens Research Council of Michigan Board of Trustees (2003-present)
- City of Detroit Health Care Task Force for the Mayor's Transition Team
- Design Regional Detroit Initiative 2006
- Detroit Opera Board of Trustees
- Detroit Regional Chamber Board of Directors and Executive Committee (2004-present)
- Friends of Scouting 2000 Community Campaign Chairman
- Greater Detroit Area Health Council, Inc. Executive Committee (2003-present)
- JARC Foundation Investment Committee (2006-present)
- Michigan Health & Hospital Association Corporation Board (2003-present) and Executive Committee (2004-present)
- Michigan Healthcare Executive Group and Associates Board (2003-present)
- New Detroit, Inc. Board of Trustees (2003-present)
- Oakland University School of Health Sciences/Board of Visitors (2002-present)

RECOGNITION

- American College of Healthcare Executives Fellow (2005)
- Crain's Detroit Business Who's Who in Metro Detroit (2005)
- Wayne State University Pathfinders in Medicine Award (2006)

Jeffrey A. Flaks

77 Wildwood Drive
Avon, CT 06001
(H) 860-673-2590 (W) 860-545-2349 (E) jflaks@harthosp.org

Professional Experience

Hartford Healthcare Corporation - Hartford Hospital **2007 to present**

Hartford Hospital, founded in 1854, is one of the largest teaching hospitals and tertiary care centers in New England. It has been training physicians for nearly 130 years, primarily in collaboration with the University of Connecticut School of Medicine. The hospital is an 867-bed regional referral center that provides high-quality care in all clinical disciplines, enhanced by robust research endeavors. Among its divisions is The Institute of Living, a 114-bed mental health facility and the Jefferson House, a 104-bed long-term care facility. The hospital's active medical staff includes over 1000 physicians and dentists.

Executive Vice President & Chief Operating Officer

Reporting to the President/CEO, responsible for the overall operations of the hospital.

Hartford Healthcare Corporation - MidState Medical Center **2004 to 2007**

MidState Medical Center is a 144 bed acute care hospital located in Central Connecticut with $165 million in net operating revenue. The hospital was recognized in 2005 as one of the top 50 small and medium size companies to work for in America.

Executive Vice President & Chief Operating Officer

Responsible for the overall operations of the hospital. Direct oversight of all clinical and non-clinical departments, managed care contracting, strategic planning, business development, physician relations, community outreach, as well as the MidState Medical Group, MidState VNA & Hospice and Meriden Imaging Partners.

- Created and developed new clinical programs including the Heart Center, Sleep Center, Wound Care Center, Thoracic and Vascular Surgery Program, Orthopedic Spine & Pain Institute and the Stroke Center.
- Led the development and implementation of a master facility planning process, resulting in the expansion of the main hospital campus and medical office building, the development of two off-site outpatient and imaging centers, the sale of the MidState Medical Center East Campus and a decrease in facility operating costs of ten percent.
- Restructured the MidState Medical Center pension plan and negotiated acceptance with Connecticut Healthcare Associates, AFSCME that resulted in an 18% annual reduction in pension expense.
- Developed the hospital ambulatory and physician development strategy through the establishment of two subsidiary for-profit corporations, including the MidState Medical Group, MidState MSO, MidState Physician Walk-In Center and the community based MidState Medical and Diagnostic Centers network resulting in 50,000 annual patient visits.
- Increased hospital operating margin by 2 percent, while achieving Press Ganey patient satisfaction ranking within the top five percent in the nation and Press Ganey Physician Satisfaction in the 98 percentile.

Saint Vincent Catholic Medical Centers of New York **2000 to 2004**

Saint Vincent Catholic Medical Centers of New York is one of the New York metropolitan area's most comprehensive health care systems, serving 600,000 people annually and is the academic medical center of New York Medical College in New York City.

Vice President for Support Services & Strategic Initiatives

Reporting to the System CEO, responsible for executive leadership of corporate support services and system-wide strategic initiatives. Direct oversight for corporate functions, including supply chain, real estate and construction, master facility planning, pharmacy, dietary and performance management. Serving as the first full time employee of newly merged health system, responsible for the overall planning, direction and implementation of strategic initiatives across the organization, including integration and business development.

- Developed and led a twenty four month system-wide turn around management process that resulted in an annualized $65M improvement from a broad range of revenue and cost containment activities that covered all aspects of the System's operations.
- Developed the Master Facility Plan resulting in the termination of 30 leases, sale of 6 properties and centralization of 565 staff members to a single location, achieving a recurring savings of $3.2M and one time cash benefit of $25M.
- Led comprehensive system-wide supply chain reorganization, resulting in a decrease in total spending from $240M to $226M, through contract/product standardization and price leveling initiatives.
- Led the recruitment of a ten person orthopedic group practice, producing 700 inpatient procedures, 1,700 ambulatory cases and the appointment of a new chair in the academic department.

Continuum Health Partners, Inc., New York, NY **1999 to 2000**

A health care system in New York City, Continuum Health Partners is a partnership of four prestigious academic medical centers. The health system is comprised of 3,400 licensed beds, 5,200 physicians, and operating revenue of $1.8 billion.

System Director for Physician Enterprise Development

Responsible for clinical program development and expansion and integration of the physician network across the health system. Reporting to the Senior Vice President for Network Development, accountable for all strategic planning and operational aspects of a 110 musculoskeletal physician network.

- Identified, recruited and operationalized prominent clinical faculty and private physician practices to support health system program development in primary and specialty care.
- Developed a 110 member musculoskeletal physician network with geographic coverage spanning the five boroughs of New York City, Long Island and Westchester County, resulting in over 2,000 new surgical cases for the health system.
- Performed operational assessments of key physician practices resulting in the re-engineering of the practice infrastructure model, including management, billing and information systems.

The Detroit Medical Center (DMC), Detroit MI — 1995 to 1999

An integrated delivery system in Southeastern Michigan, The Detroit Medical Center operates eight hospitals, two nursing centers and 130 outpatient facilities. The system has 3,000 affiliated physicians, 2,000 licensed beds and serves as the teaching and clinical research site for Wayne State University, the nation's fourth largest medical school.

Director for Health Care Initiatives and Network Services, DMC Corporate — 1998 to 1999

Responsible for planning, organizing and implementing ambulatory facilities and practice management services for faculty, employed and private physicians. Operational management for a network of three multi-specialty ambulatory centers consisting of 30 physicians and net revenues of $17 million.

- Planned and operationalized a 30,000 square foot regional ambulatory specialty center with a $45 million capital budget; including business planning, facility design/construction, staff recruitment/training, go-live planning /implementation, and technology identification/implementation, resulting in 55,000 annual visits.
- Recruited and structured a 20 member "virtual group practice", integrated through information systems and management services, resulting in common operations and operating systems amongst physician participants.
- Selected, led purchase negotiation and managed implementation process for system-wide physician practice management information system, including electronic medical record functionality.
- Developed affiliation and managed relationship with community based 100 member multi-specialty IPA.

Administrator, Professional & Support Services, DMC/Hutzel Hospital — 1996 to 1997

Line management responsibility for the division of Professional & Support Services, representing an operating budget of $15 million with 300 employees. Directed daily operations for the community health center, ambulatory surgery center, employed orthopedic group practice, real estate, facility planning, marketing and planning, public affairs, nutrition and food services, pharmacy, infection control and accreditation/regulatory compliance.

- Senior administrator responsible for hospital wide JCAHO survey resulting in successful accreditation.
- Led hospital-wide initiative for the redesign and implementation of the patient focused care model.
- Achieved $800,000 annual cost reduction through staff restructuring and the elimination of outside contracting costs.
- Re-engineered the Hutzel Community Health Center through the recruitment, negotiation and implementation of ophthalmology, urology, and orthopedic physician practices, increasing visits by 30,000 annually.
- Led an $8 million facility renovation, encompassing hospital and ambulatory services, successfully maintaining budget, client satisfaction and time objectives.

Administrative Resident, DMC/Hutzel Hospital — 1995

Governance Appointments

- Director, The Urban League of Greater Hartford (2008 to present)
- Director, The Children's Museum (2008 to present)
- Director, Eastern Rehabilitation Network (2007 to present)
- Director, Connecticut Hospital Association, Diversified Network Services, Inc. (2006 to present)
- Director, Clinical Laboratory Partners, Inc. (2005 to present)
- Director, The George Washington University Alumni Association (2004 to present)

Professional Affiliations and Development

- Trustee, The Children's Museum, 2008 to present
- 1892 Club of Greater Hartford, 2008 to present
- Fellow, American College of Healthcare Executives, 1995 to present
- Chairman, The George Washington University HSMP Alumni Association, 1996 to present
  - Preceptor and Professional Lecturer
- Trustee, The George Washington University Board of Trustees, 2001 -2004
  - Vice Chairman, Student Affairs Committee
  - Trustee Representative, Medical Center Committee
- Member, Healthcare Executive Editorial Board, 2002 – 2005
  - Chairman, 2004-2005
- Preceptor, Institute of Diversity in Health Care Management, Summer Enrichment Program, 2001 to 2004
- Trustee, The State of Michigan Arthritis Foundation Board of Governors, 1996 to 1999
  - Chairman, Southeast Michigan Board of Advisors

Text Books

Flaks, JA and Ruben, PJ: "Information Systems – The Tie That Binds" Reinventing the Integrated Delivery System, (ed. Persily, Gotlieb), McGraw Hill Healthcare, NY, October 1999, pp. 59-79

Journal Publications

Flaks JA, Weisberg JA, Federman MJ: A Flexible Approach to Working with Physicians. Health Forum Journal (43)2:60-63, 2000.

Flaks JA, Porter AT: Community Health Information Networks: A Strategic View. The Journal of Oncology Management (7)6:18-20, 1998.

Horak BJ, Campbell DJ, Flaks JA: Strategic Positioning: A Case Study in Governance and Management. The Journal of Healthcare Management 43(6):471-484, 1998.

Porter AT, Lighter D, Flaks JA: Intangibles in Mergers and Acquisitions – A Critical Success Factor in Modern Day Health Care. The Journal of Oncology Management (7)4:24-25, 1998.

Presentations

Invited Guest Faculty/Speaker

The New England Heath Information Management System Society, Leveraging IT to Impact the Patient Experience, Farmington, CT, 1/08
- How the Patient Experience Affects Strategic Direction

The American College of Healthcare Executives, 2006 Congress on Healthcare Leadership, Chicago, Ill, 3/06
- How to Create a Great Place to Work: A Strategy for Business Success

Columbia University, Mailman School of Public Health, New York, NY, 4/04
- Preparing for Success: How to Create a Winning Formula in Today's Healthcare Marketplace

The Healthcare Financial Management Association, Business Transformation Seminar, New York, NY, 4/03
- How to Manage A Turnaround Engagement

The American College of Healthcare Executives, CHA Annual Meeting, Wallingford, CT, 6/02
- Saint Vincent Catholic Medical Centers Response to the World Trade Center

The Healthcare Public Relations & Marketing Society, New York NY, 2/02
- Strategies for Building Physician Referrals

The 12th Annual National Managed Health Care Congress, Atlanta GA, 4/00
- An Entrepreneurial Approach: How to Develop New Payment Systems for Physicians

IBC Group, Effective Tools to Redesign the MSO Infrastructure, Lake Buena Vista FL, 12/98
- Strategies to Utilize the MSO as a Physician Integration Tool

American Academy of Medical Administrators, 41st Annual Conference and Convocation, Dallas TX, 11/98
- Integration "Tools of the Trade" – Emerging Innovations for Physician Enterprises

The Outpatient Care Institute, Integrated Network Development Conference, Washington DC, 9/98
- Development of the Ambulatory Care Center of the "Present" – A Case Study

Awards/Honors

- 2008 *Hartford Business Journal* "Up and Coming Executives"
- 2006 Alumni Service Award from the George Washington University (highest alumni recognition bestowed by the University, presented by the President)
- 2003 Manhattan Regent's Award from the American College of Healthcare Executives
- Appointed as the Recent Trustee and Member of the Board of Trustees of The George Washington University (2001-2004)
- 2001 *Modern Healthcare* "Up & Comer"
- 2001 *Crain's New York Business* "New York's Rising Stars: 40 Under 40"

Education

Master of Health Services Administration, The George Washington University, Washington, DC, 1996
- Volunteer Internship, The White House, Washington, DC, 1994

Bachelor of Science, Health Services Administration, Ithaca College, Ithaca, NY, 1993
- Administrative Internship, Hospital of St. Raphael, New Haven, CT, 1992
- Administrative Internship, Yale New Haven Hospital, New Haven, CT, 1991

THOMAS J. MARCHOZZI, CPA
26 Bittersweet Lane, S. Glastonbury, CT 06073
Home: (860) 430-1114 Work: (860) 545-2746

SUMMARY

A highly skilled finance executive with over twenty-four years concentrated experience in the area of business analysis, planning, budgeting, forecasting and information systems. An executive who applies logic and innovation to further the growth and development of an organization.

JOB HISTORY

Hartford Heath Care Corporation, Hartford, Connecticut August 2008 - Present
A Connecticut integrated healthcare delivery system operating three acute care hospitals, two psychiatric hospitals and multiple ambulatory sites.

Executive Vice President and CFO – Hartford Hospital and Health Care Corporation August 2008 - Present

MedStar Health, Columbia, Maryland July 2002 – August 2008
A $3.0B Maryland and Washington D.C. integrated healthcare delivery system operating six acute care hospitals, 2,650 licensed beds, a national rehabilitation hospital, three skilled nursing facilities, and multiple ambulatory sites.

Senior Vice President and CFO – Washington Hospital Center September 2006 – August 2008
The Washington Hospital Center (WHC) located in the heart of Washington D.C. is a $1.0B tertiary care hospital and the flagship hospital in the MedStar Health System. WHC underwent a significant design process to expand the campus including new patient towers, emergency department, outpatient facilities and physician joint ventures.

Responsibilities:
- Include business development, patient financial services, central scheduling, financial clearance, physician billing, medical records, management engineering, budgeting, and financial reporting.

Vice President – Finance July 2002 – September 2006
Recruited for an executive position by a large multi-state premier health system which includes the Washington Hospital Center, Georgetown University Hospital, the National Rehabilitation Hospital, and four Maryland Community Hospitals.

Responsibilities:
- Responsible for financial accounting, reporting, forecasting, analysis, and policy implementation including the MedStar Central Business Office operations and Capital resource management.
- Accountable for planning, budgeting, decision support, benchmarking, grants and audit coordination.
- Chief Financial Officer for Helix Family Choice, a managed care insurance product owned by MedStar.
- Financial representative to system-wide initiatives for insurance, executive compensation, pension redesign, supply chain program, operational improvement initiatives, rates and reimbursement, and insurance company contract negotiations.
- Member of the executive leadership team which includes hospital presidents, chief financial officer, chief operating officer, and chief executive officer.
- Staff to Finance Committee of the Board of Directors.

Jefferson Health System (JHS), Radnor, Pennsylvania 1996 - 2002
A $2.5B Pennsylvania integrated healthcare delivery system operating nine acute care hospitals, 2,398 staffed beds, three physical rehabilitation hospitals, three skilled nursing facilities, one psychiatric hospital, and multiple ambulatory sites.

Acting Chief Financial Officer and Treasurer January 2002 - July 2002
Promoted to Acting Chief Financial Officer and Treasurer after the departure of the CFO. Offered, and declined, the permanent CFO position in July 2002.

Vice President – Finance March 2001 - January 2002

Promoted to a higher senior level position in the organization, which involved more interaction with senior level executives and Board members.

Responsibilities: (Additional duties added to the AVP position):

- Accountable, with the Member and System CFO's, for the development and monitoring of system-wide financial disciplines that provide financial targets, performance, and financial integrity assurances.
- Responsible for managing the annual JHS operating budget process and developing appropriate support detail.
- Facilitate the system Standardization Group that produces recommendations for the standardization of various financial issues and standards for the Chief Financial Officer group.
- Financial representative to system-wide initiatives for Alliance activities, executive compensation, and benefits consulting group.

Associate Vice President – Finance 1999 - 2001

Management responsibilities:

- Oversees the timely and accurate preparation of financial statements and highlighting performance using variance analysis and follow-up with member CFOs.
- System office direct expense and operating budgets, including reporting and analysis.
- Review of monthly financial reports and system office financials with member Chief Financial Officers and system office Department Heads.
- Responsible for the review, analysis, and validation of material (> $500,000) capital requests and subsequent presentation to the JHS Finance Committee.
- System capital budget process that includes review and analysis of capital requests.
- Presentation of system capital budget and year-end operating statistics to Board Finance Committee.
- Work with JHS CFO in the management of the JHS business planning process.
- External audit and tax reporting.
- Year-end System Certified Financial Statement Audit.

Director of Finance 1996 - 1999

Responsibilities included budgeting, planning, cost containment, cost analysis, revenue enhancement, acquisitions, and system-wide initiatives in re-engineering, cost reduction, system installations, cash management, reporting and policy standards.

Thomas Jefferson University, Philadelphia, Pennsylvania 1984 - 1996

An academic healthcare center located in Center City Philadelphia involved in healthcare delivery, education, and research with approximately $600M in revenues.

Assistant Controller 1994 -1996

Management of ongoing financial accounting services group personnel. In charge of joint information systems and operational implementation teams installing new client server technology for payroll, human resources, benefits, and general ledger software applications. Established new financial accounting reporting standards. Administered the financial re-engineering of the Controller's Office. Development of various ad hoc reports and sensitivity analyses as required by a rapidly changing environment. Phased out the accounting operations of an unprofitable remote campus hospital. Assisted in the development of financial reporting mechanisms and policies for the JHS which includes several major hospitals.

Manager, Information Systems 1990-1994

Provided application and system support on behalf of an academic healthcare university. Applications include general ledger, university and hospital cash, fixed assets, accounts payable, purchase order, and university and hospital inventory control. Implemented change to the Boston Safe Company for tracking endowments. Evaluation committee member for university-wide cost saving employee suggestion program. Manager of the disaster recovery planning team for financial systems.

Director, Physical Resources 1985 - 1990

Operational responsibility for a $30 million operating budget and a $25 million capital budget. Automated Maintenance, Construction, Facilities Design, and Space Planning Departments. Developed service level improvements. Established a routine and preventative maintenance work order system. Directed the first photo identification badge project for the university. Developed procedures and reporting for the university capital budget.

Auditor, Internal Audit 1984 -1985

Departmental, vendor, and governmental compliance audits. University liaison with outside auditors during annual audit process.

EDUCATION

Doctoral Program, Higher Education Administration
UNIVERSITY OF PENNSYLVANIA, Philadelphia, Pennsylvania
(Completed half of the program prior to formation of JHS)

Masters of Business Administration, December, 1992
Concentration: Finance
VILLANOVA UNIVERSITY, Villanova, Pennsylvania

Bachelor of Business Administration, June, 1984
Majors: Accounting and Finance
DREXEL UNIVERSITY, Philadelphia, Pennsylvania

PROFESSIONAL ACCOMPLISHMENTS

Certified Healthcare Financial Professional – December, 1999
Certified Public Accountant - Pennsylvania, 1986
Member of the American Institute of Certified Public Accountants
Western Association of College and
University Business Officers (WACUBO)
Business Management Institute - Santa Barbara, CA - Four Year Program 1993, 1991, 1990, 1989
Finance Committee Member – American Association of Medical Colleges

PERSONAL

Martial Status: Married with two children, boys ages 22 and 26.
Hobbies: Support of Youth Sporting Activities
Community Activities: Former Board Member - Colonial School District

CURRICULUM VITAE

Gene Anthony Cardarelli, PhD, MPH, FACMP

Radiation Oncology/Helen and Harry Gray Cancer Center
Hartford Hospital
80 Seymour Street, PO Box 5037
Hartford, CT 06102-5037.
860-545-3886 Office
860-545-3882 Fax
774-826-8196 Cell

EDUCATION

Doctor of Philosophy Degree (**Ph.D.**) February 2006, University of Massachusetts Lowell, Massachusetts 02159, Biomedical Engineering & Biotechnology
Major Concentration: Medical Physics
Dissertation: "The Effects Of Small Field Dosimetry On The Biological Models Used In Evaluating IMRT Dose Distributions"

Masters of Science in Applied Physics (**M.S.**) February 1989, University of Massachusetts, Lowell, Massachusetts 02159
Major Concentration: Radiological Sciences and Protection
Thesis: "Investigation Of The Relative Surface Dose From Lipowitz Metal Tissue Compensators For 24 And 6 MV X-Ray Beams"

Master of Public Health (**M.P.H.**) May 1986, Boston University School Of Medicine Boston, Massachusetts 02118. Major Concentration: Environmental Health

Bachelor of Science (**B.S.**) May 1983, Boston College, Chestnut Hill, Massachusetts 02149. Major Concentration: Biology

PROFESSIONAL LICENSES AND BOARD CERTIFICATION

American Board of Radiology
Therapeutic Radiological Physics
(Awarded 1990)

Texas Board of Licensure for Professional Medical Physicists # MP 0383
Diagnostic Radiological Physics, Therapeutic Radiological Physics
Medical Health Physics, (1995 – Present).

Commonwealth of Massachusetts Department of Health
Installation and Servicing of X-ray Equipment
Calibration, Personal Dosimetry, Shielding, Diagnostic, Therapy.
(2009-Present)

State of Rhode Island and Providence Plantations Department of Health
Radiation Protection Services #RPS 0042, (1993 – 2009)

PROFESSIONAL AWARDS

FELLOW - THE AMERICAN COLLEGE OF MEDICAL PHYSICS (FACMP)
May 6,2008

ACADEMIC APPOINTMENTS

Research Associate (1998 – 2007), Brown University School of Medicine Department of Radiation Therapy, Division of Biology and Medicine Providence, Rhode Island 02912.

Assistant Professor (2007 – 2009), Brown University School of Medicine Department of Radiation Oncology, Division of Biology and Medicine Providence, Rhode Island 02912.

Adjunct Clinical Instructor (1999-Present), Tufts University School of Medicine Department of Radiation Oncology,136 Harrison Ave.Boston, Massachusetts 02111.

Adjunct Assistant Professor (2007-Present), University of Massachusetts – Lowell, Department of Physics and Applied Physics, One University Ave. Lowell Massachusetts 01854

HOSPITAL APPOINTMENTS

Director of Medical Physics May 2010 – Present
Radiation Oncology – Helen and Harry Gray Cancer Center, Hartford Hospital 80 Seymour Street, PO Box 5037, Hartford, CT 06102-5037.

Chief Physicist/Interim Director Radiation Oncology June 2009 – April 2010, Radiation Oncology – Southcoast Center for Cancer Care, Charlton Memorial Hospital/Southcoast Hospital Groups, Fall River, Massachusetts, 02702

Associate Chief Medical Physicist Jan 2008 – June 2009, Radiation Oncology Department, Rhode Island Hospital, 593 Eddy Street, Providence, Rhode Island 02903

Chief Radiotherapy Physicist October 2004 – December 2007, Radiation Oncology Department, Rhode Island Hospital, 593 Eddy Street, Providence, Rhode Island 02903

Associate Physicist March 1993 – October 2004, Rhode Island Hospital Radiation Oncology/Medical Physics 593 Eddy Street, Providence, Rhode Island 02903

Radiological Physicist June 1989 – March 1993, Greenville Hospital System Medical Physics Department, 705 Grove Road, Greenville, South Carolina 29605

Radiation Physicist/Radiation Safety Officer June 1985-June 1989 Boston City Hospital, Department of Radiation Physics,818 Harrison Avenue Boston, Massachusetts 02118

Radiation Specialist June 1983 – June 1985, Boston University Medical Center 75 East Newton Street, Boston, Massachusetts 02118

Nuclear Medicine Technologist Trainee May 1982 – June 1983, University Hospital 75 East Newton Street, Boston MA, 02118

HOSPITAL COMMITTEES

Charlton Memorial Hospital 2009 - Present
Oncology Implementation Group 2009-Present
Radiation Safety Committee 2010-Present

Rhode Island Hospital 1993-2009
Member Radiation Safety Committee 2005 – 2008
Legacy Committee 2004-2007
Stereotactic Radiosurgery Evaluation Team 2006
Member of Integration Team for Nemc/RIH Radiation Oncology Information System Merger using IMPAC and Viewstation Filmless implementation 2003

Greenville Hospital System 1989- 1993
Radiation Safety Committee,
Assistant Radiation Safety Officer

Boston City Hospital, 1985-1989
Radiation Safety Committee Secretary, RSO

MEMBERSHIP IN SOCIETIES

AMERICAN COLLEGE OF RADIOLOGY	**ACR MEMBER**
AMERICAN COLLEGE OF MEDICAL PHYSICS	**ACMPMEMBER**
AMERICAN ASSOCIATION OF PHYSICIST IN MEDICINE	**AAPM MEMBER**
AMERICAN SOCIETY FOR THER. RAD.ONCOLOGY	**ASTRO MEMBER**
HEALTH PHYSICS SOCIETY	**HPS MEMBER**

OFFICES

Meetings planning committee	**NEAAPM -2010**
CAMPEP Coordinator	**NEAAPM -2010**
Elected Board of Chancellors (New England)	**ACMP 2009 -2011**
Immediate Past President	**NEAAPM-2009**
President	**NEAAPM-2008**
President Elect	**NEAAPM -2007**
Board Member-at-Large	**NEAAPM-2001-2002**

COMMITTEES

On-Line Continuing Education Subcommittee	**AAPM 2010-present**
Chairman of Public Relations Committee	**ACMP 2002-present**
Chairman of Membership Committee	**ACMP 2003-2009**
Professional Economics Committee	**AAPM 2004 – 2007**
Public Relations Committee	**ACMP 2000-2002**
Scientific Program Director (Winter meeting)	**NEAAPM February 2007**
Scientific Program Director (Spring meeting) (Young Investigators Symposium)	**NEAPPM April 2007**
Scientific Program Director (Annual Meeting)	**NEAAPM June 2007**
Scientific Program Director (Autumn Meeting)	**NEAAPM October 2007**

Task Groups

No. 182 AAPM Recommendations on Electronic Brachytherapy Quality Management	**AAMP Nov 2008 – July 2010**

PUBLICATIONS LIST

1. **Cardarelli, GA**, Campbell, C., and Evdokimoff, V. ***The Superiority of the Low Energy Gamma NaI Survey Meter Over the GM to Detect P-32 Contamination.*** J HEALTH PHYS VOL. 50, No. 1, JAN 1986, 138-139.

2. **Cardarelli, GA**, Rao, SN., and Cail D. ***Investigation Of The Relative Surface Dose From Lipowitz Metal Tissue Compensators For 24 And 6 MV X-Ray Beams.*** MEDICAL PHYS VOL. 18, NO.2 MAR/APR 1991, pp 282-287.

3. Sapna, J, Dupey, D, **Cardarelli, G**, Zheng, Z and DiPetrillo, T ***Percutaneous Radiofrequency Ablation of Pulmonary Malignancies: Combined Treatment With Brachytherapy.*** American Journal of Reontgenology 2003; 181:711-715.

4. Neenad M. Shah, Todd Tenenholz, Douglas Arthur, Thomas DiPetrillo,Bruce Bornstein, **Gene Cardarelli**, Zhen Zheng, Mark J. Rivard, SethKaufman, David E. Wazer ***MammoSite and interstitial brachytherapy for accelerated partial breast irradiation: Factors that affect toxicity and cosmesis.*** CANCER VOL. 101, NO. 4 , AUGUST 15, 2004.

5. Gandhi, S, Meech, S, Puthawala, MY, Furgeson, W, **Cardarelli, GA**, Dupuy, DE.***Combined CT-guided Radiofrequency Ablation and Brachytherapy in a Child with Multiple Recurrences of Wilm's Tumor.*** Journal for Pediatric Hematology and Oncology. Volume 27, Issue 7 July 2005.

6. Evans, SB, Kaufman, SA, Price, LL, **Cardarelli, GA,** DiPetrillo, TA, Wazer,DE. ***Persistent Seroma After Intraoperative Placement of MAMMOSITE for Accelerated Partial Breast Irradiation: Incidence, Pathologic Anatomy, and Contribution Factors.*** IJROBP Vol. 65, No. 2 pp.333-339, 2006.

7. Hiatt,J, Evans, SB,Price,LL, **Cardarelli, GA**, DiPetrillo,TA, and Wazer, DE. A ***Dose Modeling Study To Compare External Beam Techniques From Protocol NSABP B-39/RTOG 0413 for Patients With Highly Unfavorable Cardiac Anatomy.*** IJROBP 2006

8. **Cardarelli, Gene** ***The Effects of Small Field Dosimetry on the Biological Models Used In Evaluating IMRT Dose Distributions.*** Doctoral Dissertation, National Library of Congress. February 2006.

9. Fast, LD, **Cardarelli, GA**, DiLeone, *G.* ***Mirasol® PRT treatment of Donor leukocytes prevents the development of xenogeneic graft-versus-host disease in Rag2-/-|*gamma*|c-/- double knockout mice.*** TRANSFUSION 2006

10. Napoli, J, Stutsman, S, Chu, JCH, Gong, X, **Cardarelli, GA**, Ryan, TP, and Favalora, GE. ***Radiation Therapy Planning using a volumetric 3-D display: PerspectaRAD.*** Proceedings of SPIE-IS&T Electronic Imaging, SPIE vol 6803 Article CID (2008).

11. Hiatt J, **Cardarelli G**, Hepel J, Wazer DE, Sternick ES: ***A Commissioning Procedure for Breast Intracavitary Electronic Brachytherapy Systems. Journal of Applied Clinical Medical Physics.*** JACMP August 2008.

PUBLICATIONS SUBMITTED OR IN PREPARATION

1. **Cardarelli, GA**, Zheng, Z, O'Connell, N, Rivard, M, DiPetrillo, T, Shah,N, Shearer, D,and Wazer,D. ***Multiple Dwell Positions with the MammoSite HDRApplicator.*** Submitted 2004 BRACHYTHERAPY Accepted with revisions in Print.

2. *Hepel JT*, Hiatt JR, **Cardarelli GA**, and Wazer DE. ***Modeling Study for Optimization of Skin Dose for Partial Breast Irradiation Using Xoft Axxent Electronic Brachytherapy Applicator.*** *Brachytherapy*. Submitted for review

PEER REVIEWED ABSTRACTS

1. **Cardarelli GA**, Cintron O, Shearer DR, ***The Comparison of Computer Generated Isodose Lines from a Commercially Available Treatment Planning system Vs.Measured Isodose Lines when One Jaw is Used Beyond the Central Axis.*** AAPM 1994.

2. Bruels MC, **Cardarelli GA**, Tolani NB. ***21 and 25 MV Installation experience.*** AAPM 1994.

3. Yee LK, Choy H, Chu MYW, Chen TM, **Cardarelli GA**, Cintron O, Glantz M, Epstein M, and Calabresi P.***9-Aminocamptothecin (9-AC): A Potent Anticancer Agent and Radiosensitizer.*** New England Cancer Society Annual Meeting 1995.

4. **Cardarelli GA**, Ma CH, Shearer DR. ***Comparison of Fixed-Separation Plane-Parallel Ionization Chamber to A Solid Water Scintillation Detector For Measurements of Dose in the Build Up Region.*** AAPM 1995.

5. **Cardarelli GA**, Shearer DR, Chougule P. ***Verification of Brachytherapy Treatment Planning Algorithm Using Syed Applicator.*** AAPM 1995.

6. **Cardarelli GA**, Cintron O, Cail D, Zheng Z, Shearer DR. ***Validity of CT Based Heterogeneity Corrections for use in Clinical Treatment Planning.*** AAPM 1995.

7. Zheng Z, **Cardarelli G**, Shearer DR and Lui C. ***Calculation of the Output Factors for the Leksell Gamma Knife by Monte Carlo Simulation Using EGS4 Codes.*** AAPM 1995.

8. Zheng Z, Shearer DR, **Cardarelli GA**, Noren G, Saris S, Chougule P. ***Quality Assurance of Beam Accuracy for Leksell Gamma Unit-A New Technique Using Film Scanner.*** 7th International Leksell Gamma Knife Society Meeting 1995.

9. **Cardarelli GA**, Ma CH, Zheng Z, Shearer DR. ***The Effect of Surrounding Phantom Material on the Markus Chamber Over Response in the Build-up Region for X-rays and Electrons.*** AAPM 1996.

10. Zheng Z, **Cardarelli GA**, Ma CH, Shearer DR. ***An Optimal Semi-empirical Formula for Sensitometric Curves.*** AAPM 1996.

11. **Cardarelli GA**, Testa V, Soehl S, Shearer DR. ***Implementation of An Electronic Treatment Record in a Radiation Oncology Department.*** AAPM 1997.

12. **Cardarelli GA**, Chen DJ, Ma CH, Cintron O, Shearer DR. ***The investigation***

of the Relative Surface Dose from Asymmetric Fields Using Enhanced Dynamic Wedges. AAPM 1998.

13. **Cardarelli, GA**, Zheng, Z, Cintron, O, Tsai, J.S., Engler, M, Shearer, D, DiPetrillo, T, Mohiuddin, M, and Wazer, D. ***Evaluation of a New Commercial QA Phantom for Intensity Modulated Radiation Therapy (IMRT) Plan Verification.*** AAPM 2001.

14. **Cardarelli GA,** Tsai J, Hiatt J, DiPetrillo T, Remis M, Puthawala MY, Bradford C, Wazer D. ***Post-Surgical Placement of MammoSite Applicator Using The PinPoint CT Scanner Integrated Stereotactic Arm.*** ABS 2005.

15. J Tsai*, **G Cardarelli**, A Corrao, J Hiatt, D Shearer, C Bradford, T DiPetrillo, Y Puthawala, D Wazer. ***Comparison of Endobronchial HDR Brachytherapy using CT Imaging and Conventional Simulator Filming.*** AAPM 2005.

16. Tsai J, **Cardarelli GA**, Hiatt J, Shearer DR, Bradford B, DiPetrillo T, Puthawala Y,Remis M, Wazer D. ***Study of the Technology of Pin-Point CT Imaging Guide System.*** AAPM 2005.

17. Hiatt J, Purviance J, Rivard MJ, Bricault RJ, Sioshansi P, **Cardarelli GA**, Wazer D. ***Dose Modeling for Partial Breast Stereotactic Brachytherapy: A New Non-Invasive APBI Concept.*** American Society of Therapeutic Radiology and Oncology, Philadelphia, 2006.

18. Chu, J, Gong, X, Kirk, M, Khan, A., Rivard, M., Melhus, C., Busher, M, **Cardarelli, GA**, Hurley,A, Heple, J. ***Holographic Image Guided Radiation Therapy (HIGRT) Treatment Planning: a Multi-Institutional Study.*** American Society of Therapeutic Radiology and Oncology, Philadelphia 2006.

19. **Cardarelli, Gene** ***The Effects of Small Field Dosimetry on the Biological Models Used In Evaluating IMRT Dose Distributions.*** American Society of Therapeutic Radiology and Oncology, Philadelphia, 2006.

20. James C H Chu, X Gong,C Cai, M C Kirk, T.Zusag, S Shott, Mark J Rivard, C Melhus, **G Cardarelli**, A Hurley, J Hepel. ***Multi-Institutional Randomized Study to Evaluate a Holographic Display for Radiation Therapy Treatment Planning.*** **(Poster)** ASTRO, Los Angeles 2007.

21. **G.A. Cardarelli, PhD**; J.R. Hiatt, MS; Mona Sanghani, MD; B. Curran, ME; E. Sternick, PhD; T. DiPetrillo, MD; D. Wazer, MD. ***External Beam Dosimetry in The Presence of Rare Earth Magnets: u or B_o*** . Rhode Island Hospital/Brown University Alpert School of Medicine, Providence, RI 02903. **(Poster)** ASTRO, Boston 2008.

22. **G Cardarelli** *, J Hiatt, A Corrao, J Garcia-Cobian, Z Zheng, S Jang, B Curran, E Sternick, T DiPetrillo, D Wazer ***Clinical implementation of Varian OBI and CBCT using IMPAC Mosaiq R&V system.*** Rhode Island Hospital Brown University Alpert School of Medicine, Providence, RI 02903. (Poster) AAPM, Houston 2008

23. E Sternick*, **G Cardarelli**, A Corrao, B Curran, J Garcia-Cobian, J Hiatt, S Jang ***Design and Implementation of Medical Physics Criteria For Performance Excellence Based On The Baldridge National Quality Program.*** Rhode Island Hospital/Brown University Alpert School of Medicine, Providence, RI 02903. (Poster) AAPM, Houston 2008.

24. S Jang*, A Hurley, **G Cardarelli**, T DiPetrillo, A Corrao, E Sternick, D Wazer, ***Evaluation of Cone Beam CT in Prostate IMRT.*** Rhode Island Hospital/Brown University Alpert School of Medicine, Providence, RI 02903. (Poster) AAPM, Houston 2008. ASTRO Boston 2008.

25. Huber K, Hiatt J, **Cardarelli G**, Wazer DE. ***Dose Modeling of the Xoft Electronic Brachytherapy for Tandem and Ovoid Applications in Patients with Cervical Cancer.*** American Brachytherapy Society, Boston, 2008.

27. J. Hiatt, J. Hepel, M. Carol, **G. Cardarelli**, D. Wazer, E. Sternick "**Physical Principles of Intensity Modulated Electronic Brachytherapy (IMEB)** (Poster) ASTRO 2008.

28. S.Sioshansi, J. Hiatt, M. Rivard, J. Hepel, **G. Cardarelli**, S. O'Leary, D. Wazer. ***Three Dimensional Dose Modeling of the AccuBoost Mammography-based Image Guided Non-invasive Breast Brachytherapy System for Partial Breast Irradiaiton.*** (Poster) ASTRO 2008.

29. **Cardarelli, GA**, Hiatt, JT, Curran, B, Segala, Sternick, E. S., Markelewicz, R, Hepel, J.T., Puthawala, MY, Wazer, DE. ***Clinical Implementation of New Endometrial Cylinder for Electronic Brachytherapy*** (Poster AAPM 2009)

30. Curran, B, Roberts, D, **Cardarelli, G**, Sternick, E. ***Dosimetric Differneces in Dynamic MLC performance as a Result of Alignment and Software Configuration.*** Poster AAPM 2009)

31. Hiatt, J, Segela, J, **Cardarelli, G**, Sternick, E.S. ***The Utility of Depth Dose Modulation (DDM) for Electronic Brachytherapy.*** (AAPM 2009)

32. Segula, J, **Cardarelli, G**, Hiatt, J, Curran, B, Sternick, E. ***Accurate Surface Dose Determination for Electronic Brachytherapy Applicators.*** (AAPM 2009)

INVITED ORAL PRESENTATIONS

1. **Cardarelli GA**, Zheng Z and Shearer DR. ***The Investigation of the Relative Surface Dose from Symmetric and Asymmetric fields using Dynamic and Conventional Wedges.*** AAPM 1994.

2. **Cardarelli GA**, Soehl S, Testa V. ***Electronic Treatment Record in Radiation Oncology Department, Myth becomes Reality***. New England RT Meeting 1996.

3. **Cardarelli GA**, Ma CHI, Zheng Z, Hillstead R. And Shearer DR. ***Calibration Verification of Sr-90+Y-90 Ophthalmic Applicator Using a Fixed Separation Plane-Parallel Ionization Chamber.*** AAPM 1996.

4. **Cardarelli GA**, Hoey J, ***Towards an Electronic Environment***. IMPAC Users Meeting. ASTRO 1997.

5. **Cardarelli GA**, Cail D, Cintron O, Dipetrillo TA, Wazer DE, Shearer DR, ***Head Scatter Measurements of Enhanced Dynamic Wedges: Cause for Non-uniform Increase In Relative Surface Dose.*** RSNA 1999.

6. **Cardarelli, G.**, Zheng, Z, Tsai, J., Engler, M., Shearer, D. , DiPetrillo, T. , and Wazer, D. ***Practical Phantom Measurement Verification of Inversely Planned Sequential Tomotherapy*** RSNA 2001.

7. **Cardarelli GA**, Donovan G, Shearer DR, ***The Use of Optically Stimulated Luminescent Dosimeters to Investigate Assumptions Made During Shielding Designs for Radiation Therapy Units.*** World Congress on Medical Physics and Biomedical Engineering 2000.

8. **Cardarelli, GA.** ***Advances in CT Simulator Technology.*** *NEAAPM Mini-Symposium on CT Dosimetry and CT Simulation* April 2002.

9. **Cardarelli, GA.** Zhen Zheng, Ph.D.,Nichole O'Connell, O. Cintron, CMD, Anita Corrao, CMD, Annette Harris, Amelia Laurence, Thomas DiPetrillo, M.D. and Douglas Shearer, Ph.D. ***Advances in CT Simulator Technology*** AAMD 2003.

10. **Cardarelli, GA**, Zheng, Z, O'Connell, N, Rivard, M, DiPetrillo, T, Shah, N, Shearer, D,and Wazer,D. ***Multiple Dwell Positions with the MammoSite HDR Applicator*** 24th American Brachytherapy Society Meeting May 2003.

11. J-S. Tsai, Ph.D.◈ ✚, C. Bradford, Ph.D.✚, **G. Cardarelli, MS, MPH◈**, D. Shearer, Ph.D.✚, G. Norén, MD, Ph.D.✚, M. Remis, MD✚, Y. Puthawala, MD✚, T. DiPetrillo, MD✚, and D. E. Wazer, MD. ***Exploration and Feasibility of Hybrid Collimator Helmets in Gamma Knife Radiosurgery.*** ICMP2005/BMT2005 Nuremberg, September 14-17, 2005.

12. **Cardarelli, GA *Clinical Implementation of Biological Modeling for IMRT* New England Chapter** AAPM Summer Meeting June 9,2006.

13. **Cardarelli, GA *Electronic Brachytherapy* New England Radiological Health Committee** October 2006.

14. **Cardarelli, GA Early *Axxent® Electronic Brachytherapy System Implementation Experience at Rhode Island Hospita,*** Xoft Symposium on Early Clinical Implementation held at the AAPM meeting July 24, 2007.

15. Joshua Napoli, Sandy Stutsman, Actuality Systems, Inc.; James C.Chu, Xing Gong, RushUniv. Medical Ctr.; Mark J. Rivard, Tufts-New England Medical Ctr.; **Gene A. Cardarelli**, Rhode Island Hospital; Thomas P. Ryan, Gregg E. Favalora, Actuality Systems, Inc. ***Radiation therapy planning using a volumetric 3D display: PerspectaRAD***, SPIE/IS&T Stereoscopic Displays and Applications 2008 (oral presentation): [6803-36]

16. **Cardarelli, GA**, Curran, B, Hiatt, Sternick, E *Role of the Physicist in Medicine,* University of Rhode Island Physics Colloquium. April 2008.

17. Hiatt, JR, Jaroslaw Hepel, MD, **G. Cardarelli, PhD**, Mark Carol, MD, Edward S.Sternick, PhD, David E. Wazer, MD ***Depth Dose Modulation (DDM) for Electronic Brachytherapy.*** American Brachytherapy Society Meeting Boston 2008.

18. Hiatt JR, **Cardarelli GA**, Wazer DE, Sternick ES. ***Principles and Practice of Electronic Brachytherapy.*** Oral Presentation, IAEA - International Conference on Advances in Radiation Oncology, Vienna, Austria, April 2009.

19. Sioshansi S, Hiatt JR, Rivard MF, Hurely AA, Lee Y, Hepel JT, **Cardarelli GA**, O'Leary S, Wazer DE. ***A dosimetric comparison of the AccuBoost noninvasive partial breast brachytherapy to electron beam tumor bed boost and 3-D conformal accelerated partial breast irradiation***. American Brachytherapy Society, Toronto, May 2009.

20. Markelewicz RJ, Hiatt JR, Hepel JT, **Cardarelli GA**, Sternick ES, Wazer DE, MacAusland SG. ***A comparison of the biological effective dose of 50 KV electronic brachytherapy to 192Ir high-dose-rate brachytherapy for vaginal cuff irradiation.*** Oral Presentation (Markelewicz), American Brachytherapy Society, Toronto, May 2009.

21. Segala J, **Cardarelli GA**, Hiatt JR, Sternick ES. ***Interface dosimetry for Electronic Brachytherapy Xoft Balloon Applicators.*** Oral Presentation (Segala), American Brachytherapy Society, Toronto, May 2009

22. Hiatt JR, Segala J, **Cardarelli GA**, Sternick ES. ***Treatment Planning Considerations for Electronic Brachytherapy (EB) Vaginal Cylinder***

Applicators. Poster, American Brachytherapy Society, Toronto, May 2009.Hiatt JR. Electronic Brachytherapy. Invited Presentation. Fox Chase Cancer Center Annual Radiation Oncology Conference, Philadelphia, May 2009.

GRANTS

1. ($15,000) *IMRT QA PHANTOM EVALUATION* (PRINCIPLE INVESTIGATOR) MED-TEC, P.O.BOX 320, ORANGE CITY, IOWA,51041 12/12/00.

2. ($90,000) *LARGE BORE CT COMPARISON TO CONVENTIONAL CT*, (CO-INVESTIGATOR). PHILIPS MEDICAL SYSTEMS. CLEVELAND, OHIO 06/06/02.

3. ($40,000) *The PinPoint CT Scanner Integrated Stereotactic Arm EVALUATION* (CO-INVESTIGATOR) PHILIPS MEDICAL SYSTEM, CLEVELAND, OHIO. JUNE 9,2004.

AWARDS

1. ($2000) BEST FELLOWSHIP AWARD AAPM 2007

HOSPITAL TEACHING ROLES

1. BASIC DOSIMETRY - RHODE ISLAND HOSPITAL RADIATION THERAPY SCHOOL 1994-1997 (3-6 STUDENTS PER YEAR)

2. RADIATION ONCOLOGY QA AND SAFETY – RHODE ISLAND HOSPITAL RADIATION THERAPY SCHOOL 1994-1997 (3-6 STUDENTS)

FORMAL GRADUATE TEACHING ROLES

1. MEDICAL PHYSICS – UNIVERSTIY OF MASSACHUSETTES – LOWELL GRADUATE SCHOOL SPRING 2007 (15 GRADUATE STUDENTS).

2. RADIATION ONCOLOGY PHYSICS – TUFTS UNIVERSITY SCHOOL OF MEDICINE NEW RESIDENTS CRASH COURSE July 2007 (1 RESIDENT).

3. RADIATION ONCOLOGY PHYSICS – TUFTS UNIVERISTY SCHOOL OF MEDICINE RESIDENTS ABR BOARD REVIEW COURSE September 2007-MAY 2008. (8 RESIDENTS)

4. MEDICAL PHYSIC – UNIVERSITY OF MASSACHUSETTES – LOWELL GRADUATE SCHOOL SPRING 2008 – SPRING 2009 (6 GRADUATE STUDENTS)

MEDICAL PHYSICIST RESIDENT PROGRAM

CHI-HSIANG MA, MS. 1994
CHRISTOPHER HORTON, PhD 1995
DIANE KASE, PhD. 1996
DONG JON CHEN, PhD 1998
KAZI HUSSAIN, PhD 2001
JEOMSOON KIM, PhD 2004

DOSIMETRIST TRAINEES

NICOLE O'CONNELL, BS 2003
JESSICA HIATT, BS 2004

GRADUATE MEDICAL PHYSICS STUDENT ADVISORSHIP
Jessica Hiatt, PhD 2006-2009 PhD Thesis Advisor
Anita Corrao, MS 2007-2008 MS Internship Advisor
Amanda Hurley, 2007-2009 MS Thesis Advisor
James Segala, PhD 2008 – 2009 Thesis Advisor/Medical Physics Intern

PERSONAL INFORMATION GENE A. CARDARELLI, PhD, MPH

Date of Birth:	MAY 9,1961
Place of Birth:	BOSTON
Citizenship:	U.S.
Social Security Number	
Home Address	26 FALCON RIDGE DRIVE EXETER, RI 02822

CURRICULUM VITAE

DONNA M. HANDLEY, M.A., R.N., B.S.N.

HOSPITAL ADDRESS:

Vice President, Cancer Program
Helen & Harry Gray Cancer Center
Hartford Hospital
80 Seymour Street
Hartford, Connecticut 06102-5037
Tel: 860.545.4673
Fax: 860.545.4079
Cell: 860.716.2217

HOME ADDRESS:

161 Hunter Drive
West Hartford, CT 06107

EDUCATION:

2005 Siena Heights University
Adrian, Michigan
Master of Arts in Health Care Administration

1979 Northeastern University
Boston, Massachusetts
BSN

CERTIFICATION:

1996 Oncology Nursing Certification

EXPERIENCE:

March 2009 – Present

Vice President, Cancer Program
Hartford Hospital, Helen & Harry Gray Cancer Center

- Responsible for
  - service line development
  - strategic plan development and implementation
  - development of integrated oncology services across Hartford Healthcare

October 2006 – March 2009

Vice President, Clinical Services
St. John Hospital and Medical Center

- Responsible for the following service lines:
  - Surgery
  - Cardiovascular Care
  - Pharmacy
  - Imaging
  - Oncology
  - Anesthesia
  - Perfusion
  - Neurodiagnostics

November 2007 - Present
Executive Sponsor
Oncology Clinical Network
St. John Health

- Responsible for directing and leading a systems approach to oncology care
- Develop and implement short and long term goals for the service line
- Develops a shared strategic vision to support the goals of the Health System

December 2002 – October, 2006
Administrative Director Oncology Services
St. John Hospital and Medical Center

- Responsible for oncology program operations and strategic planning
- New business development
- Continued primary responsibility for programs within the Van Elslander Cancer Center
- Participation in the development of St. John Health System Oncology Clinical Network.

August 2001 – December 2002
Manager/Concierge
Van Elslander Cancer Center
St. John Hospital and Medical Center

- Responsible for operational management of the cancer center, including property management and facility services staff
- Manager of Radiation Oncology
- Responsible for supervision of ancillary support services staff assigned to cancer center, such as imaging staff, lab staff, registration staff and maintenance and engineering

- Responsible for operations in the infusion center, acting as liaison between private practice physicians, pharmacy, administration and nurses
- Responsible for development of cancer center policies and procedures, including the infusion center and radiation oncology
- Responsible for annual operating and capital budget
- Clinical responsibility for coordinating of patient care, with the goal of integrating multi-disciplinary approaches of care to provide physical, emotional, psychological and spiritual care to patients
- Program development within the oncology product line
- Chairperson of service line meetings
- Assists in coordinating screening programs
- Responsible for leading multi-disciplinary JCAHO task force to a successful survey
- Responsible for developing and implementing common documentation forms within cancer center
- Liaison with St. John Health Foundation, Philanthropy

November 1999 – August 2001

Clinical Project Manager
Van Elslander Cancer Center Capital Project
St. John Hospital and Medical Center

- Member of Steering Committee
- Chair of Occupancy Planning Group
- Responsible for planning move of radiation therapy department from hospital to cancer center
- Responsible for Furniture, Fixture and Equipment budget and ordering of furniture and equipment for the cancer center
- Liaison with architects, design staff and construction crew
- Primary user representative for all clinical and operational issues as related to design and construction issues
- Organized the redesign of the Healing Arts Center, Breast Center and Radiation Oncology departments into a comprehensive program
- Coordinate with hospital departments to establish services for patients at the cancer center: valet, reception, patient registration, imaging services, laboratory, materials management, support services
- Responsible for structuring a practice model for nurses within the infusion center.
- Develop processes for delivery of patient services in the cancer center

December 1995 – November 1999

Radiation Oncology Nurse
St. John Hospital and Medical Center

- Responsible for primary care and education of patients in the Radiation Oncology Department
- Facilitator of Cancer Support Groups offered by St. John Hospital and Medical Center
- Coordinator of Look Good, Feel Better program at St. John Hospital and Medical Center, sponsored by the American Cancer Society
- Planning member of a patient education video, Cancer Care at St. John Hospital and Medical Center
- Team Leader of Radiation Oncology Continuous Quality Improvement

June 1993 – December 1995

Medical Oncology Nurse
John Burrows, M.D.

- Responsible for administration of chemotherapy and management of clinical services of a primary oncology practice
- Responsible for ordering chemotherapy and clinical supplies
- Responsible for maintaining Clia Standards in laboratory

September 1989 – June 1993

Staff Nurse – Short Stay Unit
Bon Secours Hospital
Grosse Pointe, Michigan

- Primarily caring for extended recovery patients, post-cardiac catheterization patients and inpatient chemotherapy patients
- Staff nurse representative on the Nursing Management Council

January 1984 – September 1989

Staff Nurse
Massachusetts General Hospital
Boston, Massachusetts

- Provided nursing care on a general surgical unit

September 1981 – July 1983

Visiting Nurse
Laboure Visiting Nurse Service
South Boston, Massachusetts

- Provided nursing care for the underprivileged
- Responsible for Health Promotion Program at Senior Citizen Centers

January 1976 – April 1981

Staff Nurse
Massachusetts General Hospital
Boston, Massachusetts

- Provided nursing care on a thoracic surgical step down after graduation from Northeastern University
- Northeastern University co-operative education student, working as a full-time student for six months each year, part-time the remaining six months, rotating throughout the hospital

FACULTY APPOINTMENT:

September 1988 – June 1989
Clinical Instructor
Aquinas Junior College
Milton, Massachusetts

PROFESSIONAL SOCIETIES:

American College Healthcare Executives
Association of Cancer Executives
Oncology Nursing Society
Metropolitan Chapter Oncology Nursing Society
ONS Radiation SIG Group
Sigma Theta Tau - National Honor Society for Professional Nurses

COMMITTEES:

Member	Cancer Committee	1995 – Present
Member	QVLT (Quality Values Leadership Team)	2003 - Present
Member	Bristol Myers Squibb Distinguished Faculty	1996 – 2000
Member	Metropolitan Detroit Coalition for Cancer Survivorship	1997 - 2000
Member	Oncology Improvement Council	2001 – 2008
Member	JCAHO Steering Committee	2001 – Present
Member	Quality Committee of the Board	2007 - Present

BOARD MEMBERSHIP:

Member	Wigs 4 Kids	2003 – Present
Member	Services for Older Citizens	2008 - Present

Susan A. O'Connell, M.Ed., R.T. (T)

Business Address
Hartford Hospital
Dept of Radiation Oncology
80 Seymour Street
Hartford, CT 06115
Tel. (860) 545-2803

Home Address
57 Coram Street
Hamden, CT 06517
Tel. (203) 281-6885

EDUCATION

1968-1972	**H.S.**, Sacred Heart Academy, Hamden, CT
1972-1974	**A.S.**, South Central Community College, New Haven, CT
1985-1994	Central Connecticut State College
1994-1997	**M.Ed.,** Cambridge College, Cambridge, MA

LICENSE & REGISTRATION

1974-Present	American Registry of Radiologic Technologists, #101938
1995-Present	State of CT, Department of Public Health, P#1090

APPOINTMENTS

1974-1976	**Saint Francis Hospital,** Hartford, CT Staff, Radiation Therapist, Department of Radiation Oncology
1976-1978	**Hartford Hospital,** Hartford, CT Staff, Radiation Therapist, Department of Radiation Oncology
1978-1980	**Hospital of St. Raphael,** New Haven, CT Staff, Radiation Therapist, Department of Radiation Oncology
1982-present	**Hartford Hospital**, Hartford, CT 1982: Staff Radiation Therapist, Department of Radiation Oncology 1982-1984: Simulator Radiation Therapist, Department of Radiation Oncology 1985-1987: Technical Supervisor, Department of Radiation Oncology 1987-1989: Development of Hartford Hospital Radiation Therapy Technology Program, Department of Radiation Oncology 1989-1996: Program Director, Department of Allied Health 1996-2009: Operations Manager, Department of Radiation Oncology 2009-present: Director, Department of Radiation Oncology
1994-1996	**Manchester Community Technical College**, Manchester, CT Adjunct Faculty, Distance Learning for Cox Cable TV and MCTC

PROFESSIONAL APPOINTMENTS

1974-1999	**New England Conference of Radiologic Technologies** 1986, 1987, 1996, 1999: Chairperson, Radiation Therapy Program 1988-1997: Board of Directors
1986-Present	**New England Society of Radiation Therapists** 1990-1996: Chairperson, Registry Review Course 1994- Present: Executive Board
1996	**American Society of Radiologic Technologists** Committee member, Standards of Practice in Radiation Therapy Technology
1993-1996	**New England Association of Allied Health Educators** 1994, 1995: Co-Chairperson, Annual Conference 1996: Vice-President
1995-2006	**Joint Review Committee on Education in Radiologic Technology** Chicago, Illinois Accreditation Site-Visitor

CERTIFICATES OF COMPLETION

1991	**Developing Written Tests** University of Kentucky
1991	**Developing Educational Strategies for Clinical Lab** University of Kentucky
1991	**Managing Multiple Priorities** American Management Association
1992	**Affective and Psychomotor Evaluations** University of Kentucky
1996	**Promoting Critical Thinking** University of Kentucky
1996	**Creative Problem Solving** University of Kentucky
1996	**Building Better Training Programs** American Management Association

CURRICULUM VITAE

ANDREW L. SALNER, M.D., F.A.C.R.

HOSPITAL ADDRESS:

Director of the Cancer Program
Helen & Harry Gray Cancer Center
Hartford Hospital
80 Seymour Street
Hartford, Connecticut 06102-5037
Tel: (860) 545-2852

HOME ADDRESS:
87 Pilgrim Road
West Hartford, CT 06117

EDUCATION: 1973 Sc.B. Brown University
1976 M.D. Brown University

POSTDOCTORAL TRAINING:

Internship and Residencies

1976-1977 Intern in Medicine, Hartford Hospital, Hartford, CT
1977-1978 Resident in Medicine, Hartford Hospital, Hartford, CT
1978-1981 Resident in Radiation Therapy, Joint Center for Radiation Therapy, Harvard Medical School, Boston, MA:
Beth Israel Hospital
Brigham and Women's Hospital
Children's Hospital Medical Center
New England Deaconess Hospital
Dana Farber Cancer Institute

Research Fellowship

1980-1981 Research Fellow in Radiation Therapy, Joint Center for Radiation Therapy, National Institute of Health Training Grant

LICENSURE AND CERTIFICATION:

1977 Diplomate, National Board of Medical Examiners
1978 Massachusetts License Registration
1981 American Board of Radiology, Therapeutic Radiology Certificate
1982 Connecticut License Registration

ACADEMIC APPOINTMENTS:

1981-1982 Instructor in Radiation Therapy, Joint Center for Radiation Therapy, Harvard Medical School, Boston, MA
1982-2002 Assistant Clinical Professor of Radiology, University of Connecticut Health Center, Farmington, CT
2002- Associate Clinical Professor of Radiology University of Connecticut Health Center, Farmington, CT

HOSPITAL APPOINTMENTS:

1981-1982	Assistant in Radiation Therapy, Beth Israel Hospital, Boston, MA
1981-1982	Staff Radiation Oncologist, Joint Center for Radiation Therapy, Harvard medical School, Boston, MA
1982-	Director of Radiation Oncology, Hartford Hospital, Hartford, CT
1984-1998	Director of Radiation Oncology, John Dempsey Hospital and The University of Connecticut Health Center, Farmington, CT
	Consultant in Radiation Oncology::
1996-	CT Children's Medical Center, Hartford, CT
1998-	Eastern Connecticut Health Network, Manchester, CT
1999-	John Dempsey Hospital, Farmington, CT
1998-	Johnson Memorial Hospital, Stafford Springs, CT
1998-2008	Medical Director, Northeast Regional Radiation Oncology Network
1988-	Medical Director, School for Radiation Therapy Technology, Hartford Hospital
1991-	Director of the Cancer Program and the Helen & Harry Gray Cancer Center, Hartford Hospital, Hartford, CT

AWARDS AND HONORS:

1976	Sigma Xi
1989	George Sheehan Humanitarian Award, American Cancer Society
1990	American Cancer Society Leadership Award
1992	Community Service Award, Hartford County Medical Assoc.
1998	St. George Medal, National Divisional Leadership Award, American Cancer Society
2001	Fellowship, American College of Radiology
2006	Lane Adams Quality of Life Award, American Cancer Society

MAJOR COMMITTEE ASSIGNMENTS:

1981-1982	Committee on Optimization of Radiation Dose Distribution, Joint Center for Radiation Therapy
1982-	Cancer Committee, Radiation Safety Committee, Hartford Hospital
1982-1992	Medical Affairs Committee, American Cancer Society, Connecticut Division 1988-1989, Vice Chairman; 1989-1992, Chairman
1983-1985	Board of Directors, American Cancer Society, Hartford Unit
1985-1992	Cancer Committee, Radiation Safety Committee, University of Connecticut Health Center
1986-1997	Breast Cancer Committee, American Cancer Society, Connecticut Division
1986-1992	Vice Chairman, Environmental Safety Committee, University of Connecticut Health Center

1986-1989	Chairman, Public Education Committee, American Cancer Society, Hartford Unit
1987-1997	Executive Committee, Connecticut Oncology Association
1988-1993	Executive Committee, New England Cancer Society
1989-1991	Vice President, American Cancer Society, Hartford Unit
1989-1997	Executive Committee and Board of Directors, American Cancer Society, Connecticut Division
1990-	Chairman, Radiation Safety Committee, Hartford Hospital
1991-1993	President, American Cancer Society, Hartford Unit
1993-1995	Vice President & Chairman, Cancer Control and Field Services Committees, American Cancer Society, Connecticut Division
1995-1997	President, American Cancer Society, Connecticut Division Inc.
1997-1999	Chair, Board of Directors, American Cancer Society, New England Division
1997-	Member, Board of Directors, Hartford Hospital
1997-	Member, Executive Committee of the Board, Hartford Hospital
1997-	Member, Board of Directors, Hartford Health Care Corporation
1997-2003	Member, Board of Directors, American Cancer Society New England Division
1998-2000	Vice-Secretary and Member, Executive Committee, New England Cancer Society
2000-2003	Secretary, Executive Committee, New England Cancer Society
2000-2006	Member, Nationwide Business Group on Voluntarism, American Cancer Society
2000-2003	Chair, CEO Advisory Committee on Volunteerism, American Cancer Society, New England Division
2001-2007	Chair, National Task Force on Physician Engagement, American Cancer Society
2002-2004	Member, Stakeholder Subcommittee, American Cancer Society, National
2006-2008	Co-Chair, Nationwide Business Group on Voluntarism, American Cancer Society
2003-	Member, CT Radiation Response Plan Committee
2003-	Member, CT Comprehensive Cancer Control Plan Core Consortium
2003-2008	Co-Chair, Treatment Subcommittee, CT Comprehensive Cancer Control Plan
2003-	Chair, ASTRO Nuclear Radiologic Preparedness Committee
2004-2010	Chair, Board, Connecticut Cancer Partnership (state comprehensive cancer control coalition)
2005-	Medical Delegate, New England Division, National Assembly, American Cancer Society
2007-	Chair, Board of Directors, Hartford Healthcare Corporation
2007-2008	Member, National Nominating Committee, American Cancer Society
2008-	Member, Talent Strategy Advisory Committee, American Cancer Society
2009-	Member, Prostate Cancer Advisory Committee, American Cancer Society
2009-	Bylaws Committee, American Cancer Society
2010-	Immediate Past Chair, Connecticut Cancer Partnership

PROFESSIONAL SOCIETY MEMBERSHIPS:

1976	Brown Medical Society
1980	American College of Radiology
1981	American Society of Therapeutic Radiology & Oncology
1981	American Society of Clinical Oncology
1982	Connecticut Radiological Society
1983	American Medical Association
1985	Hartford County Medical Society

MAJOR RESEARCH INTERESTS

1978-1982	1. Physiology of bone marrow stem cells 2. Modification of bone marrow stem cell self renewal 3. Delivery of optimized dose distribution by computer controlled radiation therapy
1996-	1. Cancer communications - Providing information and Support to Cancer Patients & Families. 2. Quality of Life of Cancer Survivors
2003-	1. Cancer Early Detection in Underserved Populations
2006--	1. Radiologic/nuclear incident preparedness

CURRENT and RECENT RESEARCH

Lance Armstrong Foundation 10/08-9/11
Community Grant
Salner, PI
Hartford Hospital is selected for one of eight grants in the US, and will study the impact of survivorship navigation in helping breast cancer patients learn about and be empowered by survivorship skills and strategies.

Moffitt Cancer Center 9/08-8/13
Total Cancer Care, Tampa, FL
Salner, PI
Hartford Hospital is one of 16 hospital's in the US to join with H.Lee Moffitt Cancer Center in a leading biospecimen program studying molecular and genetic fingerprints of tumors to ultimately develop personalized therapies for cancer patients,

NCI Community Cancer Centers Program 7/07-7/10
National Cancer Institute
SAIC-Frederick, Contractor
Salner, PI
Hartford Hospital is one of ten entities in the US to receive this Pilot subcontract, focusing on how the NCI can work with community hospitals to enhance cancer clinical research, efforts to improve disparities, biospecimen handling, electronic information systems, quality of care models, and survivorship programs.

Center for Disease Control and Prevention 7/5-7/07
National Cancer Prevention and Control
Special Projects Grant-Connecticut
U55/CCU121932-04

Salner PI
REACHING URBAN AFRICAN AMERICAN MEN WITH PROSTATE CANCER SCREENING INFORMATION
This study explores how to overcome barriers to information provision and screening for underserved men at increased for prostate cancer. It is in collaboration with CT's

Department of Public Health, and the Connecticut Cancer Partnership, the statewide comprehensive cancer control effort in CT.
Role: PI

1 R01 NR008260-01 1/05-3/08
Gustafson PI
Web-Based Support for Informal Caregivers in Cancer
This study is looking at reducing caregiver burden through the use of CHESS (Comprehensive Health Enhancement Support System) through information, skills building and emotional support.
Role: Consultant

1 P50 CA095817-01A1 9/03-8/08
Gustafson PI
Centers of Excellence in Cancer Communications: Component and Couple Analysis of Cancer Communication

This study is looking at patient outcomes related to different types of services delivered through CHESS (Comprehensive Health Enhancement Support System) comparing the additive/interactive efficacy of three different types of CHESS intervention components.
Role: Consultant

1 P50 CA095817-01A1 9/03-8/08
Gustafson PI
Centers of Excellence in Cancer Communications: Mentor Integration Project
This study is looking at the efficacy of CHESS (Comprehensive Health Enhancement Support System), Cancer Mentors and the integration of the two services to improve quality of life for women recently diagnosed with breast cancer.
Role: Consultant

PRINCIPAL CLINICAL RESPONSIBILITIES:

1980-1982	Principal Investigator, Clinical Investigations, Computer Controlled Radiation Therapy Project, Joint Center for Radiation Therapy, Harvard Medical School, Boston, MA Attending Physician, Breast Evaluation Clinic, Dana-Farber Cancer Institute, Boston, MA
1982-	Director of Radiation Oncology Hartford Hospital, Hartford, CT
1984-1998	Director of Radiation Oncology, John Dempsey Hospital, and The University of Connecticut Health Center, Farmington, CT
1991-	Director of the Cancer Program and the Helen & Harry Gray Cancer Center, Hartford Hospital, Hartford, CT
2007-	Principal Investigator, NCI Community Cancer Centers Program (NCCCP), Hartford Hospital

BIBLIOGRAPHY:

Original Reports:

1. Salner AL, Mullany LD, Cole SR. Methysergide induced mitral valvular regurgitation. Conn. Med. 1980, 44:6-8.
2. Salner AL, Botnick LE, Herzog AG, Goldstrin MA, Harris JR, Levene MB, Hellman S. Reversible brachial plexopathy following primary radiation therapy for breast cancer. Cancer Treat Rep. 1981, 65:797-802.
3. Salner AL, Obbagy JE, Hellman S. Differing stem cell self renewal of lectin separated murine bone marrow fractions. J Natl Cancer Inst. 1982, 68:693-641.
4. Salner AL, Alternatives in the management of early breast cancer. Hartford Hospital Bulletin. 1984, 30-34.
5. Ergin MT, Salner AL, et al, Consensus Statement by the Breast Cancer Task Force. Conn. Med. 1987, 51:311-313.
6. Saleh J, Silberstein HJ, Salner AL, Uphoff DF. Meningioma: The Role of Foreign Body and Irradiation in Tumor Formation. Neurosurgery. 1991, 29:113-118.
7. Salner AL, Greenberg S., and Rice RE. Cancer as a Cross-Service Program. in Stetler CB, Charms MP. Collaboration in Health Care. Chicago, American Hospital Association, 1995.
8. Salner AL. Lymphedema Following Prostatectomy and Radiation Therapy Cancer Practice. 1998, 6:73-76.
9. Salner AL, Edwards A, Kuzmickas P, McIntyre D, Rice R. A Regional Radiation Oncology Network is Developed to Meet Community Needs. Managed Care & Cancer. 1999, 1:10-13.
10. Distasio S, Salner A, Brant J, Fischburg D. Brachial Plexopathy After Treatment for Breast Cancer. Cancer Practice. 2000, 8:110-113.
11. Gustafson DH, Hawkins RP, Pingree S, McTavish F, Arora NK, Mendenhall JH, Cella DF, Serlin RC, Apantoku Fm, Stewart J, Salner A,. Effect of Computer Support on Younger Women with Breast Cancer. J Gen Intern Med. 2001:16:435-445.
12. Boberg E, Gustafson DH, Hawkins P, Offord KP, Koch C, Wen KY, Kreutz K, Salner A. Assessing the Unmet Information, Support and Care Delivery Needs of Men with Prostate Cancer. Patient Education and Counseling. 2003;49(3):233-242.
13. Staff I, Salner A, Bohannan R, Panatieri P, Maljanian R, Disease Specific Symptoms and General Quality of Life of Patients with Prostate Carcinoma before and after Three-Dimensional Conformal Radiotherapy. Cancer. 2003;98:2335-2343.
14. Dainiak N, Delli Carpini D, Bohan M, Werdman M, Wilds E, Barlow A, Beck C, Cheng D, Daly N, Glazer P, Mas P, Nath R, Piontek G, Price K, Albanese J, Roberts K, Salner A, Rockwell S. Development of a Statewide Hospital Plan for Radiologic Emergencies. Int J Radiation Oncology Biol Phys. 2006, 65:16-24.
15. Alexander G, Swartz H, Amundson S, Blakely W, Buddemeier B, Gallez B, Dainiak N, Goans R, Hayes R, Lowry P, Noska M, Okunieff P, Salner A, Schauer D, Trompier F, Turteltaub K, Voisin P, Wiley A, Wilkins R. BiodosEPR-2006 Meeting: Acute dosimetry consensus committee recommendations on biodosimetry applications in events involving uses of radiation by terrorists and radiation accidents. Radiation Measurements. 2007, 42: 972-996.

16. Krasna, M., Petrelli, N., Salner, A. "Part I Multidisciplinary Cancer Care: A New Model for Community Cancer Centers." *The Journal of Multidisciplinary Cancer Care*. 2009, vol. 1(5)
17. Krasna, M., Petrelli, N., Salner, A. "Part II Roundtable on Multidisciplinary Care: The NCCCP." *The Journal of Multidisciplinary Cancer Care*. 2009, vol. 2(5).
18. Mary L. Fennell, Irene Prabhu Das, Steven Clauser, Nicholas Petrelli, and Andrew Salner The Organization of Multidisciplinary Care Teams: Modeling Internal and External Influences on Cancer Care Quality. J Natl Cancer Inst Monogr 2010: 72-80; doi:10.1093/jncimonographs/lgq010

ABSTRACTS:

1. Botnick LE, Salner A, Herzog A, Goldstein M, Harris J, Levene M, Hellman S. Brachial plexus neuropathy following definitive irradiation for breast cancer - an uncommon and reversible entity. Proc Am Soc Clin Oncol. 1980, 21:394.
2. Salner AL, Kijewski PK, Chin LM, Bloomer WD, Chaffey JT, And Rose CM. The clinical application of computer-controlled radiation therapy. Int J Radiat Oncol Biol Phys. 1981, 7:1248
3. Salner AL, Pinkerton A, Mas P, Kwok V, Cavanaugh N. Iridium-192 implantation in the treatment of paranasal sinus carcinoma. Int J Radiat Oncol Biol Phys. 1988, 15:223
4. Cheng Y, Salner AL, Brady E, Ricci A, Ductal Carcinoma In Situ of the Breast. Proc. New England Cancer Society. 1997, 30.
5. Ward, D., Staff, I., Ford, J., Salner, A. (2004). Descriptive study of breast cancer patients' patterns of use and satisfaction with the Internet-based information and support program CHESS (Comprehensive Health Enhancement Support System). *Oncology Nursing Forum*, 31(2), 422.
6. Hawkins, R.P., Pingree, S., Shaw, B., Serlin, R.C., Swoboda, C. , Han, J., Carmack-Taylor, C. and Salner, A., 2008-05-21 "Mediating Porcesses and Effects of Two Communication Interventions for Breast Cancer Patients" *Paper presented at the annual meeting of the International Communication Association, TBA, Montreal, Quebec, Canada Online <PDF>. 2009-05-23 from http://www.allacademic.com/meta/p233943_index.html*

PERSONAL DATA:

Date of Birth: May 16, 1951
Place of Birth: Philadelphia, Pennsylvania

CURRICULUM VITAE

NAME: Helaine F. Bertsch, M.D.

ADDRESS: 53 Deer Run
Avon, CT 06001
Telephone: 860-404-0860 (h)
860-545-2803 (w)
Email: hbertsc@harthosp.org

BORN: December 9, 1967
Flushing, New York

EDUCATION:

1989 - 1993	M.D. - University of Vermont - Burlington, Vermont
1985 - 1989	B.A. - State University of New York at Binghamton (Binghamton University) - Binghamton, New York

POST GRADUATE TRAINING;

1997 - 1998	Fellowship in the Department of Radiation Oncology Hospital of University of Pennsylvania - Philadelphia, PA
1996 - 1997	Chief Resident in the Department of Radiation Oncology University of Maryland Medical Systems - Baltimore, Maryland
1994 - 1996	Resident in the Department of Radiation Oncology University of Maryland Medical Systems - Baltimore, Maryland
1993 - 1994	Internship in Internal Medicine, State University Hospital of New York at Stony Brook - Stony Brook, New York

SUB-SPECIALITY ROTATION DURING TRAINING:

2/97 - 3/97	Genitourinary Service, Department of Radiation Oncology Massachusetts General Hospital Boston, Massachusetts
1/97 - 2/97	Gastrointestinal Service, Department of Radiation Oncology Massachusetts General Hospital Boston, Massachusetts

9/96 - 10/96	Pediatric Service, Department of Radiation Oncology University of Pennsylvania Philadelphia, PA
11/95	Breast Service, Department of Radiation Oncology Fox Chase Cancer Center Philadelphia, PA

CERTIFICATION:

Diplomat of the National Board of Medical Examiners
Diplomat of the American Board of Radiology, June 1998
Recertification ABR, October 2008

PROFESSIONAL MEMBERSHIP:

Alpha Phi Fraternity
American College of Radiology
American Medical Association
American Society of Therapeutic Radiology and Oncology
American Society of Women Radiologists
Connecticut State Medical Society
Psi Chi Honor Society

NON-CLINICAL ACTIVITIES:

1996 - 1997	Co-coordinator of Education Program for Residents in Radiation Oncology
1994 - 1997	Monthly Lecturer in Clinical Radiation Oncology for Rotating Medical Students
2/99 - present	Lecturer in Clinical Radiation Oncology for Radiation Therapy Students, Pediatrics and Breast Cancers
7/98 - present	Assistant Clinical Professor, University of Connecticut
2/99 - present	Yearly Lecturer to the Dental Residents on Head and Neck
Clinical	Radiation Oncology
6/00 - present	Yearly Lecturer in Clinical Radiation Oncology for Radiation Therapy Students for their Registry Review course

RESEARCH:

Vines E, Bertsch HF, Goldwein JG. Radiotherapy. Tumors of the Pediatric Central Nervous System. Keating, Goodrich and Packer. Thieme publishers (in press)

Chang JH. Vines E. Bertsch H. Fraker DL. Czerniecki BJ. Rosato EF. Lawton T. Conant EF. Orel SG. Schuchter L. Fox KR. Zieber N. Glick JH. Solin LJ. The impact of a multidisciplinary breast cancer center on recommendations for patient management: the University of Pennsylvania experience. *Cancer. 91(7):1231-7, 2001 Apr 1.*

Bertsch HF, Schultz DJ, Fox K, Staley J, Vines E, Glick J, Solin LJ. Ten Year Outcome After Combined Modality Therapy for Inflammatory Breast Cancer. (Poster presentation October 1998, American Society for Therapeutic Radiology and Oncology) Submitted May 1999 to Journal of Clinical Oncology

Bertsch HF, Rudoler S, Needle M, Molloy P, Sutton L, Belasco J, Meadows A, Goldwein JG. Emergent/Urgent Therapeutic Irradiation in Pediatric Oncology:
Patterns of Presentation, Treatment, and Outcome (Medical and Pediatric Oncology, in 30:101-105,1998)

Bertsch HF, Ames JW, Griner J, Cotto-Cumba C, Myers RAM. Hyperbaric oxygen in the prevention of osteoradionecrosis of the mandible. (Oral presentation May 1997, American Radium Society)

Bertsch HF, Cotto-Cumbra C, Ames JW, Myers RAM. Hyperbaric oxygen in the treatment of soft tissue radionecrosis in the head and neck. (Oral presentation June 1997, Undersea and Hyperbaric Medical Society)

Bertsch HF, Zietman AL, Shipley W. Neoadjuvant hormones in prostate cancer: Animal models and clinical results. (Molecular Urology, in 1:2/3:159-167, 1997)

LaCouture TA, Bertsch HF, Ruffer JE, Golden J, Goldwein JW. OncoLink Electronic Case of the Month-December 1997 [posted, December21] OncoLink: The University of Pennsylvania Cancer Resource [Resource on the World-Wide-Web]; URL: "http//www. oncolink.upenn.edu/specialty/ped". Available from the Internet. Accessed 1997, December 21.

Anderson PR, Bertsch HF, Guttenberg M, Womer R, Goldwein JW. OncoLink Electronic Case of the Month-January 1998 [posted 1998, January 12] OncoLink: The University of Pennsylvania Cancer Resource [Resource on the World-Wide-Web]; URL: "http://oncolink.upenn.edu/specialty/ped-onc/cotm/jan98/". Available from the Internet. Accessed 1998, January 12.

Curriculum Vitae

Timothy S. Boyd, M.D.

ADDRESS: Hartford Hospital
The Gray Cancer Center
80 Seymour St.-P.O. Box 5037
Hartford, CT 06102-5037
Tel: (860)-545-2803; Fax: (860)-545-1500
E-Mail: tboyd@harthosp.org

PERSONAL: Birth date: October 15, 1968
Marital Status: Married; wife: Kathryn E. Boyd, PhD

LICENSURE: Connecticut, Wisconsin

BOARD CERTIFICATION: American Board of Radiology (Therapeutic), 1999 (recertified 2009)

ACADEMIC EDUCATION:

1986-90 B.A., Phi Betta Kappa, Summa Cum Laude, Biology, Hamilton College, Clinton, New York

1990-94 M.D., State University of New York Health Science Center at Syracuse, Syracuse, New York

POSTGRADUATE TRAINING:

1994-95 Transitional Residency Program, Mary Imogene Bassett Hospital, Cooperstown, New York

1995-98 Residency, Radiation Oncology, University of Wisconsin-Madison, Madison, Wisconsin

1998-99 Clinical Instructor, Radiation Oncology, University of Wisconsin-Madison, Madison, Wisconsin

PROFESSIONAL SOCIETIES:

Hartford County Medical Society

Connecticut State Medical Society

American Society for Therapeutic Radiology and Oncology

HOSPITAL APPOINTMENTS:

1999-Present	Staff Physician, Hartford Hospital, Hartford, Connecticut
1999-Present	Staff Physician, Connecticut Children's Medical Center, Hartford, Connecticut
1999-Present	Staff Physician, Manchester Memorial Hospital, Manchester, Connecticut
1999-Present	Staff Physician, Johnson Memorial Hospital, Stafford Springs, Connecticut
1999-Present	Staff Physician, University of Connecticut Health Center, John Dempsey Hospital, Farmington, Connecticut

TEACHING EXPERIENCE:

2000-Present	Instructor, Radiotherapy Technology School, Hartford Hospital
1995-99	Instructor, Radiotherapy Technology School, University of Wisconsin-Madison

PUBLICATIONS

1. Boyd T, Mehta M: A comprehensive review of the role radiosurgery in patients with intracranial metastases; Kondziolka D (ed): Radiosurgery 1997. Radiosurgery. Basel, Karger, 1998, vol 2, pp 31-50.

2. Mehta M, Boyd T, Sinha P: The status of stereotactic radiosurgery for cerebral metastases in 1997: ***J Radiosurg*** 1998; 1:17-30.

3. Mehta M, Boyd T, Loeffler J: Linear accelerator stereotactic radiosurgery and fractionated stereotactic radiotherapy for cerebral metastases. In Maciunas RJ (ed): **Advanced Techniques in Central Nervous System Metastases,** pp 135-154. Park Ridge, Il, AANS, 1998.

4. Boyd TS, Harari PM, Tannehill SP et al: Planned post-radiotherapy neck dissection in patients with advanced head and neck cancer. ***Head and Neck*** 1998; 20:132-137.

5. Boyd TS, Mehta M: Stereotactic radiosurgery for brain metastases. Oncology 13:1397-1407, 1999.

6. Boyd T, Mehta MP: Radiosurgery for brain metastases; Kondziolka D (ed): Neurosurgery Clinics of North America 10(2):337-350, 1999.

CURRICULUM VITAE

Judith A. Buckley, M.D.
10 Cobble Road
Harwinton, Connecticut 06791
(203) 485-1961

PERSONAL

Born:	January 5, 1951, Waterbury, Connecticut
Married:	1972 to Sheldon A. Piperno, D.D.S., three children
Health:	Excellent, no physical limitations

EDUCATION

1972	B.A., Magna Cum Laude, Biology Honors Northeastern University, Boston, Massachusetts Honors: Phi Sigma - Honor Society of Biologists The Academy - Honor Society of the College of Liberal Arts Phi Kappa Phi - Interdisciplinary National Honor Society
1976	M.D., New York University School of Medicine, New York, NY
1976-77	Intern, Bellevue Hospital, New York University Medical Center
1977-79	Resident, Joint Center for Radiation Therapy Harvard Medical School, Boston Massachusetts
1979-80	Chief Resident, Joint Center for Radiation Therapy Harvard Medical School, Boston, Massachusetts

APPOINTMENTS

1980-81	Instructor, Presbyterian Hospital The Columbia-Presbyterian Medical Center, New York, NY
1981-82	Assistant Clinical Professor. Presbyterian Hospital The Columbia-Presbyterian Medical Center, New York, NY
1982	Courtesy Staff with Assignment Hartford Hospital, Hartford, CT
1984	Associate Staff – Radiation Oncology, Hartford Hospital Hartford, CT
1987	Senior Staff - Radiology, Hartford Hospital, Hartford, CT
1990 - Present	Senior Staff - Radiation Oncology, Hartford Hospital, Hartford, CT
1993 -97	Treasure Medical Staff, Hartford Hospital, Hartford, CT
1998 –2001	Assistant Director, Department of Radiation Oncology, Hartford Hospital, Hartford, CT

LICENSURE

1980	New York State
1981	Therapeutic Radiology Certification by The American Board of Radiology
1982	Massachusetts
1982	Connecticut

PROFESSIONAL AFFILIATIONS

1976 American Medical Association
1980 American Society of Therapeutic Radiologists
1982 American College of Radiology
1982 New England Society of Radiation Oncology
1984 New England Cancer Society
1988 American Society of Clinical Oncologists
1994 Hartford County Medical Society

BIBLIOGRAPHY

Trentham, D.E., Belli, J.A., Anderson, R.J., Buckley, J.A., Goetzl, E.J., David, J.R., and Austen, K.F.
Clinical and immunologic effects of fractionated total lymphoid irradiation in refractory rheumatoid arthritis.
New England Journal of Medicine. 1981; 305:976-82.

McCune, W.J., Buckley, J.A., Belli, J.A., and Trentham, D.E.
Partial suppression of type II collagen-induced arthritis by fractionated total lymphoid irradiation. Clin. Res. 1981; 29:160A Abstract.

Revised 9/25/03

CURRICULUM VITAE

STEPHEN H. HAUSER, MD

March 1, 2010

Address / Phone Numbers

Professional	Helen and Harry Gray Cancer Center, Radiation Oncology Hartford Hospital 80 Seymour Street, P.O. Box 5037 Hartford, CT 06102-5037 Telephone (860) 545-2803 FAX (860) 545-1500
E-mail	shauser@harthosp.org
Home	328 North Steele Road West Hartford, CT 06117-2231 Telephone (860) 236-3098

Personal

Date / Place of Birth:	March 2, 1963 / New Haven, CT
Citizenship:	United States Citizen
Marital Status:	married, two children

Education

Undergraduate: Sep. 1981 - Jun. 1985	Fairfield University / Fairfield, CT B.S. Biology, Summa Cum Laude
Medical School: Sep. 1985 - Jun. 1989	Tufts University School of Medicine / Boston, MA M.D.

Post-Graduate Training

Internship: Jul. 1989 - Jun. 1990	Carney Hospital / Boston, MA Transitional Medicine
Residency: Jul. 1990 - Jun. 1994	New England Medical Center / Boston, MA Radiation Oncology

Board Certification

July 1, 1990	Diplomate, National Board of Medical Examiners Certificate # 366873
June 9, 1994	Board Certified in Radiation Oncology American Board of Radiology

Appointments

Jul. 1993	- Jun. 1994	Chief Resident, Department of Radiation Oncology New England Medical Center, Boston, MA
Jul. 1994	- Jun. 1997	Staff, Department of Radiation Oncology
Jul. 1997	- Sep. 1997	Assistant Chief, Department of Radiation Oncology Wilford Hall Medical Center, Lackland AFB, TX
Oct. 1997	- Jun. 2001	Chief, Radiation Oncology VA Boston Healthcare System, Boston, MA
Jul. 1999	- Sep. 2000	Chair, Cancer Committee VA Boston Healthcare System, Boston, MA
Apr. 2000	- Jun. 2001	Clinical Director, Radiation Oncology New England Medical Center, Boston, MA
Jul. 2001	- present	Staff, Radiation Oncology, Hartford Hospital, University of Connecticut Health Center and Manchester Memorial Hospital, with: - 9 board certified radiation oncologists - 8 medical physicists - 9 high energy linear accelerators; Helical Tomotherapy; Intensity, Modulated Radiation Therapy; Image Guided Radiation Therapy; Cranial and Extracranial Stereotactic Radiosurgery and High Dose Rate Brachytherapy.
Feb. 2009	- present	Medical Director, Radiation Oncology Northeast Regional Radiation Oncology Network, Manchester, CT

Teaching Experience

June 1997	- Sept. 1997	Director of Education, Radiation Oncology Wilford Hall Medical Center, Lackland AFB, TX
Oct. 1997	- June 2001	Assistant Professor, Radiation Oncology Resident Program, New England Medical Center, Tufts Univ. School of Medicine, Boston, MA
Nov. 1998	- June 2001	Adjunct Assistant Professor, Radiation Medicine Brown Univ. School of Medicine, Providence, RI
July 2001	- present	Assistant Clinical Professor of Radiation Oncology Univ. of Connecticut School of Medicine, Farmington, CT

Honors / Awards / Certificates

Undergraduate	Alpha Epsilon Delta Honor Society, 1983 - 1985
Medical School	U.S. Air Force Health Professions Scholarship, 1984 Alpha Omega Alpha Honor Society, 1988 Medical Class of 1929 Award for Outstanding Work in the Course of Anatomy, 1989
Residency	Radiological Society of North America Research Resident Grant, 1993 Fletcher Society Resident Presentation Award, 1994
Staff	Radionics Radiosurgery Xknife Training Course, 1995 Air Force Outstanding Unit Award, 1996 Research Coordinator, Uniformed Services Radiation Oncology Group, 1996 - 1997 Texas Prostate Brachytherapy Services Practical Course in Transperineal Prostate Brachytherapy, 1998

Organizations

American Society for Therapeutic Radiology and Oncology
American College of Radiology
American Society of Clinical Oncology
Gilbert H. Fletcher Society
Massachusetts Medical Society
Connecticut State Medical Society
Radiation Therapy Oncology Group, 1999 - present
Principal Investigator, Boston VA Medical Center
National Surgical Adjuvant Breast and Bowel Project, June 6, 2006 - present

Grant Support

Radiological Society of North America Research Resident Grant, $25,000 in salary support, 1993 - 1994.

USPG Pfizer, Inc. Unrestricted Educational Grant, $50,000 to the National Kidney Foundation 1997 - 1998.

Medical License

Pennsylvania	10/18/94 - present
Massachusetts	03/29/95 - present
Texas	06/28/95 - present
Rhode Island	01/12/98 - present
Connecticut	04/16/01 - present

Publications

Curran WJ, Scott C, Langer C, Komaki R, Lee JS, **Hauser S**, Movsas B, Wasserman TH, Rosenthal S, Byhardt R, Sause W, Cox J: Phase III Comparison of Sequential vs. concurrent Chemoradiation for Patients (Pts) with Unresected Stage III Non-Small Cell Lung Cancer (NSCLC): Initial Report of Radiation Therapy Oncology Group (RTOG) 9410. Proc. Am. Soc. Clin. Oncol., #1891, 2000. Abstract.

Gao Q, **Hauser SH**, Liu XL, Wazer DE, Madoc-Jones H, Band V: Mutant p53-induced Immortalization of Primary Human Mammary Epithelial Cells. Cancer Res. 56:3129-3133, 1996.

Calorini L, Simile MM, **Hauser SH**, Gattoni-Celli S: Re-Expression of the Major Histocompatibility Complex (MHC) Class I Antigen H-2Kb by M1 (B16-F10) Murine Melanoma Cells. Intern. J. Oncology. 5:741-748, 1994.

Hauser SH, Calorini L, Wazer DE, Borek C, Gattoni-Celli S: Radiation-Enhanced Expression of Major Histocompatibility Complex (MHC) Class I Antigens in B16 Melanoma Cells. Cancer Res. 53:1952-1955, 1993.

Calorini L, **Hauser SH**, Gattoni-Celli S: Major Histocompatibility Complex (MHC) Class I Antigen Expression and Cell-Cell Communication in B16 Melanoma Cells. Intern. J. Of Rad. Onc. Biol. Phys. 24(suppl 1):267, 1992. Abstract.

Presentations (National Conferences)

Lung Cancer: Team Approach to Therapy Satellite Videoconference. The Federal Forum Oncology Educational Series: Second of Five Programs, The VA Learning University EES, Birmingham, AL Feb 2000.

A Unique p53 Mutant that Induces Dominant Immortalization of Human Mammary Epithelial Cells. 38th Annual Air Force Regional Meeting of the American College of Physicians, San Antonio, TX Mar. 1996.

Prevention of Radiation Induced Mucositis Using Daily Fluconazole. First Annual Meeting of the Uniformed Services Radiation Oncology Group. Tempe, AZ. May 1995.

The Role of p53 Mutations in Radiation Transformed Human Mammary Epithelial Cells. 19th Annual Gilbert H. Fletcher Society Scientific Meeting, Houston, TX Apr. 1994.

Radiation-Enhanced Expression of Major Histocompatibility Complex (MHC) Class I Antigens in B16 Melanoma Cells. 34th Annual American Society for Therapeutic Radiology and Oncology Meeting, San Diego, CA, Oct. 1992.

CURRICULUM VITAE

NAME: **Kenneth A. Leopold, M.D.**

BUSINESS ADDRESS: Radiation Oncology
80 Seymour St
Hartford, CT 06106

BUSINESS PHONE: (860) 533-4000

BUSINESS FAX: (860) 533-4011

HOME ADDRESS: 3 Mountain Estates Drive
Avon, CT 06001

HOME PHONE: (860-) 679-9392

DATE OF BIRTH: August 20, 1956

PLACE OF BIRTH: Philadelphia, PA

EDUCATION:

Haverford College, Haverford, PA
Bachelor of Arts (Phi Beta Kappa, Junior year)
May 15, 1978

University of Pennsylvania School of Medicine, Philadelphia, PA
Medical Doctor, May 17
1982

POSTDOCTORAL TRAINING

Residency

1982 - 1983	Intern in Medicine The Graduate Hospital Philadelphia, PA
1983 - 1985	Resident in Radiation Oncology Joint Center for Radiation Therapy Harvard Medical School Boston, MA

1985 - 1986 Chief Resident
Joint Center for Radiation Therapy
Harvard Medical School
Boston, MA

Research Appointments

1983 - 1986 Research Fellow in Radiation Therapy,
Harvard Medical School, Boston, MA

LICENSURE/CERTIFICATION

July 1, 1983 Certified by the National Board of Medical Examiners: #258508

June 6, 1986 Certified by the American Board of Radiology in Therapeutic Radiology

June 7, 1986 - 1994 North Carolina State Medical License: #30197

May 31, 1991 - 1994 Virginia State Medical License: #0101046645

April 7, 1993 – June 30, 1999 New Hampshire State Medical License: #8920

August 4, 1993 – November 30, 2000 Vermont State Medical License: #42-0008795

February 26, 1999 - present Connecticut State Medical License: #037543

ACADEMIC APPOINTMENTS

5/1999 – present Clinical Assistant Professor, Department of Diagnostic Imaging & Therapeutics, University of Connecticut Health Center, Farmington, CT

1993 – 4/99 Associate Professor, Department of Medicine, Section of Radiation Oncology, Dartmouth Medical School, Hanover, NH.

1986 -1993 Assistant Professor, Division of Radiation Oncology, Duke University Medical School, Durham, NC

HOSPITAL APPOINTMENTS - Current

1999 - present Hartford Hospital, Hartford, CT; Active

1999 - present Eastern Connecticut Health Network, Manchester-Rockville, CT, Active

1999 - present John Dempsey/U. Connecticut Health Center, Farmington, CT; consulting

1999 - present Connecticut Children's Hospital, Hartford, CT; consulting

1999 - present Johnson Memorial Hospital, Enfield, CT; consulting

AWARDS

1983-1985 American Cancer Society Research Fellowship Award

1990-1993 Clinical Oncology Career Development Award of the American Cancer Society

MAJOR COMMITTEE ASSIGNMENTS AND CONSULTATIONS

NATIONAL AND REGIONAL:

2001 – present CHESS National Advisory Board/Prostate Cancer

HOSPITAL COMMITTEE ASSIGNMENTS - active

2001 – present Cancer Care Committee, Rockville Hospital

2000 – present Institutional Review Board, Hartford Hospital

1999 – present Cancer Care Committee, Manchester Memorial Hospital

PROFESSIONAL SOCIETIES

1987 - present American Society of Therapeutic Radiology and Oncology
1993 - present American Society of Clinical Oncology
1999 –present CT State Medical Society
1999 –present Hartford County State Medical Society
1999 –present Manchester County State Medical Society
1999 –present MedServ IPA
1999 –present American Medical Association

BIBLIOGRAPHY (selected)

BOOK CHAPTERS

1. Leopold, K.A.; Prosnitz, L.R. Radiation Therapy. In: Essentials of Plastic, Maxillofacial, and Reconstructive Surgery, Volume 2. Georgiade, N., ed. Williams and Wilkins, Baltimore, 1992.
2. Leopold, K.A.; Marks, L.B. Complications from Thoracic Radiation. In: Complications In Thoracic Surgery Recognition and Management. Wolfe, W., ed. B.C. Decker, Philadelphia, Pennsylvania, 1992.
3. Amdur, RJ, Leopold KA, Heaney JA. Brachytherapy for Prostate Cancer. In: Rous S (Ed.) Urology Annual, 1995 ,(Volume 9), pages 25-50,W.W. Norton & Co., Inc. New York, NY, 1995.
4. Leopold K; Issels R. Thermoradiotherapy and thermochemotherapy for soft tissue sarcomas. In: Thermoradiotherapy and thermochemotherapy, Volume 2: Clinical Applications. Seegenschmiedt MH, Fessenden P, and Vernon CC (eds). Springer, Heidelberg, 1996.

5. Amdur RJ; Leopold KA; Schned AR; Heaney JA, and Ernstoff M. Using PSA Response to predict outcome following radiotherapy for prostate cancer. In: Rous S (Ed.) Urology Annual 1997 (volume 11), pp 25-37, W.W. Norton & Co., Inc. New York, NY, 1997.

SELECTED PAPERS IN REFEREED JOURNALS

1. Loeffler, J.S.; Leslie, N.T.; Leopold, K.A.; Recht, A.; Weinstein, H. Emergency Pre-biopsy Radiation for Mediastinal Masses: Impact Upon Subsequent Pathology and Outcome. Journal of Clinical Oncology 4:716-721, 1986.
2. Crnkovich, M.; Leopold, K.A.; Hoppe, R.; Mauch, P. Stage I-IIB Hodgkin's disease: The Combined Experience at Stanford University and the Joint Center for radiation therapy. Journal of Clinical Oncology 5:1041-1049, 1987.
3. Leopold, K.A.; Harrelson, J.; Prosnitz, L.R.; Samulski, T.; Dewhirst, M.; and Oleson, J.R. Preoperative Hyperthermia and Radiation for Soft Tissue Sarcomas: Advantage of Two vs. One Hyperthermia Treatments Per Week. Int. J. Radiat. Oncol. Biol. Phys. 16:107-115, 1989.
4. Leopold, K.A.; Recht, A.; Schnitt, S.J.; Connolly, J.L.; Rose, M.A.; Silver, B.; and Harris, J.R. Results of Conservative Surgery and Radiation Therapy for Multiple Synchronous Cancers of One Breast. Int. J. Radiat. Oncol. Biol. Phys. 16:11-16, 1989.
5. Leopold, K.A.; Canellos, G.; Rosenthal, D.; Shulman, L.N.; Weinstein, H.; and Mauch, P. Stage IA-IIB Hodgkin's Disease: Staging and Treatment of Patients with Large Mediastinal Adenopathy. J. Clin. Oncol. 7:1059-1065, 1989.
6. Leopold, K. A.; Dewhirst, M.; Samulski, T.; Harrelson J.; Tucker, A.; George, S.; Dodge, R.; Grant, W.; Clegg, S.; Prosnitz, L. R.; Oleson, J. R. Relationships Among Tumor Temperature, Treatment Time, and Histopathological Outcome Using Preoperative Hyperthermia and Radiation in Soft Tissue Sarcomas. Int. J. Radiat. Oncol. Biol. Phys. 22:989-998, 1992.
7. Hoyt, D.; Leopold, K.; Fisher, S. Voice Quality After Laryngeal Irradiation. Laryngoscope 102:477-480, 1992.
8. Leopold, K. A.; Dewhirst, M. W.; Samulski, T. V.; Dodge, R. K.; George, S. L.; Blivin, J. L.; Prosnitz, L. R.; Oleson, J. R. Cumulative Minutes with T90 Greater Than Tempindex is Predictive of Response of Superficial Malignancies to Hyperthermia and Radiation. Int. J. Radiat. Oncol. Biol. Phys. 25:841-847, 1993.
9. Deutsch MA, Leopold KA, Crawford J, Wolfe W, Foster W, Blackwell S, Yost R. Carboplatin, etoposide, and radiotherapy, followed by surgery, for the treatment of marginally resectable non-small cell lung cancer. Cancer treatment reviews19 Suppl C:53-62, 1993.
10. Brizel, D. M.; Fisher, S. R.; Panella, R. J.; Leopold, K. A.; Fine, R. L.; Bedrosian, C.; Kenan, P. D.; Huang, A.; LaChance, T.; Dodge, R.; Prosnitz, L. R. A Phase II Trial of Hyperfractionated Irradiation and Concurrent Chemotherapy for Locally Advanced Squamous Cell Carcinoma of the Head and Neck. Int. J. Radiat. Oncol. Biol. Phys. 28:213-220, 1993.
11. Leopold, K.A.; Oleson, J.R.; Clarke-Pearson, D.; Soper, J.; Berchuck, A.; Samulski, T.; Page, R.; Bliven, J.; Dewhirst, M. Intraperitoneal cisplatin and regional hyperthermia for ovarian carcinoma. Int. J. Radiat. Oncol. Biol. Phys. 27(5):1245-51, 1993.
12. Amdur R; Leopold KA; Conine F. Arytenoid sparing during irradiation of early stage glottic carcinoma. Int. J. Radiat. Biol. Phys. 32 (3):801-808, 1995.

13. King S; Acker J; Kussin P; Marks L; Weeks K; Leopold K. Hyperfractionated radiotherapy using a concurrent boost technique in the treatment of Unresectable Nonsmall Cell Lung Cancer. Int. J. Radiat. Oncol. Biol. Phys. 36:593-599, 1996.
14. Leopold KA, MD; Tim Ahles, PhD; Thomas Oxman, MD; Susan Walch, PhD; Robert Amdur, MD; Leila A. Mott, MAS. Prevalence Of Mood Disorders And Utility Of the PRIME-MD In Patients Undergoing Radiation Therapy. Int. J. Radiat. Oncol. Biol. Phys 42:1105-1112, 1998.
15. Amdur, K.A. Leopold, D. Gladstone. Prostate seed implant quality assessment using MR and CT image fusion. Int. J. Radiat. Oncol. Biol. Phys 43:67-72, 1999.
16. Vokes EE. Herndon JE 2nd. Crawford J. Leopold KA. Perry MC. Miller AA. Green MR. Randomized phase II study of cisplatin with gemcitabine or paclitaxel or vinorelbine as induction chemotherapy followed by concomitant chemoradiotherapy for stage IIIB non-small-cell lung cancer: cancer and leukemia group B study 9431. Journal of Clinical Oncology. 20(20):4191-8, 2002.

Christine Bak
29 Laurel Street
Enfield, CT 06082
(860) 741-5121

EDUCATION

United States Army, Fort Brag, North Carolina (Nursing) 1985-1986
Springfield Technical Community College, Radiologic Technologist 1988-1990
Springfield Technical Community College, Radiation Therapy June 1990-1991

SUMMARY OF EDUCATION AND PROFFESSIONAL DEVELOPMENT

Hartford Hospital, 867 Bed Patient Care Facility, Hartford, CT

Treatment Units
2300 Trilogy
Varian Clinac 600C, 2100C, 2100CD
Varian Clinac EX,
Nucletron HDR Afterloader

Radiation Oncology Information Systems
Aria Record and Verify System
Varis Record and Verify System

Simulator Units
Varian Acuity with CT

Beam Shaping Devices
Multi Leaf Collimation System

PROFESSIONAL EXPERIENCE

Staff Radiologic Technologist
Baystate Medical Center, Springfield, MA
1990-1991
Staff Radiation Therapist
New Britain General Hospital, New Britain, CT
1991-August 1992
Staff Radiation Therapist &
C.T./Simulation/HDR Therapist
Hartford Hospital, Hartford, CT
August 1992- Present

LICENSES & CERTIFICATIONS:

CPR Validation
ARRT Certification (R) (T)
Connecticut State License (Radiographer- Dept. of Public Health)
Member of NESRT (New England Society Of Radiation Therapists)
Member of ASRT (American Society of Radiation Therapist)

Francis Blanchard
160 Silver Lake Drive
Agawam, MA 01001
(413) 786-9595

EDUCATION

Holyoke Community College Radiography 1993-1995
Radiation Therapy Program, September 1995-1997

SUMMARY OF EDUCATION AND PROFFESSIONAL DEVELOPMENT

Clinical and Didactic Curriculum (1995-1997)
Hartford Hospital, 867 Bed Patient Care Facility, Hartford, CT
University of Connecticut, John Dempsey Hospital, 224 Bed Academic Research and Patient Care Facility, Farmington, CT
Midstate Medical Center, 122 Bed Community Patient Care Facility, Meriden, CT

Treatment Units
2300 Trilogy
Varian Clinac 600C, 2100C, 2100CD
Varian Clinac EX, Philips SLI Eleckta,
Nucletron HDR Afterloader

Radiation Oncology Information Systems
Aria Record and Verify System
Varis Record and Verify System
IMPAC Record and Verify System

Simulator Units
Varian Acuity with CT
Varian Ximatron
Philips SLS
Toshiba Scanner

Beam Shaping Devices
Multi Leaf Collimation System
Huestis Block Cutting System
PAR Medical Block Cutting System

PROFESSIONAL EXPERIENCE

Staff Radiation Therapist
Hartford Hospital, Hartford, CT
September 1997- December 1997
Staff Radiation Therapist
Valley Cancer Center, Holyoke, MA
January 1998- June 1998
C.T./ SIMULATION/ HIGH DOSE RATE Radiation Therapist
Hartford Hospital, Hartford, CT
December 1998- Present

LICENSES & CERTIFICATIONS:

CPR Validation
ARRT Certification (R) (T)
Connecticut State License (Radiographer- Dept. of Public Health)
Member ASRT (American Society of Radiologic Technologist)

Allison Conners
85 North Main St. #109
East Hampton, CT 06424
(860) 930-8705

EDUCATION

Middlesex Community College September 1998- June 2000
Radiation Therapy Program, September 2000-2003

SUMMARY OF EDUCATION AND PROFFESSIONAL DEVELOPMENT

Clinical and Didactic Curriculum (2000-2003)
Hartford Hospital, 867 Bed Patient Care Facility, Hartford, CT
University of Connecticut, John Dempsey Hospital, 224 Bed Academic Research and Patient Care Facility, Farmington, CT
Midstate Medical Center, 122 Bed Community Patient Care Facility, Meriden, CT
Manchester Memorial Hospital, John DeQuattro Community Cancer Care, 249 Bed Community Patient Care Facility, Manchester, CT

Treatment Units
2300 Trilogy
Varian Clinac 600C, 2100C, 2100CD
Varian Clinac EX, Philips SLI Eleckta,
Nucletron HDR Afterloader

Radiation Oncology Information Systems
Aria Record and Verify System
Varis Record and Verify System
IMPAC Record and Verify System

Simulator Units
Varian Acuity with CT
Varian Ximatron
Philips SLS

Beam Shaping Devices
Multi Leaf Collimation System
Huestis Block Cutting System
PAR Medical Block Cutting System

PROFESSIONAL EXPERIENCE

Staff Radiation Therapist
Hartford Hospital, Hartford, CT
September 2003-October 2007
C.T./ SIMULATION/ HIGH DOSE RATE Radiation Therapist
Hartford Hospital, Hartford, CT
October 2007- Present

LICENSES & CERTIFICATIONS:

CPR Validation
ARRT Certification
Connecticut State License (Radiographer- Dept. of Public Health)
Member of NESRT (New England Society Of Radiation Therapists)
Member ASRT (American Society of Radiologic Technologist)

Karl Harris
80 Barry Circle
Bloomfield, CT 06002
(860) 982-1980

EDUCATION

Touro College, September 1998 to June 2000
UCONN, September 2001 to January 2002
CCSU, September 2002 to December 2005
Radiation Therapy Program, September 2006 to July 2008

SUMMARY OF EDUCATION AND PROFFESSIONAL DEVELOPMENT

Clinical and Didactic Curriculum (2006-2008)
Hartford Hospital, 867 Bed Patient Care Facility, Hartford, CT
University of Connecticut, John Dempsey Hospital, 224 Bed Academic Research and Patient Care Facility, Farmington, CT
Midstate Medical Center, 122 Bed Community Patient Care Facility, Meriden, CT
Manchester Memorial Hospital, John DeQuattro Community Cancer Care, 249 Bed Community Patient Care Facility, Manchester, CT
Saint Francis Hospital, 617 Bed Patient Care Facility, Hartford, CT
Middlesex Cancer Center, Out Patient Clinic, Middletown, CT

Treatment Units
2300 Trilogy
Varian Clinac 600C, 2100C, 2100CD
Varian Clinac EX, Philips SLI Eleckta
Stabilipan (Orthovoltage Unit)
Nucletron HDR Afterloader

Radiation Oncology Information Systems
Aria Record and Verify System
Varis Record and Verify System
IMPAC Record and Verify System

Simulator Units
AcQUSIM CT Simulator
Varian Acuity with CT

Beam Shaping Devices
Multi Leaf Collimation System
Huestis Block Cutting System
PAR Medical Block Cutting System

PROFESSIONAL EXPERIENCE

C.T./ SIMULATION/ HIGH DOSE RATE Radiation Therapist
Hartford Hospital, Hartford, CT
July 2008- Present

LICENSES & CERTIFICATIONS:

CPR Validation
ARRT Certification
Connecticut State License (Radiographer- Dept. of Public Health)
Member of NESRT (New England Society Of Radiation Therapists)

ROBERT F. HOFFMAN

bobhoffman09@yahoo.com (860) 573-2048 31 Woodland St, # 6D, Hartford, CT 06105

SUMMARY OF QUALIFICATIONS

Medical Physicist for Hartford Hospital. Previous experience in Information Technology, Quality Assurance and Nuclear Engineering.

EXPERIENCE IN MEDICAL PHYSICS

Hartford Hospital, Hartford, CT – September 2008 to present
Medical Physicist at the Harry Gray Cancer Center. Clinical duties include second, and weekly chart checks, Monthly and Annual Linac Quality Assurance, and Stereotactic Radiosurgery/Therapy Planning and Treatment. Completed part 1 of ABR certification process.

Duke University - Medical Physics Graduate Program

- Completed thesis on comparison of perfusion in brain lesions measured with CT and MRI.
- Clinical practicum included brachytherapy, IGRT, SRS/SBRT, electron beam therapy and Total Body irradiation procedures; as well as daily, weekly, and monthly QA, IMRT QA using ion chamber and MapCheck, and TG 51 calibration with the medical physics staff at Duke Hospital.

EDUCATION

Duke University, Durham, North Carolina, August 2006 to August 2008
MS degree in Medical Physics; 3.73 GPA
Pennsylvania State University, University Park, Pennsylvania, 1976-1978
MS level coursework in Nuclear Engineering, Pennsylvania State University
Emory and Henry College, Emory, Virginia, 1976
BS degree, Physics, magna cum laude

EXPERIENCE IN THE NUCLEAR POWER INDUSTRY

Entergy Nuclear Northeast (ENN)- Indian Point Energy Center (IPEC), Buchanan, NY; July 2000 to March 2004; **IT Consultant**
Information Technology department Corrective Action and Self Assessment co-coordinator; IPEC Site Software Qualify Assurance Co-Coordinator, member of Emergency Response team. Performed Software Quality Assurance audits and self assessments at ENN operated plants. Procurement of hardware and software, vendor and customer interface, planning and scheduling of process computer system maintenance activities.

ABB Combustion Engineering Nuclear Power (CENP), Windsor, CT; October 1995 to January 2000 **Consultant**
Assistant Project Manager for the Y2k project, providing technical direction, project metrics and reports; performed Y2k product assessments and reviewed company readiness for Y2k transition. Member of ABB-CENP's support team for Millstone Unit 2 restart effort from 1996-1998; responsible for identification and validation of regulatory commitments and supporting technical analyses.

Emanon Consultants, Inc., Windsor, CT; Sept. 1992 to October 1995, Consultant
Responsible for technical design and testing for Emanon Consultant software products and services. Proposal development and customer support.

ROBERT F. HOFFMAN

bobhoffman09@yahoo.com (860) 573-2048 6614 Chantilley Pl., Bahama, NC 27503

EXPERIENCE IN THE NUCLEAR POWER INDUSTRY, continued

ABB Combustion Engineering, Inc., I&C Computer Services, Windsor, CT; March 1982 to Sept. 1992, Consulting Engineer
Application program design and testing for ABB-CE's process computer projects. Performed emergency response survey on behalf of Japanese client representing a consortium of Japanese utilites. Responsible for project budgets, proposals, and customer support. Conducted user training on process computer systems.

Combustion Engineering, Inc., Windsor, CT; Sept. 1978 to March 1982, Engineer II
Engineering analyses used to support Combustion Engineering power plants.

PUBLICATIONS

1. "Advanced Computer Applications for Plant Monitoring Systems"; R. F. Hoffman, et. al., Nuclear Plant Journal, May June 1989.
2. "Interfacing Plant Computers With Training Simulators Using SMEXEC", R. F. Hoffman, A. M. Ansari, Society for Computer Simulation Conference, April, 1995

COMMUNITY SERVICE

- Hartford Hospital: Volunteer in palliative care unit; June 2005 through June 2006
- Talcott Mountain Music Festival: Customer service volunteer; Summer 2005 and 2006
- Literacy Volunteers of America: Reading tutor; February through May 2000

AAPM member since 2007

REFERENCES

Available upon request

Blanche Jackson

EDUCATION

Springfield Technical Community College, Radiologic Technologist 1986
Springfield Technical Community College, Radiation Therapy June 1992

SUMMARY OF EDUCATION AND PROFFESSIONAL DEVELOPMENT

Hartford Hospital, 867 Bed Patient Care Facility, Hartford, CT

Treatment Units
2300 Trilogy
Varian Clinac 600C, 2100C, 2100CD
Varian Clinac EX,
Nucletron HDR Afterloader

Radiation Oncology Information Systems
Aria Record and Verify System
Varis Record and Verify System

Simulator Units
Varian Acuity with CT
Toshiba Scanner

Beam Shaping Devices
Multi Leaf Collimation System

PROFESSIONAL EXPERIENCE

X-Ray Technician/ Acting Supervisor
Baystate Medical Center
1986-1992
Staff Radiation Therapist &
C.T./Simulation/HDR Therapist
Hartford Hospital, Hartford, CT
August 1992- Present

LICENSES & CERTIFICATIONS:

CPR Validation
ARRT Certification (R) (T)
Connecticut State License (Radiographer- Dept. of Public Health)
Member of NESRT (New England Society Of Radiation Therapists)
Member of ASRT (American Society of Radiation Therapist)

Robert M. Lindeyer
367 North Granby Road
North Granby, CT 06060
(860) 653-2157

EDUCATION:

1975 – 1980: University of Hartford
BS, Biology

1970-1975: Loomis Chaffee, Windsor, CT

WORK EXPERIENCE:

1997 to present: Clinical Engineer,
Radiation Oncology Department

1987 to 1997: Accelerator Engineer,
Radiation Oncology Department

1984 to 1987: Machinist-Repairman,
Radiation Oncology Department

1977 – 1984: Phlebotomist,
Hartford Hospital

1973 - 1977: Veterinarian Assistant,
MacDonald's Veterinarian Hospital
Bloomfield

1971 – 1973: Farmhand,
Kendrick's Tobacco
Windsor, CT

MEMBERSHIPS:

Secretary, Zoning Board of Appeals, Town of Granby

Financial Secretary, First Church, Granby CT

Member, Granby Cemetery Association

REFERENCES:

Upon request

Deborah Nelson RTT, CMD
56 Redwood Rd Manchester, CT 06040
(T) 860.597.8733 (E) bolongobaby@hotmail.com

Education

1992 **Bellevue Community College Radiation Therapy Program**
2006 **MDCB** certification

Professional Experience

October 2007-present — **Hartford Hospital** Hartford, CT
Medical Dosimetrist
* **IMRT, 3D, ISC, Forward Segmented, Irreg Planning**
* **Electron MU calculations**
* **Weekly chart checks**
* **Teach a segment of the RTT curriculum to senior radiation therapy students**

November 2006-May 2007 — **Mercy Therapeutic Radiological Associates** DesMoines, Iowa
Locum Medical Dosimetrist
* **Performed duties of a staff dosimetrist in a fast paced clinic treating approx. 120 patients daily**
* **IMRT, 3D, Forward segmented planning**

January 2005-May 2006 — **Virginia Mason Medical Center** Seattle, WA
Medical Dosimetrist
* **IMRT, 3D, Forward planning, prostate implant volume studies in a high volume clinic**
* **Hand MU calculation checks on Forward plans and 3D plans**
* **Calculation of diode readings for the therapists**
* **Electron MU calculations via film densitometry or dose measurements**

July 2002-January 2005 — **Olympic Medical Cancer Center** Sequim, WA
Medical Dosimetrist
* **Solo dosimetrist responsible for all aspects of dosimetry in a clinic treating 25-35 patients daily**
* **Developed and implemented dosimetry, simulation, therapy procedures, and also helped set policies for a new state of the art cancer center**
* **Educated the therapists on how to read 3D and IMRT plans, also taught the therapists MU calculations as they were responsible for the initial double check**

* **Responsible for keeping the therapists trained in emergency on-call procedures as they pertained to dosimetry**

June 2001-July 2002 — **Olympic Care and Rehabilitation Center** Sequim, WA
Business Office
* **Responsible for billing OT, PT, Speech therapy, glucose monitoring, and any other Medicare Part B services to private insurance companies**

June 1996-December 2000 — **Olympic Medical Cancer Center** Sequim, WA
Radiation Therapist
* **Deliver prescribed treatment, chart checks, weekly ports block fabrication, patients scheduling, MU checks**
* **Assist the nursing staff with patient care and nutrition**

March 1995-June 1996 — **Harrison Memorial Hospital** Bremerton, WA
Tacoma Radiation Oncology Center Tacoma, WA
Locum Tenens- Radiation Therapist
* **Provided extra help as a staff therapist**

September 1992-Dec 1993 — **Olympia Radiological Associates** Olympia, WA
Radiation Therapist
* **Entry level therapist duties including simulation and on-call**

Equipment Knowledge

* **Adac Pinnacle TPS with DMPO, Eclipse TPS**
* **Impac and ARIA R&V**
* **MU check, Rad Calc MU validation programs**
* **Vidar Scanner**
* **Acculoc, BAT, SonArray localization programs**
* **Treatment Units**
  CO60, CL-4, CL6100, 2100CD, 2100 EX, 2100IX, Orthovoltage Supervoltage
* **Simulator Units**
  Cascade, Ximitron, Oldelft, Acuity
* **CT scanners**
  GE Lightspeed, other GE models, Toshiba

Licenses and Professional Affiliations

* **ARRT, ASRT**
* **State of CT (radiographer)**
* **MDCB, AAMD**

Kevin J. Norton, M.S., DABMP
64 Old Cider Mill Rd
Southington, CT 06489
860-621-9841

Certification
American Board of Medical Physics, Radiation Oncology Physics

Work Experience

Jan 2001 - Present	Lead Medical Physicist-Avon Facility (April 2008). Hartford Hospital, Hartford, CT. Primary duties: Management of dosimetrists and equipment for Avon facility, radiation therapy medical physics, oversight of treatment planning, IMRT planning and QA, SRS/SRT, teaching, serving several satellite facilities.
5/00–12/00	Medical Physicist. Radiation Therapy Associates, P.C., Garden City, MI. Primary duties: Radiation therapy medical physics and treatment planning.
1989-2000	Medical Physicist. St. Vincent Mercy Medical Center, Toledo, OH. Primary duties: Radiation therapy (1990 - 2000) and diagnostic radiology (1989-1991) physics. Also: Nuclear medicine physics, radiation safety, regulatory compliance, teaching diagnostic radiology physics and radiation biology.
1987	Assistant Health Physicist. Radiation Control Service, The University of Michigan, Ann Arbor, MI. Duties: Eye dosimetry in cardiac catheterization laboratory, review of radioactive materials use by researchers, and other general health physics issues.
1985-1987	Assistant Nuclear Medicine Physicist. The University of Michigan Hospitals, Ann Arbor, MI. Duties: Instrumentation quality assurance, Iodine-131 therapies, and regulatory compliance.
1986-1987	Survey Meter Calibration Technician. Medical Physics Consultants, Ann Arbor, MI. Duties: Cs-137 calibration of survey meters.

Education

1987-1989	Wayne State University, Detroit, MI. Two years of course-work toward Ph.D. in Medical Physics.
1985-1987	M.S. in Radiological Health. The University of Michigan, Ann Arbor, MI.
1981-1985	B.S. in Biology. The University of Michigan, Ann Arbor, MI.

Selected Continuing Education

April 2006	Varian OBI/CBCT Training Course, Las Vegas, NV.
June 2004	Elekta IMRT Course, William Beaumont Hospital, Royal Oak, MI.
Sept 2001	Practical Implementation of Intensity Modulated Radiation Therapy, Medical Technology Management Institute, New York, NY.
August 1996	Ultrasonically Guided I125/Pd103/Ir192 Implantation for the Treatment of Prostate Cancer. Pacific Northwest Cancer Foundation, Seattle, WA.

Publications/Research

2005	A method for deconvolution of integrated electronic portal images to obtain incident fluence for dose reconstruction. JACMP Vol 6, No. 4, Fall 2005.
1986-1987	Master's Thesis. Investigation of fetal dose to nuclear medicine technologists from exposure to patient-scattered Tc-99m photons.

Member
American Association of Physicists in Medicine
Connecticut Area Medical Physics Society

Kevin Pacini
1 Whitman Court 2A
Hartford, CT 06106
(845) 494-4910

EDUCATION

WCSU, January 2001- June 2006
Radiation Therapy Program, September 2006 to July 2008

SUMMARY OF EDUCATION AND PROFFESSIONAL DEVELOPMENT

Clinical and Didactic Curriculum (2006-2008)
Hartford Hospital, 867 Bed Patient Care Facility, Hartford, CT
University of Connecticut, John Dempsey Hospital, 224 Bed Academic Research and Patient Care Facility, Farmington, CT
Midstate Medical Center, 122 Bed Community Patient Care Facility, Meriden, CT
Manchester Memorial Hospital, John DeQuattro Community Cancer Care, 249 Bed Community Patient Care Facility, Manchester, CT
Saint Francis Hospital, 617 Bed Patient Care Facility, Hartford, CT
Middlesex Cancer Center, Out Patient Clinic, Middletown, CT

Treatment Units
2300 Trilogy
Varian Clinac 600C, 2100C, 2100CD
Varian Clinac EX, Philips SLI Eleckta
Stabilipan (Orthovoltage Unit)
Nucletron HDR Afterloader

Radiation Oncology Information Systems
Aria Record and Verify System
Varis Record and Verify System
IMPAC Record and Verify System

Simulator Units
AcQUSIM CT Simulator
Varian Acuity with CT

Beam Shaping Devices
Multi Leaf Collimation System
Huestis Block Cutting System
PAR Medical Block Cutting System

PROFESSIONAL EXPERIENCE

Staff Radiation Therapist &
C.T./ SIMULATION/ HIGH DOSE RATE Radiation Therapist
Hartford Hospital, Hartford, CT
July 2008- Present

LICENSES & CERTIFICATIONS:

CPR Validation
ARRT Certification
Connecticut State License (Radiographer- Dept. of Public Health)

Monica C Rossi

244 Knollwood Rd., Manchester, CT 06042

Phone: 860-647-8504, Cell: 276-870-5681

E-mail: monicacrossi@yahoo.com

EDUCATION:

- **M.S., Radiological Medical Physics** (therapy emphasis and CAMPEP accredited)
  - **University of Kentucky**
  - Expected completion in June 2007, current graduate GPA 4.0 / 4.0
- **M.S., Physics**, Stevens Institute of Technology, NJ, May 2001, GPA 3.9 / 4.0
- **B.S., Physics**, University of Timisoara, Romania, June 1993, GPA 3.72 / 4.0

HONORS AND AWARDS:

- Government scholarship at University of Timisoara
- Awarded Teaching Assistant position at Stevens Institute of Technology

PROFESSIONAL MEMBERSHIPS:

AAPM

WORK EXPERIENCE:

- Medical Physicist, Hartford Hospital, 10/07 - present
- Extensive 18 months clinical practicum in medical physics
- Taught college algebra at Black River Technical College, AR, 2001
- Teaching Assistant, Stevens Institute of Technology, NJ 1/99 – 12/00
- Physicist, County Hospital Arad, Romania, 8/93 – 4/97

WORKING and PRACTICUM EXPERIENCE:

- **External Beam RT Treatment Planning** using CMS XiO and Eclipse planning system (2D, 3D & IMRT, practice plans ranging from head an neck, breast tangents, lung, abdomen, pelvis, extremity to IMRT),

- **Brachytherapy** **LDR** planning - prostate implant planning, seed loading and assistance during implant, VariSeed used for planning
  HDR planning and treatment deliveries
  - more than 70 plans done either using the Tandem and Ovoids, Wright Applicator, or Endobronchial – Brachyvision is used for treatment planning and Prowess for double check
  - Performed quarterly and daily QA on the HDR unit

- Performed dose measurements using TLD's with Harshaw TLD reader, and WinREMS software
- **Monthly QA** for Clinac 2100EX, 600 c and **annual linac** QA and calibrations using TG-51
- Performed simulator, CT and superficial QA testing
- **Chart checks**
- **Shielding** survey and shielding calculations
- Power Point presentations: Shielding for Radiation Therapy, Gamma Knife (treatment of AVM using Gamma Knife), Pituitary Tumors

RESEARCH IN HEALTH RELATED RADIATION SCIENCE:

Shielding – Use Factors for oblique beams

EXPERIENCE WITH THE FOLLOWING EQUIPMENT:

- Varian Clinac 2100EX series Linear Accelerator with MLC
- Varian 600 C with MLC and EPID
- Varian 21 iX with MLC and OBI
- VariSource HDR
- Wellhofer Scanning System and Densitometer
- Siemens CT simulator
- Conventional Ximatron simulator
- Capintec Dose Calibrator

EXPERIENCE WITH THE FOLLOWINN TREATMENT PLANNING SOFTWARE:

- VariSeed
- Computerized Medical System, Focus XiO
- Eclipse Treatment Planning System

COURSEWORK:

Human Anatomy and Physiology
General Medical Radiological Physics
Interaction of Radiation with Matter
Mammalian Radiation Biology
Advanced Radiation Dosimetry
Physics of Diagnostic Imaging
Radiation Oncology
Physics of Radiation Therapy
Radiation Health Science
Radiation Science Seminar: Brachyphysics, Special Procedures

PERSONAL:

- Married to Victor Rossi, MD
- Citizenship: American
- Languages: English, Romanian

References available upon request

Theodore Roosevelt Steger, III, Ph.D.

35 Warwick St.
Longmeadow, MA 01106
Mobile Phone: (832) 563-0740
Email: tsteger@gmail.com

EDUCATION

University of Louisville Brown Cancer Center
Clinical Radiation Physics Residency: Completed November 2008 (CAMPEP Accredited)
Advisor: Michael D. Mills, Ph.D.

University of Texas-Houston/M.D. Anderson Graduate School of Biomedical Sciences
Ph.D. in Biomedical Sciences (Medical Physics): 2004 (CAMPEP Accredited)
Dissertation: *Investigation of Arterial Spin Labeling MRI for Quantitative Cerebral Blood Flow Measurement*
Advisor: Edward F. Jackson, Ph.D.

University of Texas-Houston/M.D. Anderson Graduate School of Biomedical Sciences
M.S., Biomedical Sciences (Medical Physics Program): 2001 (CAMPEP Accredited)
Thesis: *Implementation and Verification of Techniques for Real-Time Analysis and Clinical Distribution of Functional Magnetic Resonance Imaging Data*
Advisor: Edward F. Jackson, Ph.D.

University of North Carolina (Chapel Hill, NC)
B.S. Physics (Chemistry minor) with Distinction (GPA 3.5/4.0) 1998

PROFESSIONAL EXPERIENCE

Hartford Hospital Helen and Harry Gray Cancer Center
(November 2008 – Present) Radiation Oncology Physicist
Developed OBI, Acuity QA program; Led quality improvement project focused on improving HDR APBI efficiency and quality;

University of Louisville Brown Cancer Center
(June 2007 – November 2008) Radiation Physics Resident
Hands on clinical experience in a broad range of treatment planning, QA, and special procedure activities detailed below; Spearheaded projects to streamline DICOM-RT transfers and inter-vendor communication

GE Healthcare
(October 2004 – May 2007) MR PSD/Applications Development Engineer
Team leader for release of Signa HDx product; Responsible for pulse sequence development and resolution of product quality issues for various pulse sequences; Lead programmer for LAVA-XV feature

Department of Imaging Physics, University of Texas M.D. Anderson Cancer Center
(Fall 1998 – Summer 2004) Graduate Research Assistant
Developed and carried out research on arterial spin labeling and functional MRI; Full course work and clinical rotations in Radiation Therapy Physics and Diagnostic Imaging Physics

Department of Physics, University of North Carolina
(Spring – Fall 1997) Research Assistant
Researched properties of solid-state materials at low temperature, assembled probe for use in nuclear magnetic resonance (NMR) experiments

CLINICAL PROFICIENCIES

External Beam QA:
- -Delivery QA on Varian Trilogy IMRT plans with portal dosimetry, MapCheck, and film
- -Responsible for monthly QA on Varian 23IX 6X/18X linac
- -Acceptance testing and commissioning Varian 21IX 4X/10X linac
- -Performed 4 linac annuals including TG-51 protocol
- -Commissioning, daily and annual QA, and dose calculations for Mobetron intraoperative unit
- -Chart check responsibilities: Aria and Impac for billing/R&V
- -Responsible for secondary checks and TLD dosimetry for plan verification

Treatment Planning:
- -Varian Eclipse for IMRT (prostate, bladder, H&N) and body stereotactic planning
- -CMS Xio for 3D conformal plans
- -FastPlan for SRS and SRT planning
- -TomoTherapy treatment planning
- -BrachyVision for HDR (GYN, prostate, bronchial) and LDR (GYN, interstitial) plans
- -VariSeed for prostate implants
- -BrachyVision and ADAC Pinnacle for LDR planning, eye plaques

Brachytherapy:
- -Planning, daily, source exchange and annual QA on VariSource HDR
- -Planning and loading/unloading of LDR T&O, interstitial
- -Planning and assisting in Pd-103 prostate implants, including post-planning

Stereotactic Radiosurgery:
- -Image fusion and planning of cranial frameless (bite block) SRS and SRT
- -Treatment planning for lung body stereo program including 4D CT and Cone Beam CT
- -Performing daily calibration and assisting in cone-based and MLC-based treatments

TomoTherapy:
- -H&N and prostate planning
- -Daily, monthly, annual QA and delivery QA

IGRT/Imaging:
- -Respiratory gating and 4D CT with Varian RPM
- -Calibration of portal imager for portal dosimetry
- -Daily, monthly, and annual QA on conventional and CT (Philips Big Bore 16 slice) simulators
- -Developed monthly QA program for Trilogy On Board Imagers and CBCT

CERTIFICATIONS

Passed Parts I and II of the ABR Therapeutic Physics Exam; Oral Exam to be taken May 24th
Authorized user on NRC HDR license at Hartford Hospital

SKILLS

Extensive knowledge and experience with: DICOM, DICOM-RT; C, Perl, and MATLAB programming
Comfortable with patient contact through clinical SRS and brachytherapy responsibilities, MRI studies, and through M.D. Anderson Volunteer Services experience
Excellent personal communication, presentation, writing, and teaching skills

AWARDS

Winner of American College of Medical Physics Best Diagnostic Imaging Paper, 2004
Young Investigators Award, Southwest Chapter of the American Association of Physicists in Medicine, Spring Meeting 2002.
Graduate School of Biomedical Sciences Presidential Fellowship Recipient, 1998-2002

PUBLICATIONS

K. Gifford, J. Horton, E. Jackson, **T. Steger**, M. Heard, F. Mourtada, A. Lawyer, G. Ibbott, "*Comparison of Monte Carlo calculations around a Fletcher Suit Delclos ovoid with radiochromic film and normoxic polymer gel dosimetry*", Medical Physics Jul;32(7):2288-94, 2005.

T.R. Steger, R.A. White, E.F. Jackson, "*Input parameter sensitivity analysis and comparison of quantification models for continuous arterial spin labeling*", Magnetic Resonance in Medicine, Apr;53(4):895-903, 2005.

T.R. Steger, E.F. Jackson, *"Experience in implementing continuous arterial spin labeling on a commercial MR scanner"*, Journal of Applied Clinical Medical Physics. Winter;6(1):94-100. Epub Jan 12 2005.

T.R. Steger, E.F. Jackson, "*Real-time motion detection of functional MRI data*", Journal of Applied Clinical Medical Physics, Vol. 5, No. 2, Spring 2004.

SELECTED PRESENTATIONS

Z. Li, **T.R. Steger**, B.J. Mock, "*Sequence optimization for oblique diffusion weighted imaging with simultaneous diffusion encoding,*" International Society for Magnetic Resonance in Medicine 15th Annual Meeting, Munich, Germany, 2007.

T.R. Steger, Z. Li, R.S. Hinks, B.J. Mock, "*Use of Gradient Crushers on Multiple Axes for Diffusion Imaging of Thin Slices with Reduced TE*", International Society for Magnetic Resonance in Medicine 14th Annual Meeting, Seattle, Washington, 2006.

K. Gifford, J. Horton, E. Jackson, **T. Steger**, M. Heard, F. Mourtada, A. Lawyer, G. Ibbott, "*Verification of Monte Carlo calculations around a Fletcher Suit Delclos ovoid with radiochromic film and normoxic polymer gel dosimetry,*" American Association of Physicists in Medicine Annual Meeting, Pittsburgh, PA, 2004.

T.R. Steger, E.F. Jackson, "*Analysis of noise propagation in continuous arterial spin labeling using Monte Carlo simulations,*" American Association of Physicists in Medicine Annual Meeting, San Diego, California, 2003.

T.R. Steger, E.F. Jackson, "*Motion detection on a commercial real-time fMRI system and correlation with motion correction limits*", International Society for Magnetic Resonance in Medicine 10th Annual Meeting, Honolulu, Hawaii, 2002.

T.R. Steger, E.F. Jackson, "*Correlation coefficient generation on a commercially available real-time fMRI scanner with rapid fusion of anatomic data for application to image-guided surgery*", International Society for Magnetic Resonance in Medicine 9th Annual Meeting, Glasgow, Scotland, 2001.

T.R. Steger, E.F. Jackson, "*Implementation of a recursive correlation coefficient analysis technique on a commercially available real-time fMRI system with rapid fusion of anatomic data*", American Association of Physicists in Medicine, Annual Meeting, Salt Lake City, Utah, 2001.

PROFESSIONAL SOCIETIES

Full Member, American Association of Physicists in Medicine (AAPM)
Junior Member, American College of Medical Physicists (ACMP)
Full Member, International Society for Magnetic Resonance in Medicine (ISMRM)

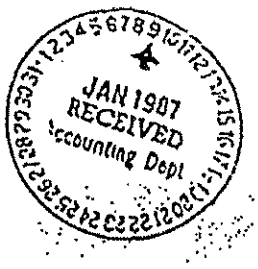
Attachment D

Verification of Non-Profit Status

Internal Revenue Service

Department of the Treasury

Washington, DC 20224



Hartford Hospital
80 Seymour Street
Hartford, CT 06115

Person to Contact: Mr. Chasin
Telephone Number: (202) 566-3969

Refer Reply to:
CP:E:EO:R:4

Date: 11 DEC 1986

EIN: 06-0646668
Key District: Brooklyn

Legend:

J = Hartford Hospital
K = Hartford Health Care Corporation
L = Jefferson Street Medical Building, Inc.
M = H.H.M.O.B. Corporation
N = Hartford Hospital Real Estate Corporation
P = Hartford Hospital Medical Laboratory, Inc.
Q = H. H. Management Services, Inc.

Dear Sir or Madam:

This is in response to your letter dated December 27, 1985, wherein, you requested certain rulings regarding the federal income tax consequences of the transactions and reorganization described below.

The information available indicates that J is a nonstock corporation that is recognized as exempt under section 501(c)(3) of the Internal Revenue Code and is classified as an organization described in sections 509(a)(1) and 170(b)(1)(A)(iii). The principal purpose of M is to provide medical or hospital care.

K is a nonstock membership corporation that has applied for exemption under section 501(c)(3) of the Code and classification as a supporting organization described in section 509(a)(3). The principal purpose of K is to benefit, perform the functions of, and carry out the purposes of J.

L is a stock corporation that is recognized as exempt under section 501(c)(2) of the Code. J is the sole shareholder of L. The exclusive purpose of L is to hold title to property on behalf of J, and turning over the net income from such property to J.

M is a for-profit, stock corporation with J as its sole shareholder. The primary purpose of M is to act as the corporate general partner in a limited partnership which will construct, operate, and lease a medical office building in the vicinity of J's facility to physicians of J.

FAA

Hartford Hospital

M is a for-profit, nonstock corporation with J as its sole member. The primary purpose of M is to own and operate certain parking garages in the vicinity of J's facility.

P is a for-profit, nonstock corporation with J as its sole member. The primary purpose of P is to provide clinical laboratory services to J and to the public.

Q is a for-profit, stock corporation with J as its sole shareholder. The primary purpose of Q is to provide pharmacy services to the public and other related health care services.

Due to the complexities of operating an acute care hospital along with the numerous associated activities, you propose to reorganize your present corporate group structure. Under the reorgnization plan J would become a subsidiary of K. The present members of J would become instead members of K, which, in turn, would become the sole member of J. The present directors of J would continue in that capacity and, at least initially, would also serve as directors of the new parent. Furthermore, J's present subsidiaries would become subsidiaries of K. Appropriate amendments will be made to the organizational documents of the involved organizations to adjust memberships, and J will transfer the shares of stock it owns in L, M, and Q to K to accomplish the restucturing. J has amended its organizational document to require that at least a majority of its directors shall also be on the the board of K, and such individuals shall constitute at least a majority of J's board. You have represented that K will not be controlled directly or indirectly by one or more disqualified persons other than foundation managers and other than one or more publicly supported organizations. Sufficient cash to provide working capital may be transferred to K from J at the consummation of the reorganization, and additional transfers of cash or assets among the exempt organizations are anticipated to further the goals of efficient management. Upon completion of the reorganization, K will function as the parent and will provide overall direction and control to the other corporate entities in the structure that will result from the reorganization.

The overall objective of the proposed reorganization is to enable J to better achieve its exempt purposes. The specific reasons include: (1) to facilitate compliance with governmental reporting requirements, (2) to segregate hospital assets from non-hospital assets so as to limit third party liability, (3) to separate regulated and non-regulated activities, (4) to remove the management of non-hospital activities and assets from hospital management, (5) to increase flexibility in undertaking capital expenditure projects, and (6) to facilitate long range planning.

Hartford Hospital

After the reorganization, J, K, and L will share certain assets, personnel, and services in an effort to reduce, through economies of scale, the overall cost of providing health care services. You have represented that any transactions between the exempt organizations and the nonexempt organizations within the structure will be conducted on an arm's length basis, and charges for goods or services provided in connection with such transactions would be at fair market value.

Section 501(c)(3) of the Code provides for the exemption from federal income tax of organizations organized and operated exclusively for charitable purposes, no part of the net earnings of which inures to the benefit of any shareholder or individual.

Rev. Rul. 78-41, 1978-1 C.B. 148, describes a trust, the sole purpose of which was to accumulate and hold funds for use in satisfying malpractice claims against a hospital. The trust was determined to be an integral part of the hospital because it was controlled by the hospital and because it was performing a function that the hospital could do directly. The ruling concluded that the trust was entitled to exemption under section 501(c)(3) of the Code.

Section 170 of the Code provides for the deductibility of "charitable contributions," which generally includes any gift to or for the use of an organization described in section 501(c)(3).

Section 509(a)(1) of the Code provides, in part, that an organization is not a private foundation if it is described in section 170(b)(1)(A)(iii).

Section 509(a)(3) of the Code provides that an organization is not a private foundation if it is --

(A) organized and operated exclusively for the benefit of an organization described in section 509(a)(1) or 509(a)(2);

(B) operated, supervised, or controlled by or in connection with one or more organizations described in 509(a)(1) or 509(a)(2); and

(C) not controlled directly or indirectly by one or more disqualified persons other than foundation managers and other than one or more organizations described in 509(a)(1) or 509(a)(2).

Section 1.509(a)-4(c)(1) of the Income Tax Regulations sets forth, generally, the organizational test for supporting organizations, and provides that the organization's governing instrument must satisfy the following requirements:

(i) limit the purposes of the organization to purposes set forth in section 509(a)(3)(A) of the Code;

(ii) not expressly empower the organization to engage in activities which are not in furtherance of such purposes;

(iii) state the specified publicly supported organizations on whose behalf the organization is to be operated; and

(iv) not expressly empower the organization to support or benefit any organization other than the specified publicly supported organizations.

Section 1.509(a)-4(e) sets forth the operational test for supporting organizations, and provides that the organization must engage solely in activities which support or benefit the specified publicly supported organizations. A supporting organization is not required to pay over its income to the publicly supported organizations in order to meet the operational test, and may satisfy the test by using its income to carry on an independent activity or program which supports or benefits the specified publicly supported organizations.

Section 1.509(a)-4(h)(1) of the regulations provides that in order for a supporting organization to be "supervised or controlled in connection with" one or more publicly supported organizations, there must be common supervision or control by the persons supervising or controlling both the supporting organization and the publicly supported organizations to insure that the supporting organization will be responsive to the needs and requirements of the publicly supported organizations. Therefore, the control or management of the supporting organization must be vested in the same persons that control or manage the publicly supported organizations.

Section 511 of the Code imposes a tax on the unrelated business taxable income of organizations described in section 501(c).

Section 512(a)(1) of the Code defines the term "unrelated business taxable income" as the gross income, less allowable deductions, derived by any organization from any unrelated trade or business regularly carried on by it.

Section 512(b)(1) of the Code excludes dividends in computing unrelated business taxable income.

Section 512(b)(4) of the Code provides that notwithstanding 512(b)(1), in the case of debt-financed property there shall be included, as an item of gross income derived from an unrelated trade or business, the amount ascertained under section 514(a).

Section 513(a) of the Code provides that the term "unrelated trade or business" means any trade or business the conduct of which is not substantially related (aside from the need of an organization for income

or funds or the use it makes of the profits derived) to the exercise or performance by an organization of its charitable, educational, or other exempt purposes.

The information submitted indicates that the proposed corporate restructuring is intended to enable J to better achieve its charitable purpose under section 501(c)(3) of the Code. The reorganization is expected to promote more efficient health care delivery by reason of enhanced risk management and a more flexible and specialized governance structure. J will continue to provide acute care and related medical services to the public after the reorganization. Accordingly, J will continue to qualify for exemption under section 501(c)(3) and will be described in sections 509(a)(1) and 170(b)(1)(A)(iii).

After the proposed reorganization, K will perform services in support of J which J could perform for itself consistent with its exempt functions. Therefore, by reason of the close and continuous relationship after the reorganization, K could be considered an integral part of J and would qualify for exemption under section 501(c)(3) of the Code. See Rev. Rul. 78-41, 1978-1 C.B. 148. In addition, K will be a supporting organization described in section 509(a)(3). K will satisfy the organizational test of section 1.509(a)-4(c)(1) and the operational test of section 1.509(a)-4(e). K will be "supervised or controlled in connection with" J pursuant to section 1.509(a)-4(h)(1) because of the commonality of control between J and K, and you have represented that K will not be controlled directly or indirectly by one or more disqualified persons other than foundation managers and other than one or more publicly supported organizations. The foregoing conclusions are not affected by K's ownership of all the stock of M and Q, or its status as sole member of N and P, because K's ownership or status as sole member of those organizations will assure that after-tax profits which are available for distribution will be applied to the exempt purposes of J or otherwise returned to K in the form of dividends.

The transfers of assets necessary to consummate the proposed reorganization will be isolated transfers and will not possess the characteristics of a trade or business, because they will not be regularly carried on within the contemplation of section 512(a)(1) of the Code. After the reorganization, the sharing of services and facilities and the transfer of cash and assets among the exempt organizations will be substantially related to the performance of exempt purposes and will not constitute unrelated trade or business activities within the meaning of section 513(a). Also, any dividends paid by M, N, P, or Q to K after the reorganization will be excluded in computing the unrelated business taxable income of K pursuant to section 512(b)(1), but subject to the limitation set forth in section 512(b)(4).

Hartford Hospital

Therefore, assuming that the proposed reorganization is carried out as described in your ruling request, we rule that:

1. After the proposed reorganization, J will continue to qualify for exemption under section 501(c)(3) of the Code and will be described in sections 509(a)(1) and 170(b)(1)(A)(iii).

2. After the proposed reorganization, K will be described in sections 501(c)(3) and 509(a)(3).

3. K's ownership of, or status as sole member of M, N, P, and Q, including the receipt of dividends from these taxable organizations, will have no adverse effect on K's status under sections 501(c)(3) and 509(a)(3).

4. Dividends received by K from M, N, P, or Q will not be unrelated business taxable income and, therefore, will not give rise to the imposition of tax under section 511. (However, this ruling is limited to situations where section 512(b)(4) is not applicable.)

5. The contemplated transfers of cash and other assets and sharing of personnel, services, facilities, and expenses by J, K, and L will not: (a) jeopardize the tax-exempt status of J or K under section 501(c)(3); (b) adversely affect the status of J or K as public charities under sections 509(a)(1) and 509(a)(3), respectively; nor (c) give rise to tax under section 511 to any of the involved exempt organizations.

6. After the proposed reorganization, contributions to J and K will be deductible by the donors as provided in section 170.

This ruling is directed only to the organizations that requested it. Section 6110(j)(3) of the Code provides that it may not be used or cited as precedent.

Sincerely yours,

Milton Cerny

Milton Cerny
Chief, Exempt Organizations
Rulings Branch

Attachment E

License

STATE OF CONNECTICUT

DEPARTMENT OF PUBLIC HEALTH

Division of Health Systems Regulation

TO: Administrator
Hartford Hospital
80 Seymour Street and 200 Retreat Avenue
Hartford, CT 06106

FROM: Colleen Judge
Processing Technician

DATE: March 1, 2010

We are enclosing a corrected license showing a change for your facility:

( ) Change of Administrator

( ) Change of Medical Director

( ) Change of Director of Nurses

( ) Increase of bed capacity from _____ to _____ Eff: _____.

( ) Decrease of bed capacity from _____ to _____ Eff: _____.

(X) Other change, describe below:
Added (1) Satellite – Duncaster Primary Care Satellite, 40 Loeffler Road, Bloomfield effective 1/26/10.

Please note that this license is in effect only for the operation of the facility as it is now organized. This division should be notified immediately if you:

1. Change your Administrator
2. Change your Director of Nurses
3. Change your Medical Director
4. Plan to relocate
5. Plan to sell your facility
6. Plan to discontinue operation.

Any of these changes or proposed changes also require written notification to this division.

If we can be of any assistance, please do not hesitate to call the licensure office.
Enclosure

Phone: (860) 509-7444
Telephone Device for the Deaf (860) 509-7191
410 Capitol Avenue - MS # 12HFL
P.O. Box 340308 Hartford, CT 06134
An Equal Opportunity Employer

STATE OF CONNECTICUT

Department of Public Health

LICENSE

License No. 0046

General Hospital

In accordance with the provisions of the General Statutes of Connecticut Section 19a-493:

Hartford Hospital of Hartford, CT, d/b/a Hartford Hospital is hereby licensed to maintain and operate a General Hospital.

Hartford Hospital is located at 80 Seymour Street and 200 Retreat Avenue, Hartford, CT 06106

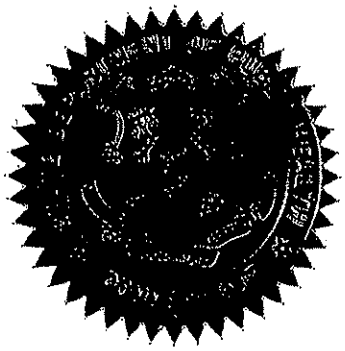
The maximum number of beds shall not exceed at any time:
819 General Hospital beds
48 Bassinets

This license expires **December 31, 2011** and may be revoked for cause at any time.

Dated at Hartford, Connecticut, January 1, 2010.

License revised to reflect:
* Added (1) Satellite effective 1/26/10

Satellites
The Iol Day Program At Bloomfield, 2 Northwestern Drive, Bloomfield, CT
West Hartford Surgery Center, 65 Memorial Road, Suite 500, West Hartford, CT
*Duncaster Primary Care Satellite, 40 Loeffler Road, Bloomfield, CT



J Robert Galvin MD, MPH, MBA

J. Robert Galvin, MD, MPH, MBA,
Commissioner

Attachment F

Vendor Quotes and Schedule of Depreciation

Hartford Hospital
Docket Number 10-31577-CON
Acquisition of a CT Simulator
Schedule of Capital Expenditures and Depreciation

Item	Capital Expenditure	Estimated Useful Life	Annual Depreciation Expense
Aquillion LB	$599,262	5	$119,852
Support Software	$54,090	5	$10,818
Licenses	$28,000	5	$5,600
CT Upgrade	$37,800	5	$7,560
Imaging Equipment	$719,152		$143,830
Injector	$30,000	5	$6,000
Brachytherapy module	$6,375	5	$1,275
Carbon Fiber Breastboard	$10,000	5	$2,000
2 Prone Breastboards	$9,702	5	$1,940
Other Medical Support Equipment	$2,852	5	$570
Medical Equipment	$58,929		$11,785
Bariatric Chair	$898	10	$90
Chairs	$1,151	10	$115
Miscellaneous	$209	10	$21
PC's	$6,800	5	$1,360
CCTV Monitor	$275	5	$55
Non-Medical Equipment	$9,333		$1,641
Construction	$185,000	5	$37,000
Construction Contingency	$27,000	5	$5,400
Construction	$212,000		$42,400
Total	$999,414		$199,656

TOSHIBA
Leading Innovation >>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER SUMMARY

OMT NO: 374952
DATE: 3/15/2010 QUOTE NO: 96123

PRESENTED TO: (COMPLETE LEGAL NAME)

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

DELIVER TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

EQUIPMENT SUMMARY:

#AQLB **AQUILION LARGE BORE CT SCANNER**

CT SCANNER AQ LB WITH EXTENDED COUCH

CT ACCESSORY KIT - EXTENDED COUCH 1800 MM

MED-TEC IPPS™ CT INSERT TABLETOP FOR EXTENDED 1800 MM COUCH

CT PHANTOM

CONSOLE DESK 65" X 36" X 30"

(2) CHAIR WITH ADJUSTABLE ARMS AND BACK

(5) MEDIA FOR DVD-RAM DRIVE (9.4 GB)

CABLE CATEGORY 5E/RJ45 5M

This quotation shall remain valid for 30 days (not to exceed 60 days) from date of submission.
All prices are F.O.B. destination.
Payment terms are: Cash - 10% down payment, 70% upon shipment, 20% net 30 days after shipment or upon availability for first use by purchaser, whichever comes first.

Additional terms and conditions appear at the end of this quotation. McKesson Agreement Required _____Yes __X___No
Vital Software License Agreement Required _____Yes __X___No
Please return signed quotation to: Toshiba America Medical Systems, 2441 Michelle Drive, Tustin, CA 92780.

ACCEPTED AGREED AND ORDERED:

CUSTOMER REQUESTED DELIVERY DATE: _____ _____ _____
TOSHIBA REP/CONTACT DATE

_____ _____ _____ _____
PURCHASER'S SIGNATURE/TITLE DATE ZONE SALES MANAGER DATE

QUOTATION/ORDER ORDER SUMMARY

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO: (COMPLETE LEGAL NAME)

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

EQUIPMENT SUMMARY: (continued)

CABLE CATEGORY 5E/RJ45 35M

(2) SERVICE MODEM CABLE

FLOOR LEVELING EPOXY KIT

DICOM MODALITY WORKLIST MANAGEMENT (MWM) SERVICE CLASS USER (SCU) SYSTEM

VARIAN RPM RESPIRATORY GATING

RESPIRATORY GATING SYSTEM

RESPIRATORY GATING JAN06~

POWER CONDITIONER/DISTRIBUTOR 125 KVA UNIVERSAL

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

#AQLB

AQUILION LARGE BORE CT SCANNER

Aquilion LB is a large bore Computed Tomography (CT) scanner that provides uncompromised patient positioning with outstanding image quality and clinical performance.

The system was designed for uncompromised patient positioning and image quality necessary for CT simulation and oncology treatment planning. This includes:

- Widest bore opening in the industry (90 cm) for easy patient positioning and maximum flexibility for treatment planning, and
- Largest true (non-extrapolated) field-of-view (70 cm), which covers more anatomy with greater accuracy then ever before by using Toshiba's Quantum^{PLUS} Detector

The Aquilion LB solves one of the biggest problems faced in oncology - the positioning of a large patient on a breast board with both arms up and the board tilted to its maximum (25%).

Aquilion's Quantum^{PLUS} detector introduces true isotropic resolution to oncology. This enables the user to scan in one plane and reconstruct information in another plane with the same image quality, allowing clinicians to use 3-D volumetric information when needed. Aquilion's Quantum^{PLUS} detector is the only detector to provide three slice-width combinations - 16x0.5, 16x1 and 16x2 mm - and it achieves an industry-leading, low-contrast resolution without using additional dose.

The combination of a high-speed scanner and a powerful, high-voltage generator meets every diagnostic requirement. Solid-state, multi-row detectors and optimal reconstruction techniques ensure high-quality images. A high-performance CPU, large color monitors, hybrid keyboard and refined Graphic User Interface (GUI) make the operating environment highly efficient.

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

COMPONENTS

- Large-aperture, 90 cm, slip-ring gantry and extra-wide couch (47 cm)
- MEDTEC CT table insert/overlay
- High-frequency X-ray generator and high-heat-capacity X-ray tube
- Ergonomic operator console
- Volumetric image processor
- High-capacity hard disk
- CD-R / DVD-RAM Drive – 9.4 GBytes (double sided DVD RAM)
- Image data transfer link
- Patient comfort accessories
- Operator manuals and quality assurance phantoms

KEY FEATURES

Uncompromised Patient Positioning: The industry's largest aperture of 90 cm and the 70 cm true reconstruction field-of-view provides extreme flexibility during CT simulation and uncompromised treatment planning.

Routine Fast Scanning: Using slip-ring technology, Aquilion LB is able to perform 0.32-second partial scans and 0.5-second routine scans to meet the demands of dynamic and helical examinations.

High Image Quality: The Aquilion LB features 994 channels in 40 rows of solid-state detectors; specialized, user-selectable, image-reconstruction algorithms; and a wide selection of slice thicknesses. The system provides outstanding low-contrast resolution of 2 mm at 0.3% and high-contrast resolution of 0.35 mm.

High-Power Generator: Robust, high-voltage circuits generate 60 kW of power and 500 mA, providing support for the 7.5 MHU X-ray tube that makes possible helical scans up to 100 seconds and scans with metal-free scan range of up to 1,800 mm.

Multiple kV Selections: 80, 100, 120 and 135 kV.

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

Fast Image Reconstruction Time: Up to 10 images per second.

SURE**Technology:** Provides maximum productivity and best image quality at the lowest possible dose. Real-time helical display, which provides instantaneous visualization of acquired images, allows the operator to rapidly assess if additional images are needed. SUREStart bolus tracking software, which is included in the standard configuration, provides the ability to monitor contrast media in real-time.

Easy Operation: Perform easy operations using the 18-inch LCD monitor, mouse and hybrid keyboard. Scan automatically by programming procedures with eXam Plan and vocal instructions through VoiceLink™.

Optimal Space Utilization: The Aquilion LB has only three components – gantry, couch and console – with a footprint of only 27 square meters.

DOSE REDUCTION FEATURES

The Aquilion CT systems from its dual-supported anode grounded x-ray tube, to the ultra-efficient Quantum Detector system and low noise data acquisition system (DAS), to the dose-saving SUREExposure3D (x, y ,z mA modulation software), to advanced adaptive reconstruction (QDS) and noise reduction algorithms (Boost3D), have been designed to deliver the best image quality at the lowest possible dose.

Quantum Denoising Software - QDS (Adaptive Noise Reduction) :
Toshiba's Quantum Denoising Software is an adaptive noise reduction algorithm that works in the image data space by preferentially smoothing areas of uniform density while preserving the edge information of the image. QDS works in both two and three dimensions and can drastically reduce image noise, allowing a corresponding savings in patient dose of up to 50%. Most importantly, QDS works in conjunction with the SUREExposure3D software to adjust the mAs based on the expected noise reduction from QDS. In this way, patient dose reduction is totally integrated in the Aquilion console software prior to turning on the x-ray beam.

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

SURE**Exposure3D (x, y, z automated mA modulation software) :** Toshiba's SUREExposure3D software automatically adjusts the mAs rapidly during the scan to adapt to and compensate for changes in attenuation level produced by the non-uniformity of the anatomy being imaged. Therefore, as the scan moves from the shoulders to the lung, the mAs goes down, and as the tube rotates around the patient, less mAs is used anterior-posterior than laterally. For the same image quality level, compared to non-modulated scanning, SUREExposure3D can reduce the dose by up to 40%.

Boost3D : Boost3D is an adaptive, three-dimensional algorithm that virtually eliminates degradation of image quality due to highly attenuating anatomical structures, such as the pelvis or shoulders. Without dose reduction algorithms, like Boost3D, these highly attenuating areas require increased mAs and kVp to overcome the low photon count. Instead, Boost3D seeks out portions of the raw-projection data where there is a disproportionate loss in x-ray signal and applies a three-dimensional algorithm locally to reduce the image noise and streak artifacts.

EQUIPMENT DESCRIPTION

Aquilion LB Gantry
The Aquilion LB gantry uses a direct-drive design to provide accurate alignment between beam and detector, and to reduce rotational noise for higher-quality images.

A low-voltage slip ring assures reliable, continuous power transfer.

- Digital signal transmission facilitated by innovative optical-coupling technology moves information to the volumetric image processor
- Generator is inside the gantry to conserve space

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

Other features include:

- Industry's largest aperture: 90 cm
- Five scan fields of view: 24, 32, 40, 55 and 70 cm
- Gantry controls on both sides
- Patient positioning lights
- Wide range of scan times provides greater flexibility for optimal image quality (0.32 partial; 0.5, 0.75, 1, 1.5, 2 and 3 seconds full)
- Slice thickness selections of 16x0.5, 16x1 and 16x2 mm with the capability of stacking images to the desired slice thickness

Couch

- 47 cm wide, metal-free couch top
- Horizontal stroke of 2,190 mm and a scanning range of 1,800 mm for tall patients
- Couch top can be lowered to 30 cm (12 inches)
- Manual control of table movement from both the gantry and console or programmed by an exam protocol
- Couch top supports up to 450 lbs. while maintaining accuracy of ±0.25 mm

Couch Insert/Overlay

- Toshiba IPPS™ table overlay uses MEDTEC's patented indexing feature for rapid, accurate and repeatable patient set-up
- 53 cm wide, 200 cm long, 10 cm thick and 14 kg weight
- Constructed of foam core covered with carbon fiber

Dual CT Consoles

- Consists of hybrid keyboards, mouse, monitors and Navibox
- Controls the entire system, including power
- Image display
- Scanoscope control
- Remote control of couch-top movement
- Window level and width adjustment
- Three preset windows can be stored in the eXam Plans
- Other mouse-operated, image-processing functions

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

- High line-rate, 18-inch LCD monitors
- Displays images in 512x512 or 1024x1024
- CT number display ranges from -1,536 to +8,191
- 32 programmable voice commands

X-ray Tube
The Aquilion LB is equipped with the MegaCool™ X-ray tube. This compact, high-performance tube was designed specifically to minimize tube-cooling delays in heavy patient-load conditions using 0.5-second scan time.

Other features include:
- Dual focal spots
- Anode capacity of 7.5 MHU
- Dissipation rate of 1,386 kHU per minute maximum

Detectors
The Quantum^{PLUS} detector design allows Toshiba to generate a 70 cm true field-of-view – the largest in the industry – for uncompromised positioning.

Other features include:
- Solid-state detector array
- Low-contrast resolution of 2 mm at 0.3%
- 994 detector channels and 40 rows of detector elements
- 1,800 views per second to produce high-resolution images

Computer
- Two 32-bit processors
- Capable of simultaneous scanning, retrieving, reconstructing, archiving and filming without interruption – true multi-tasking system
- Ultra-fast, 217 GB hard disk
- 100,000 images on both scan and display console
- 3,600 rotations of raw data maximum
- CD-R / DVD-RAM Drive – 9.4 GBytes (double sided DVD RAM)
- DICOM CD writer *(option)* – Archive up to 1000 images

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

PATIENT AND IMAGE MANAGEMENT

Patient Demographics Management

- Enter individual patient information at the time of examination manually or imported from Modality Worklist Management query.
- On-line patient appointment file management

Image Management

Aquilion LB images can be stored on hard disk, magneto-optical disk or transferred via gigabit Ethernet connection using DICOM 3.0 standards.

DICOM 3.0 (Storage SCU)

- Allows the CT scanner to export images to CT simulation, 3-D workstations or any other device on the network
- Consists of software only and utilizes pre-existing Ethernet ports on the CT scanner to connect to a coax-Ethernet-based network running TCP-IP communication protocols
- The system can be set to automatically transfer images to the network after an exam is complete

DICOM 3.0 (Print SCU)

- Allows the CT scanner to send image data that has been acquired and reconstructed to a film imager for printing via Ethernet in conformance with DICOM 3.0 standards

Image Display

- Display in multiple formats ranging from 1 to 16
- Overlay an inset scanogram for quick reference marking
- Add, subtract, rotate or filter images
- Adjust window width and level non-linearly, accommodating up to six built-in curves and six user-defined curves

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

IMAGE QUALITY ENHANCEMENTS

Automatic, 2-Pass, Beam-Hardening Correction (BHC): Compensates for the non-uniform, beam-hardening effect of bone for more accurate reconstruction. Reduction of streak artifacts in the posterior fossa and elimination of cupping artifact in the mid-brain.

Raster Artifact Suppression Protocol (RASP): Reduces artifacts caused by non-uniform attenuation such as in the shoulders and pelvis, and may be applied prospectively or retrospectively.

Reconstruction Algorithms: Grouped by anatomical application, more than 20 algorithms are provided for customized image reconstruction according to the diagnostic information needed or physician preference.

HELICAL SCAN & FUNCTIONALITY

MultiView: Built into protocol for fast, multi-planar reconstruction in batch mode specifically for multislice data sets. Coronal, sagittal and axial images are created from isotropic volume data.

3-D Imaging: Provides excellent image quality with surface shaded-renderings and volume-rendered 3-D images. Provides zooming and panning over the 3-D surface and performs distance measurements. Other features include:

- 3-D surface display
- 3-D shaded volume display
- Maximum intensity projection (Max – IP)
- Minimum intensity projection (Min – IP)
- Intensity volume rendering

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

Quantitative Analysis
- Profile display of CT numbers along a selected line in the axial plane
- Distance measurement and display
- CT number display
- Histogram display
- Circulatory function analysis fits a curve to CT number changes over time for a selected region of interest (ROI)
- Functional images based on peak height, peak time, appearance time, area under curve, mean transit time, second moment and transit time
- ROIs can be rectangular, circular or irregular

Image Manipulation
- Vari-area allows pre-selection of ROI for accurate display field of view (DFOV) using raw data for immediate viewing
- User-defined, post-processing filters for edge enhancement and smoothing

Annotation
- Four lines of comments and arrow display
- 36 exam information fields that can be selectively masked or shown depending on site requirements

eXam Plan Protocols
- 684 eXam Plan protocols that can be adjusted while scanning
- Four preset reconstructions
- eXam Plan sets can be stored on optical disks and copied to other Toshiba scanners

Archiving
- Can be automated with each eXam Plan
- Data can be stored on and retrieved from MOD
- Raw data and image data can be protected to prevent deletion

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

Filming
- Auto filming can be set as part of the eXam Plan
- Images are displayed in 512x512 or 1024x1024

CUSTOMER CARE SERVICES

InnerVision
Remote diagnostics proactively monitor the system to minimize downtime

Image Maker Express
The Image Maker Express is a marketing support online resource designed exclusively for Toshiba customers that helps you create outreach programs to generate awareness about your imaging services.
- Includes positioning and messaging guides to help you strategize your communications efforts and tactics
- Contains product information, ready-to-use collaterals, and ideas for creating custom materials to promote your new imaging capabilities

Image Maker Express gives you access to:
- Product images
- Clinical images
- PowerPoint presentations
- Sample brochures
- Sample press releases
- Marketing strategy tutorials
- Updates at www.imagemaker.toshiba.com/express

**Offerings may vary per product*

Build demand by:
- Sending a press release
- Developing a strategic plan
- Creating brochures
- Finding tips on effective presentations

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

Application Training
Each system includes three phases of training.

Phase I: A one-week intensive course on the operation of the scanner
- Conducted at the Toshiba Training Academy in Irvine, California
- Accredited for continuing education by the ASRT Education Foundation
- Two attendance vouchers good for course and travel expenses provided with each system
- One technologist must attend prior to system installation
- The second voucher is valid for six months following installation
- Additional vouchers available for $3,500

Phase II: 32 hours of training that builds on the Phase I academy training
- On-site at client facility
- Training for up to four technologists
- Technologist who attends the academy course must attend Phase II

Phase III: 32 hours of follow-up training
- On-site at client facility
- Approximately 8-10 weeks after Phase II training

Additional On-Site Training:
Additional On-site training available for purchase.

Applications support is available by phone on the toll-free ASSIST line.

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

COMPONENT SUMMARY:

#CA-3110P	**AQUILION LB EXTENDED COUCH**
TSX-201A/1L	**CT SCANNER AQ LB WITH EXTENDED COUCH**
CT-9058	**CT ACCESSORY KIT - EXTENDED COUCH 1800 MM**

Accessory Kit for Extended Couch -Includes each of the following items:

- "The Shield" Table Pad
- Rolled Edge Foot Extension Pad
- Protective Table Cover
- Chin Strap
- Forehead Strap with Adult Pad
- Adult Head Rests
- Tilt Wedge
- Knee Wedge
- Coronal Head Positioner
- Pediatric Lift Pad

CAFT-016A/1B **MED-TEC IPPS™ CT INSERT TABLETOP FOR EXTENDED 1800 MM COUCH**

The IPPS™ CT Couch Overlay is designed to provide rapid, accurate, and repeatable patient setup and localization. The MED-TEC indexing system provides convenient and consistent orthogonal alignment.

- Optimum patient comfort
- Treatment flexibility
- Quick set-up and ease-of-use
- Highly repeatable patient positioning

Note: Applies to Aquilion 64, 32, 16, 8 and Super 4 ***extended 1800 mm couches.***

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

DCHIS-CT-PHANTM	**CT PHANTOM** Measures image quality to ensure compliance to Toshiba standards for: • High-contrast resolution • Low-contrast resolution • Slice thickness • Noise • Contrast scale
SK-03050-1	**CONSOLE DESK 65" X 36" X 30"** Measures 65" x 36" x 30"
E31752-CHAIR (Qty 2)	**CHAIR WITH ADJUSTABLE ARMS AND BACK**
LM-HB94LU (Qty 5)	**MEDIA FOR DVD-RAM DRIVE (9.4 GB)** 9.4 GB Removable Cartridge Media for DVD-RAM Drive. • Type 4, Double-sided • 3x Speed
L88C5EGRY-05M	**CABLE CATEGORY 5E/RJ45 5M**
L88C5EGRY-35M	**CABLE CATEGORY 5E/RJ45 35M**
TNULL9F9M-75 (Qty 2)	**SERVICE MODEM CABLE**
1559	**FLOOR LEVELING EPOXY KIT**

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

COT-32D	**DICOM MODALITY WORKLIST MANAGEMENT (MWM) SERVICE CLASS USER (SCU) SYSTEM**

Allows the CT system to receive patient demographic data from an HIS/RIS system in conformance with the DICOM 3.0 standard.

Note: This option does not include a DICOM gateway for the HIS/RIS system.

#GATING-RESPLB	**RESPIRATORY GATING PACKAGE**

Toshiba's Respiratory Gating option provides a comprehensive package of hardware and software for the Aquilion LB to perform 4-D respiratory gating using the Varian RPM system. This provides tumor tracking during respiration. The system detects the patient's respiratory cycle prior to scanning and allows the user to define respiratory phase or phases for gated scanning or image reconstruction.

Toshiba's Prospective Respiratory Gating software will allow you to acquire multiple series of Axial scans that correspond to multiple phases of inspiration provided by Varian RPM system or you may choose to acquire only one series of axial scans at a pre selected phase, example inspiration, in order to reduce table time and exposure.

Toshiba's Retrospective Respiratory Gating software will allow you to acquire a single low pitched helical scan. During this scan the raw data is tagged with time information that is received from the Varian RPM system. After the scan is completed the images are reconstructed in the selected phases by the CT system. Up to 10 phases can selected for reconstruction.

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

Respiratory Gating 4D package includes:

- Toshiba Respiratory Gating Software (CKRS-003A/1B) for acquisition and reconstruction of Prospectively Gated Images.
- Toshiba Respiratory Gating Software (CKRS-003B/1B) for acquisition and reconstruction of Retrospectively Gated Images.
- Varian RPM PC Workstation running the system software. The monitor displays motion data, live video images from the tracking camera, and, in the standard simulation room.
- Varian Reflective Marker Block which you position on the patient to track respiration motion.
- Varian Tracking Camera. The (CCD) tracking camera acquires video images of the marker block.
- In-room viewfinder (monitor) that shows the image from the tracking camera to confirm visualization of the marker block position by the camera.

Important Note – This package only provides respiratory gating acquisition capability. It is recommended that the end user have a CT Sim workstation or Treatment planning system that supports 4-D analysis and image manipulation.

Note – Med-Tec IPPS™ CT Insert Tabletop is required for mounting of the Respiratory Gating camera. This item comes standard with the Aquilion Large Bore.

<RPM-VARIAN2	**VARIAN RPM RESPIRATORY GATING**
<CKRS-003B/1B	**RESPIRATORY GATING SYSTEM**
<CKRS-003A/1B	**RESPIRATORY GATING JAN06~**

PURCHASER		TOSHIBA REP/ CONTACT	
INITIALS	DATE	INITIALS	DATE

QUOTATION/ORDER
ORDER DETAIL

OMT NO: 374952
DATE: 3/15/2010 QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

PCDU-TW/U

POWER CONDITIONER/DISTRIBUTOR 125 KVA UNIVERSAL

The PCDU-CT is engineered to address the vast majority of common power problems found in the hospital environment, thus providing clean power and good grounding for optimal reliability and performance of CT systems.

This device provides most of the electrical site preparation requirements of Toshiba CT systems, including:

Power Conditioning
The PCDU contains a combination of a shielded, ultra-low impedance isolation transformer with matched L-R-C low-pass filters and surge suppressors. The quality of power to the Toshiba system is improved in many ways:

- The isolation transformer re-references the power line to the local ground point (with connection to local building steel), isolating the system from upstream, ground-quality problems.
- The transformer shield helps protect against ground impulses and noise (*common mode* disturbances).
- The sine wave tracking filter protects against both high-frequency noise and fast-voltage impulses (*normal mode* disturbances), clamping spikes and filling-in notches.
- The surge suppressors protect against slower voltage impulses that have frequency below the filter cutoff.

Voltage Conversion
Wiring costs are significantly reduced since the PCDU accepts a single, 480V delta input with code minimum ground, supplying 120/208V wye to the generator and the various other parts of the system.

Distribution
The PCDU comes prepackaged with the distribution breakers needed for each system feed. Having all system breakers in one location also makes it easier for service personnel to remove power.

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

Control
The PCDU includes a circuit breaker on the input (primary) and a 24 VAC control signal for remote, emergency off control of the circuit breaker.

Impedance Control
The ultra-low impedance design of the isolation transformer helps ensure the power feed meets the low impedance requirement of today's CT labs as spelled out in the Toshiba Optimal Power Specifications (TOPS) manuals.

Planning
Planning is simplified by having all these components and functions delivered in a single box.

Installation
Installation is much faster, more predictable, and less expensive with a factory-assembled and tested system.

Approvals
UL listing will reduce time and uncertainties obtaining local electrical inspection approvals.

Reduced Site Preparation Costs
The PCDU comes equipped with an input-shunt, trip-circuit breaker, eliminating, in most cases, the need for a room breaker. Only an Emergency Power Off button for remote breaker control is required.

Note: Not for use with Aquilion ONE

TOTAL QUOTE PRICE **$599,266.00**
Applicable Sales Tax Additional

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

TOSHIBA
Leading Innovation >>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

ADDENDUM

ALL INFORMATION CONTAINED IN THIS QUOTATION IS CONFIDENTIAL AND MAY NOT BE DISCLOSED TO ANY THIRD PARTY WITHOUT TOSHIBA'S PRIOR WRITTEN CONSENT.

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

PRODUCT WARRANTY AND SERVICES COVERAGE

SYSTEM WARRANTY TERMS

Toshiba America Medical Systems, Inc. (TAMS) warrants to Customer that the product(s) to be delivered hereunder will be free from defects in material, manufacturing workmanship, and title. Any product or part furnished to Customer during the warranty period (stated in the table below) to correct a warranty failure shall be warranted to the extent of the unexpired term of the warranty applicable to the repaired or replaced product or part.

The warranty period shall commence on the date the Product is delivered to Customer. However, if TAMS installs the product, the warranty period for such product shall commence on the date the installation of the product is complete. Notwithstanding the foregoing, in the event that the installation of the product is delayed for a total of thirty (30) days or more from the date of delivery for any reason or reasons for which TAMS is not responsible, the warranty period for such product may, at TAMS' option, commence on the thirtieth (30th) day from the date such product is delivered to Customer.

WARRANTY EXCLUSIONS

Warranty coverage does not include any defect which results, in whole or in part, from (1) negligent storage or handling of the product by Customer, its employees, agents, or contractors, (2) failure of Customer to prepare the site or provide power requirements or operating environmental conditions in compliance with any applicable instructions or recommendations of TAMS, (3) absence of any product, component, or accessory recommended by TAMS but omitted at Customer's direction, (4) any design, specification or instruction furnished by Customer, its employees, agents, or contractors, (5) any alteration of the product by persons other than TAMS, (6) combining TAMS' product with any product furnished by others, (7) combining incompatible products of TAMS, (8) improper use of the product, improper maintenance of the product by a party other than TAMS, or failure to comply with any applicable instructions or recommendations of TAMS, or (9) acts of God, acts of civil or military authority, fires, floods, strikes or other labor disturbances, war, riot, or other causes beyond the reasonable control of TAMS.

TAMS does not warrant any products not manufactured by Toshiba such as, without limitation, monitors, cameras, computer equipment, etc. Such items will be furnished subject only to the manufacturer's warranty, if any, and without any warranty whatsoever by Toshiba.

Warranty coverage also excludes consumables, including but not limited to cryogens, cassettes, magazines, imaging screens, disks, cartridges, etc.

GLASSWARE WARRANTY

Glassware, including X-ray tubes and Image Intensifiers, are provided separate warranties. Glassware included with the purchase of a new system is governed by the glassware warranty, described below, not the system warranty.

CT X-ray tubes carry a prorated warranty based on the number of rotations shown below or 12 months, whichever comes first.

Tube Type	Prorated Warranty
CXB-350	150,000 rotations*
CXB-400 (Helicool)	150,000 rotations*
CXB-650	150,000 rotations*
CXB-750/D/4A (Megacool™)	200,000 rotations*
CXB-750/E/2A (Megacool™ V) Aquilion Premium	100,000 rotations*
CXB-750/E/2A (Megacool™ V) Aquilion ONE	100,000 rotations*

*A rotation is any 360-degree or single rotation of the gantry with X-rays on.

The following time-based warranty terms apply to all other glassware:

Tube Type	Time-Based Warranty
Liquid Bearing Tubes (DSRX-TXXXX)	12 months, non-prorated
All Other X-ray tubes	12 months, non-prorated
Image Intensifiers	18 months, non-prorated

GLASSWARE PRORATION CALCULATION:

Credits for glassware that fails during the warranty periods stated above will be calculated as follows:

Tubes with Prorated Rotation Warranty:

$$\text{Credit} = 1 - \frac{\text{Number of Rotations Used}}{\text{Number of Rotations Warranted}}$$

Credit will be applied to the purchase of the replacement X-ray tube or Image Intensifier. Complete glassware coverage during warranty period may be purchased from the local services organization at an additional charge.

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

QUOTATION/ORDER ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

Tubes with Non-Prorated, Time-Based Warranty:

Tubes with a non-prorated warranty will be replaced during the initial warranty period at no charge to the customer. The replacement tube carries the remainder of the original warranty. For example, a tube with a 24-month non-prorated warranty fails at month thirteen (13), the tube is replaced at no charge and carries eleven (11) months of warranty.

REMEDIES
If TAMS determines that any product fails to meet any warranty during the applicable warranty period, TAMS shall correct any such failure by either, at its option, repairing, adjusting, or replacing without charge to Customer any defective or nonconforming parts of the product. TAMS shall have the option to furnish either new or remanufactured replacement parts or assemblies. During the warranty period, Toshiba will furnish free of charge any upgrades, including software required to correct any defect in the warranted products or as required under applicable laws.

WARRANTY SERVICE
Warranty service during the applicable warranty period will be performed without charge to Customer during TAMS' normal business hours, Monday through Friday, excluding holidays. Subject to the availability of personnel, after-hours service is available upon request at an additional charge.

The remedies set forth herein are conditional upon Customer promptly notifying TAMS within the applicable warranty period of any defect or nonconformance and making the product available for correction.

DISCLAIMERS AND LIMITATIONS ON LIABILITY
TAMS' obligation to repair or replace defective parts will be Customer's sole and exclusive remedy for a breach of the warranty set forth above. SUCH WARRANTY WILL BE IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION, THE WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

In no event shall TAMS be liable for special, incidental or consequential damages. Toshiba does not warrant that the operation of the warranted products will be uninterrupted.

WARRANTIES BY PRODUCT LINE

	COMPUTERIZED TOMOGRAPHY	MAGNETIC RESONANCE	PACS SYSTEMS	ULTRASOUND	X-RAY VASCULAR	X-RAY R/F & RAD
SYSTEMS AND MAJOR COMPONENTS	12 Months	12 Months	12 Months	12 Months	12 Months	12 Months
ACCESSORY OPTIONS	6 Months	6 Months	6 Months	6 Months	6 Months	6 Months
REPLACEMENT & OPTIONAL PARTS	90 Days	90 Days	90 Days	90 Days	90 Days	90 Days
UPGRADE COMPONENTS	90 Days	90 Days	N/A	12 Months	6 Months	6 Months
MISC. WARRANTY ITEMS	Detectors: Solid State 12 Months	N/A	N/A	Transducers: 12 Months	N/A	N/A

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

TOSHIBA
Leading Innovation >>

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

TERMS AND CONDITIONS OF SALE

1. GENERAL TERMS. Unless otherwise specified on the face of this document, this Quotation/Order ("Agreement") will remain valid only if accepted by Customer no later than 60 days from date of submission to Customer.

2. TITLE AND RISK OF LOSS. Title and risk of loss to the Equipment purchased under this Agreement will pass to Customer: (a) if Toshiba is to provide installation, upon Toshiba's completion of installation, or (b) if Toshiba will not provide installation, upon delivery by Toshiba to a common carrier at Toshiba's facility from which the Equipment is shipped.

3. TERMS OF PAYMENT. Unless otherwise specified on the face of this document, prices stated are F.O.B. Customer's facility. All taxes which are payable by Toshiba in connection with the sale, use, or possession of the Equipment (excluding income taxes), will be paid by Customer in addition to the quoted price. Terms of payment for, C.T., M.R.I, X-Ray, and the McKesson System will be cash-10% upon execution of this Agreement, 70% upon delivery, balance due upon completion of installation and/or availability for first use, whichever is earlier. Terms of payment for Ultrasound and Nuclear will be cash-10% upon execution of this Agreement, 90% NET upon completion of installation and/or availability for first use, whichever is earlier. All invoices paid after due date will be assessed a late payment charge of the lesser of 1 1/2% per month or the maximum rate permitted by law.

4. DELAYS. If Customer changes the scheduled delivery date specified on the face of this document ("Scheduled Delivery Date") during the period of 120 days preceding such date, Customer will nevertheless pay the installment of the purchase price which would have been payable upon delivery, on the Scheduled Delivery Date as if delivery had been made on such date. In addition, Customer will pay all extra costs incurred by Toshiba as a result of such delay, including, without limitation, storage and transportation. Storage fees will be charged at commercially comparable rates for storage on Toshiba's site. If delivery is delayed by 12 months or more from the Scheduled Delivery Date, except through the fault of Toshiba, the price set forth in this Agreement may be increased by Toshiba to a level equal to the prevailing price in effect at the time of the revised delivery date.

5. ACCEPTANCE BY TOSHIBA. This Quotation/Order will not be binding on Toshiba even if signed by a Toshiba employee, until Customer's order for the Equipment is booked by Toshiba's Headquarter office.

6. EQUIPMENT INSTALLATION. Toshiba will install all Equipment purchased under this Agreement and connect them to existing power and/or plumbing lines at no additional charge to Customer. Customer will be responsible for electrical wiring, plumbing, carpentry, plastering, painting, or all other site preparation required prior to installation and connection of the Equipment by Toshiba. Customer will provide space at the installation site for the safe storage of Toshiba's tools, test equipment and other materials used for installation at no charge to Toshiba. Customer shall, at its cost, obtain all permits and licenses required by governmental authorities in connection with the installation and operation of the Equipment. The Equipment may contain certain components, which may have been re-manufactured. However, such components will meet the manufacturer's specifications for new components as of the date of completion of installation. Customer acknowledges that the System and Software are designed to operate within certain power, temperature, airborne contamination, and humidity ranges. Customer will be responsible for, without limitation: (i) preparing and maintaining the Customer facility in conformance with the Site Preparation Guide; (ii) maintaining its network infrastructure; (iii) providing Toshiba, McKesson or its subcontractors access to a network connection in or near the area of the System being serviced by the equipment service staff; and (iv) supplying computer grade AC power. The Equipment relies upon a stable grounded connection to the main power grid in order to function effectively. Customer acknowledges that AC power supply quality may be a problem in old facilities or in those facilities receiving poor quality utility service and that power conditioning may be necessary in such cases.

7. EQUIPMENT OPERATION AND INDEMNITY. Customer agrees that all Equipment purchased under this Agreement will be operated exclusively by duly qualified technicians and/or medical doctors in a safe and reasonable manner in accordance with Toshiba's written instructions, applicable laws and regulations, and for the purposes for which such Equipment was intended.

8. LIMITED WARRANTY AND REMEDY. A. For the Toshiba Equipment: For the warranty period described below by product, Toshiba, as its only obligation, will replace or repair, without charge to Customer during Toshiba's normal working hours (if Customer requests warranty service outside such hours, Customer will pay overtime premium for labor), any component of the Equipment that is defective in materials or workmanship, provided such defect is reported to Toshiba within the warranty period. Toshiba's warranty

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

period is as follows: (a) Systems and Major Components – one year from date of completion of installation; (b) Accessories/Options (except glassware) – six months from date of completion of installation. Components not manufactured by Toshiba will be furnished subject only to the manufacturer's warranty, if any, and without any warranty whatsoever by Toshiba. During the warranty period, Toshiba will furnish free of charge any upgrades, including software required to correct any defect in the Equipment or as required under applicable laws.

B. For the McKesson System: The McKesson System ("System") will be covered by a 12-month warranty beginning the date of completion of installation of the System (the "Warranty Period"). The warranty covers repair of any defects in materials or workmanship related to the computer equipment ("Equipment") that is included in the System purchased by Customer under this Agreement. The warranty also covers correction of any McKesson software ("Software") that does not conform with its functional specifications. In order to receive services during the Warranty Period, Customer must provide McKesson and Toshiba with remote access through a VPN. During the Warranty Period, Customer is entitled to (a) all Generally Available Software Updates except for Updates that are separately priced and marketed by Toshiba or McKesson, and (b) all Generally Available Software Upgrades, except for Upgrades that are separately priced and marketed by Toshiba or McKesson. *"Software Updates"* means Software modifications, enhancements, corrections, improvements, and patches to the existing functionality of Customer's licensed version of the McKesson Software (e.g., version 4.1 to 4.3 to 4.5). *"Software Upgrades"* means new versions and future releases of the McKesson Software (e.g. version 4.x, 5.x, 6.x). Software Updates or Upgrades that provide new features not originally purchased may be separately priced and marketed. Software Updates and Software Upgrades to the McKesson Software will be delivered remotely, on-line. The warranty does not include any non-McKesson Software, the labor and travel expenses associated with on-site installation of a Software, or any hardware addition or modification.

The warranty set forth in this Section will not apply:

a. if Customer operates the Software on equipment other than Equipment purchased from Toshiba or attaches other equipment to the System not approved by Toshiba;
b. if a person or entity other than McKesson or its authorized third party suppliers modifies the Software;
c. as a result of Customer's improper use, abuse, neglect of the Equipment, including failure to maintain environmental conditions within the operating range specified by the Equipment manufacturer or accident;
d. as a result of viruses or other corruption caused by external entities; or
e. for damages resulting from a Force Majeure condition described in Section 13 below.

C. The Following Applies to Both the Toshiba Equipment and the McKesson System: Toshiba does not warrant that the operation of the Equipment of the System will be uninterrupted. All defective parts replaced by Toshiba will become the property of Toshiba. Replacement parts may be re-manufactured. However, such parts will meet the manufacturer's specifications for new components as of the date of completion of installation. TOSHIBA'S OBLIGATION TO REPAIR OR REPLACE DEFECTIVE PARTS OR SOFTWARE WILL BE CUSTOMER'S SOLE AND EXCLUSIVE REMEDY FOR A BREACH OF THE WARRANTY SET FORTH IN THIS AGREEMENT. SUCH WARRANTY WILL BE IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION, THE WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. The warranty set forth in this Agreement will not apply to, and Toshiba will not be liable for any defects resulting from misuse, repairs performed by unauthorized third parties, accidents, acts of God, or neglect of anyone other than Toshiba.

9. LIMITATION OF LIABILITY. NEITHER TOSHIBA NOR CUSTOMER WILL UNDER ANY CIRCUMSTANCES BE LIABLE FOR CONSEQUENTIAL, SPECIAL, INCIDENTAL, OR EXEMPLARY DAMAGES OR ECONOMIC LOSS ARISING OUT OF OR RELATED TO THE TRANSACTIONS CONTEMPLATED IN THIS AGREEMENT, EVEN IF EITHER PARTY IS APPRISED OF THE LIKELIHOOD OF SUCH DAMAGES OCCURRING. IN NO EVENT WILL EITHER PARTY'S LIABILITY TO THE OTHER (WHETHER BASED ON AN ACTION OR CLAIM IN CONTRACT, TORT, INCLUDING NEGLIGENCE, STRICT LIABILITY, OR OTHERWISE) ARISING OUT OF OR RELATING TO THE TRANSACTIONS CONTEMPLATED IN THIS AGREEMENT EXCEED THE AGGREGATE AMOUNT ACTUALLY PAID BY CUSTOMER TO TOSHIBA UNDER THIS AGREEMENT. THE LIMITATION OF LIABILITY SET FORTH ABOVE WILL NOT APPLY TO CLAIMS FOR PERSONAL INJURY OR PROPERTY DAMAGE CAUSED BY EQUIPMENT DEFECTS, OR TO CLAIMS FOR PATENT INFRINGEMENT.

10. SECURITY INTEREST. Toshiba hereby reserves and Customer grants to Toshiba a security interest pursuant to the Uniform Commercial Code, in and to the Equipment (and all products and proceeds of it) until full payment of the purchase price is received.

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

QUOTATION/ORDER
ORDER DETAIL

DATE: 3/15/2010

OMT NO: 374952
QUOTE NO: 96123

PRESENTED TO:

HARTFORD HOSPITAL
80 SEYMOUR ST
HARTFORD, CT. 06115

11. REMOVAL OF EQUIPMENT. Until Toshiba has received full payment of the purchase price, Customer will not remove all or any part of the Equipment from Customer's premises, nor will Customer sell, lease, transfer or otherwise part with the possession of, or permit any lien or encumbrance to be placed on all or any part of the Equipment.

12. REMEDIES OF TOSHIBA. If Customer fails to make any payment when due under this Agreement or under any other agreement between Customer and Toshiba, or becomes insolvent or makes an assignment for the benefit of creditors, or if a petition in Bankruptcy is filed by or against Customer, or if the financial responsibility of Customer becomes impaired or unsatisfactory in Toshiba's reasonable judgment, or if Customer otherwise breaches any of the terms and conditions of this Agreement, then Toshiba may, without prior notice or demand, defer shipments, cancel the balance of the order, suspend performance of any obligation (including without limitation, all obligations set forth under Limited Warranty And Remedy above), and/or take immediate possession of the Equipment delivered, until the full purchase price of the Equipment is paid by Customer or, at Toshiba's discretion, until security satisfactory to Toshiba is given by Customer. Any costs incurred by Toshiba as a result of suspending performance or repossession or collection will be payable by Customer. Toshiba may sell repossessed Equipment with proceeds to be applied to unpaid balance and expenses incurred in sale, repossession and collection. Customer will pay any remaining deficiency. Toshiba may exercise any other rights available to it by law.

13. EXCUSED PERFORMANCES. Neither party will be liable to the other for non-performance or delay in performance resulting directly or indirectly from any occurrences beyond such party's control, including without limitation, strikes or other labor troubles, acts of God, war, accidents, fires, floods, other catastrophes, inclement weather, transportation, unavailability of materials and labor, delays caused by suppliers, or laws, regulations, or acts of any governmental agency.

14. SOFTWARE. All rights and interest in any software that may be furnished under this Agreement, and any updates and enhancements to it, will remain the property of Toshiba. Such software is being furnished to Customer under a non-exclusive license. Customer will not, or allow others to decompile, modify, copy, reproduce, or transcribe the software nor allow third parties to use the same without Toshiba's prior written consent. Upon Toshiba's request, Customer will execute an End-User Software License Contract, in a form to be mutually agreed between the parties.

15. CANCELLATION. Customer may not cancel the order subject to this Agreement except with Toshiba's prior written consent. In the event of such cancellation, Toshiba will be entitled to recover any and all damages suffered by it caused by the cancellation as allowed by law, but in no event less than an amount equal to twenty percent (20%) of the purchase price for a restocking charge.

16. ASSIGNMENT. Neither party may assign any of its obligations under this Agreement without the prior written consent of the other party However, some of the obligations stated in this Agreement, such as the ones relating to installation of the McKesson System and warranty may be performed by Toshiba's contractors or suppliers.

17. EXPORT REGULATIONS. This Agreement involves products, and/or technical data that may be controlled under the U.S. Export Administration Regulations and may be subject to the approval of the U.S. Department of Commerce prior to export. Any export or re-export by Customer, directly or indirectly, in contravention of such Regulations is prohibited.

18. ENTIRE AGREEMENT. This quotation as well as the attached McKesson Pass Through Terms and Conditions contains the entire agreement between the parties and supersedes all prior and contemporaneous agreements between the parties, whether oral or written, relating to its subject matter, including, without limitation, all different or additional terms and conditions which may be contained in Customer's bid documents, purchase order or any other documents furnished by Customer. The provisions of this Agreement may not be modified unless in writing and executed by both parties.

PURCHASER	
INITIALS	DATE

TOSHIBA REP/ CONTACT	
INITIALS	DATE

VARIAN
medical systems

Quotation

TYM20091020-001

Quotation For:

Bob Lindeyer
Hartford Hospital
80 Seymour Street
Hartford, CT 06101
(860) 545 - 4346 FAX: (860) 545 - 1500

Please address inquiries and replies to:

Timothy Macfarlane
Varian Medical Systems
11 Commerce Drive
Second Floor
Cranford, NJ 07016
(732) 499 - 2260 FAX: (732) 381 - 1060
timothy.macfarlane@oscs.varian.com

Your Reference:	*Quotation Firm Until:* **December 9, 2009**
FOB Point:	*Shipping Allocation:*
Payment Terms:	**Varian Terms and Conditions of Sale 1652T Attached**

Acuity and Gating Move for H770168 / H780168
Customer Responsibility Section

Hartford Hospital

Quotation Total of: USD $48,500 Accepted by:

Signature: _____

Name: _____

Title: _____

Date: _____

For this purchase, we designate **NOVATION** as our Institution's Primary Group Purchasing Organization affiliation. Any change will be Indicated below:

☐ **AmeriNet**	☐ **Aptium**	☐ **BJC**	☐ **Broadlane**
☐ **CHW**	☐ **Consorta/HPG**	☐ **KP Select**	☐ **Magnet**
☐ **Matrix**	☐ **MedAssets**	☐ **Novation**	☐ **Premier**
☐ **ROI**	☐ **USO**	☐ **VA Gov**	☐ **None**

Varian Medical Systems

Submitted by:

_____
(Signature)

Name: **Timothy Macfarlane**

Title: **District Manager**

Date: **October 20, 2009**

Item	Qty	Product Description	Offer Price
Section 1		**Acuity and Gating Move for H770168 / H780168**	
1.01	1	**Removal**	Included
1.02	1	**Equipment inspection and preparation for move.**	3,000.00
1.03	1	**Rig-out and Varian supervision**	5,500.00
1.04	1	**Installation**	Included
1.05	1	**New site coordination**	2,500.00
1.06	1	**Rig-in and Varian supervision**	5,500.00
1.07	1	**Installation of Lasers and Gating**	5,000.00
1.08	1	**Acuity Installation (7-10) days**	27,000.00
1.09	1	**Completion of move will be upon acceptance.** Acceptance will be SVS and CAP.	Included
		Section Total $	48,500.00
Section 2		**Customer Responsibility Section**	
2.01	1	**Customer will reuse base frame and cables.** Customer will extract baseframe and cables from current vault and reuse it in the new vault. All costs associated with this activity are the sole responsibility of the Hartford Hospital, Hartford, Ct. The condition of the base frame and cables post extraction must be in excellent condition for reuse in new vault. Any issue which causes delay or necessity for replacement of the cables for proper operation of the Acuity for control signals and power will be done on a T&M basis. Customer will grout the base frame using in-house facilities.	Included
		Section Total $	0.00
		Quotation Total $	48,500.00

Item	Qty	Product Description	Offer Price

Terms & Conditions of Sale

This offer is subject to credit approval and is exclusive of any applicable sales taxes or duties.

Early Termination Hardware Support Agreements:

Customer may, without charge, terminate this Hardware Support Agreement after thirty (30) days written notice and opportunity to cure in the event of material default by Varian. Customer may further, without charge, terminate this Hardware Support Agreement with respect to the Covered Product in the event the Covered Product is replaced by another product supplied by Varian. If this Hardware Support Agreement covers multiple Covered Products, and is terminated as to some, but not to all the covered products, Varian will adjust the Maintenance Fee in an appropriate manner to reflect removal of the replaced Covered Product, such adjustment to be determined by Varian in its sole and absolute discretion. Customer may terminate for any other reason upon ninety (90) days written notice to Varian and payment for the amount applicable to service performed, including parts supplied and labor, of period expired plus 25% of the remaining annual contract fee for the year in which terminated. Varian may terminate this Support Agreement without notice and without refund or other liability in the event of default by Customer. This Support Agreement will terminate automatically if Customer becomes insolvent.

Customers, who prematurely terminate this Hardware Support Agreement and have received under it, deferred payment terms for new hardware, additional software licenses or an Upgrade Release, will be liable for the cost of the hardware, licenses or Upgrade as defined in the non-contract quotation provided by the Varian Upgrades Department. The Cost includes all hardware, software, installation labor, and applications training provided to perform the Upgrade. Payment is due within thirty (30) days of termination.

Early Termination Software Support Agreements:

Customer may, without charge, terminate this Software Support Agreement after thirty (30) days written notice and opportunity to cure in the event of material default by Varian. Customer may further, without charge, terminate this Software Support Agreement with respect to the Covered Product in the event the Covered Product is replaced by another product supplied by Varian. If this Software Support Agreement covers multiple Covered Products, and is terminated as to some, but not to all the covered products, Varian will adjust the Maintenance Fee in an appropriate manner to reflect removal of the replaced Covered Product, such adjustment to be determined by Varian in its sole and absolute discretion. Customer may terminate for any other reason upon ninety (90) days written notice to Varian and payment for the amount applicable to service performed of period expired plus 25% of the remaining annual contract fee for the year in which terminated. Varian may terminate this Support Agreement without notice and without refund or other liability in the event of default by Customer. This Support Agreement will terminate automatically if Customer becomes insolvent.

Customers, who prematurely terminate this Software Support Agreement and have received under it, deferred payment terms for new hardware, additional software licenses or an Upgrade Release, will be liable for the cost of the license or Upgrade as defined in the non-contract quotation provided by the Varian Upgrades Department. The Cost includes all hardware, software, installation labor, and applications training provided to perform the Upgrade. Payment is due within thirty (30) days of termination.

FINANCING AVAILABLE: For lease and finance plans, call Tony Susen, Director - Varian Customer Finance, at (508) 668-4609.

DONATI CONTRACTING

October 23, 2009

Mr. Robert Lindeyer
Hartford Hospital Cancer Center
80 Seymour Street
Hartford, CT 06115

PROPOSAL to provide support services for the installation of a new Toshiba Aquilion-LB CT Scanner and relocate existing Varian Acuity Simulator.

DONATI PROPOSAL No. 361-09

Dear Bob:

DONATI CONTRACTING is pleased to submit this BUDGET proposal for the installation of your new Toshiba Aquilion-LB CT scanner and the relocation of your existing Varian Acuity Simulator. As we understand it, our effort is to include the following:

ROOM # 111
Remove existing base frame from room #111concrete floor and save for relocation in room # 107
Cut concrete floor to accommodate new Toshiba Aquilion LB CT scanner base frame and power trench.
Install base frame and grout in place
Patch and repair flooring finishes
Modify existing bi-fold door with new hardware
Modify existing power configuration for new equipment installation

ROOM # 107
Remove existing base frame and millwork closets
Cut concrete floor to accommodate Varian Acuity Simulator base frame and modify power trench.
Install base frame and grout in place.
Patch and repair flooring finishes
Run new conduits from control room to rear of equipment
Modify existing power configuration for equipment installation from existing power in hot lab room.

Our price for the work described above is $97,500.00 Tax Exempt.
(Ninety-Seven Thousand Five Hundred Dollars)

411 Summer Street • Plantsville, CT 06479
Phone (860) 621-3325 • Fax (860) 621-4067

Included in that fee is a one-year warranty on all labor provided by DONATI CONTRACTING, LLC. Parts and materials are covered by standard warranties provided by their manufacturers. Warranty periods begin when installation is completed. The owner has a one-week period following the completion of the installation to accept or reject work performed by DONATI CONTRACTING, LLC, after which time it will be assumed that the work has been accepted.

DONATI CONTRACTING, LLC assumes normal workday access to the job site and payment in full within 30 days after receipt of each invoice. DONATI CONTRACTING, LLC will not be held responsible for normal wear and tear. The removal and disposal of asbestos and toxic materials are the owner's responsibility. This proposal is valid for a period of 30 days from the date shown at the top of this proposal, after which time we will be happy to provide an adjusted quote if necessary.

We look forward to performing this work for you. Please contact us at 860-621-3325 if you have any questions.

Thank you for your consideration,

DONATI CONTRACTING, LLC

Louis C. Donati Jr.
President

ACKNOWLEDGED AND ACCEPTED

BY: _____

DATE: _____

P.O. NO.: _____

Attachment G

Current Rate Schedule

Radiation Oncology CDM - FY 2010

CDM	Description	Price 1	Prof Fee	GL	Rev Code	Point	CPT4
1800240-2	HDR IR-192 SOURCE	358.54	0.00	609	278	179.2700	C1717
1800243-6	AU198 SEED EACH	260.00	0.00	609	278	130.0000	C1716
1800244-4	IR192 SEED EACH	106.89	0.00	609	278	42.7550	C1719
1800245-1	PNCF NEEDLE EACH	35.00	0.00	609	272	10.0000	
1800246-9	SR89 PER MCI	2170.74	0.00	609	636	1085.3700	A9600
1800247-7	SM-153,TO 150MCI	2261.70	0.00	609	636	1130.8500	A9604
1800253-5	I125 SEED LOOSE	55.00	0.00	609	278	22.0000	C2639
1800254-3	I125 SEED STRAND	92.50	0.00	609	278	37.0000	C2638
1800256-8	PD103 SEED LOOSE	112.50	0.00	609	278	45.0000	C2641
1800257-6	PD103 SEED STRAND	120.00	0.00	609	278	60.0000	C2640
1800268-3	PROST STABILI SET	142.00	0.00	609	621	71.0000	
1800269-1	VAGINAL DILATOR S	31.50	0.00	609	621	9.0000	
1800270-9	CONDOM	21.70	0.00	609	270	6.2000	
1800271-7	RECTAL TUBE	21.00	0.00	609	270	6.0000	
1800800-3	NUCL HDR CONNECT	110.00	0.00	609	270	55.0000	
1800850-8	HDR STERIL NEEDLE	87.50	0.00	609	270	35.0000	
1800865-6	SFT TISSUE MARKER	390.00	0.00	609	272	195.0000	
1800900-1	DISP NEEDLE TEMPL	65.00	0.00	609	270	26.0000	
1800902-7	TATTOO KIT	28.70	0.00	609	270	8.2000	
1800905-0	CATHETER TRAY	19.64	0.00	609	272	4.9100	
1800912-6	GEL PADS	32.90	0.00	609	270	9.4000	
1800950-6	METLX FOAM SHT4X8	25.62	0.00	609	270	7.3200	
1800994-4	RADONC NUCLIDE-RX	0.00	0.00	609	621	1.0000	
1800996-9	TMT DEVICE PHYS	0.00	0.00	609	621	1.0000	
2580001-2	RADONC NUCLIDE-RX	0.00	0.00	609	621	1.0000	
2580002-0	TMT DEVICE PHYS	0.00	0.00	609	621	1.0000	77399
1800002-6	PORT FILM INTERP	188.00	0.00	610	333	2.0000	77417
1800004-2	SPECIAL TREATMENT	1782.43	0.00	610	333	27.0000	77470
1800012-5	STEREO GUIDED IMG	290.61	0.00	610	333	5.0000	77421
1800025-7	RADPHRM TX Y-90	40464.00	0.00	610	636	20232.0000	A9543
1800111-5	IMRT TREATMENT	1689.74	0.00	610	333	15.0000	77418
1800121-4	SIMP TMT MED E	411.25	0.00	610	333	5.0000	77403
1800122-2	SIMP TMT MED E-R	411.25	0.00	610	333	5.0000	77403
1800124-8	SIMP TMT HIGH E	426.60	0.00	610	333	5.0000	77404
1800127-1	INT TMT MED E	504.48	0.00	610	333	7.0000	77408
1800128-9	INT TMT MED E-R	350.56	0.00	610	333	7.0000	77408
1800133-9	INT TMT HIGH E	518.18	0.00	610	333	7.0000	77409
1800134-7	INT TMT HIGH E-R	350.56	0.00	610	333	7.0000	77409
1800139-6	COMP TMT MED E	632.12	0.00	610	333	9.0000	77413
1800140-4	COMP TMT MED E-R	632.12	0.00	610	333	9.0000	77413
1800142-0	COMP TMT HIGH E	649.63	0.00	610	333	9.0000	77414
1800143-8	COMP TMT HIGH E-R	450.72	0.00	610	333	9.0000	77414
1800145-3	COMP TMT VHI E	719.32	0.00	610	333	9.0000	77416
1800149-5	SIMP TMT VHI E	250.39	0.00	610	333	5.0000	77406
1800150-3	INT TMT VHI E	482.22	0.00	610	333	7.0000	77411
1800175-0	CAT SCAN - RT	887.00	0.00	610	333	10.0000	77014
1800177-6	ECHO GUIDANCE-RT	356.47	0.00	610	333	3.0000	76950
1800200-6	SIMULATION-S	664.10	0.00	610	333	8.0000	77280
1800205-5	SIMULATION-I	1062.26	0.00	610	333	10.0000	77285
1800210-5	SIMULATION-C	1335.95	0.00	610	333	12.0000	77290
1800216-2	RADONC KVP TMT	450.72	0.00	610	333	9.0000	77401
1800280-8	VENIPUNCTURE ROUT	20.00	0.00	610	300	1.0000	36415

Radiation Oncology CDM - FY 2010

CDM	Description	Price 1	Prof Fee	GL	Rev Code	Point	CPT4
1800366-5	ADMIN INFLUENZ VC	40.00	0.00	610	771	1.0000	G0008
1800368-1	ADMIN PNEUMO VAC	40.00	0.00	610	771	1.0000	G0009
1800400-2	PORT FLUSHING	105.02	0.00	610	333	0.9000	96523
1800410-1	RADPHAR MONO ABIV	1427.82	0.00	610	333	9.0000	79403
1800415-0	PAP SMEAR	25.68	0.00	610	923	1.0000	Q0091
1800417-6	LARYNGOSC DX FLEX	256.18	0.00	610	333	1.0000	31575
1800434-1	URINE DIP STICK	30.00	0.00	610	307	1.0000	81002
1800500-9	STEREOTACTIC,1 TR	14285.81	0.00	610	333	224.0000	G0173
1800502-5	STEREOTACTIC,MULT	4890.45	0.00	610	333	52.0000	G0251
1800601-5	N-MINIMAL-5MIN	65.00	0.00	610	280	1.0000	99201
1800602-3	N-BASIC-15MIN	75.00	0.00	610	280	2.0000	99202
1800603-1	N-MODERATE-30MIN	100.00	0.00	610	280	3.0000	99203
1800604-9	N-COMPLEX-45MIN	125.00	0.00	610	280	4.0000	99204
1800605-6	N-CMPRHENS-60MIN	170.00	0.00	610	280	6.0000	99205
1800611-4	E-MINIMAL-5MIN	65.00	0.00	610	280	1.0000	99211
1800612-2	E-BASIC-10MIN	75.00	0.00	610	280	2.0000	99212
1800613-0	E-MODERATE-15MIN	75.00	0.00	610	280	3.0000	99213
1800614-8	E-COMPLEX-25MIN	100.00	0.00	610	280	4.0000	99214
1800615-5	E-CMPRHENS-40MIN	130.00	0.00	610	280	6.0000	99215
1800740-1	BLOOD COLLECT VAD	81.50	0.00	610	361	1.0000	36591
1800742-7	IV CATH INSERT	138.53	0.00	610	361	2.0000	36000
1800746-8	BLD COLLECT PICC	77.51	0.00	610	361	1.0000	36592
1800747-6	DECLT THROMBYLTIC	276.69	0.00	610	361	1.0000	36593
1800749-2	FINGER STICK	19.00	0.00	610	361	1.0000	36416
1800770-8	IV TX/DX/PX <=1HR	294.60	0.00	610	940	1.0000	96365
1800771-6	IV TX/DX/PX EA AD	117.00	0.00	610	940	1.0000	96366
1800772-4	INJECTION (SC/IM)	89.50	0.00	610	940	1.0000	96372
1800773-2	IV HYDRA 31-60MIN	256.77	0.00	610	260	1.0000	96360
1800774-0	IV HYDR EA ADD HR	103.06	0.00	610	260	1.0000	96361
1800825-0	ADMIN INFLU H1N1	40.00	0.00	610	771	1.0000	G9141
1800999-3	RADONC NO CHARGE	0.00	0.00	610	333	1.0000	
1800003-4	BASIC CALC-R	427.20	0.00	611	333	5.0000	77300
1800005-9	BASIC CALC	427.20	0.00	611	333	5.0000	77300
1800006-7	SPECIAL PLAN	954.00	0.00	611	333	22.0000	77321
1800007-5	SPECIAL DOSIMETRY	408.75	0.00	611	333	10.0000	77331
1800008-3	3D SIM PLAN	4084.04	0.00	611	333	64.0000	77295
1800010-9	SIMPLE PLAN	537.12	0.00	611	333	10.0000	77305
1800015-8	INTERMEDIATE PLAN	751.59	0.00	611	333	15.0000	77310
1800020-8	COMPLEX PLAN	1021.33	0.00	611	333	20.0000	77315
1800026-5	BRACHYPLAN-S	607.08	0.00	611	333	10.0000	77326
1800027-3	BRACHYPLAN-I	943.19	0.00	611	333	15.0000	77327
1800028-1	BRACHYPLAN-C	1249.62	0.00	611	333	20.0000	77328
1800029-9	BRACHYRX INFUSION	764.18	0.00	611	333	15.0000	77750
1800030-7	BRACHYRX IC-S	1246.53	0.00	611	333	50.0000	77761
1800035-6	BRACHYRX IC-I	1665.00	0.00	611	333	60.0000	77762
1800040-6	BRACHYRX IC-C	1963.50	0.00	611	333	70.0000	77763
1800041-4	BRACHYRX IS-S	2754.41	0.00	611	333	55.0000	77776
1800042-2	BRACHYRX IS-I	2459.00	0.00	611	333	65.0000	77777
1800043-0	BRACHYRX IS-C	3149.69	0.00	611	333	75.0000	77778
1800044-8	BRACHYRX SURFACE	342.00	0.00	611	333	15.0000	77789
1800045-5	FAB SIMPLE	470.00	0.00	611	333	6.0000	77332
1800046-3	FAB-S2	470.00	0.00	611	333	6.0000	77332

Radiation Oncology CDM - FY 2010

CDM	Description	Price 1	Prof Fee	GL	Rev Code	Point	CPT4
1800047-1	FAB INT	621.67	0.00	611	333	9.0000	77333
1800049-7	FAB-I2	621.67	0.00	611	333	9.0000	77333
1800050-5	FAB COMP	947.12	0.00	611	333	12.0000	77334
1800051-3	FAB-C2	947.12	0.00	611	333	12.0000	77334
1800060-4	RADIOELEMENT HAND	329.00	0.00	611	333	5.0000	77790
1800112-3	IMRT PLANNING	3908.00	0.00	611	333	40.0000	77301
1800151-1	RADONC PHYSICS II	703.00	0.00	611	333	15.0000	77370
1800152-9	RADONC PHYSICS I	507.86	0.00	611	333	7.0000	77336
1800155-2	DSGN MLC DEV IMRT	333.58	0.00	611	333	7.0000	77338
1800180-0	HI INT BRACHY 1-4	2691.82	0.00	611	333	60.0000	77781
1800182-6	HI INT BRACHY 5-8	3004.70	0.00	611	333	65.0000	77782
1800184-2	HI INT BRACHY9-12	3311.84	0.00	611	333	70.0000	77783
1800186-7	HI INT BRACHY >12	4168.43	0.00	611	333	75.0000	77787
1800187-5	HI INT BRACHY 1	3425.78	0.00	611	333	60.0000	77785
1800188-3	HI INT BRACHY2-12	3724.57	0.00	611	333	75.0000	77786

HOSPITAL AFFIDAVIT

Applicant: **Hartford Hospital**

Project Title: **Acquisition of CT Simulator**

I, Thomas J. Marchozzi, Senior Vice President and CFO
(Name) (Position – CEO or CFO)

of Hartford Hospital being duly sworn, depose and state that the
(Hospital Name)

information submitted in this Certificate of Need application is accurate and correct to the best of my knowledge. With respect to the financial impact related to this CON application, I hereby affirm that:

1. The proposal will have a capital expenditure in excess of $15,000,000.

   ☐ Yes ☒ No

2. The combined total expenses for the proposal's first three years of operation will exceed one percent of the actual operating expenses of the Hospital for the most recently completed fiscal year as filed with the Office of Health Care Access.

   ☐ Yes ☒ No

RECEIVED
2010 JUN 10 P 3:1
CONNECTICUT OFFICE OF HEALTH CARE ACCESS

Signature

6/8/10
Date

Subscribed and sworn to before me on June 8, 2010

Diana Nino

Notary Public/Commissioner of Superior Court

My commission expires: 11/30/2012

Hospital Affidavit
Revised 7/02

JUN 09 2010

FILING FEE COMPUTATION SCHEDULE

APPLICANT: **Hartford Hospital** PROJECT TITLE: **Acquisition of a CT Simulator – DN 10-31577-CON** DATE: **06/09/10**	FOR OHCA USE ONLY: 1. Check logged (Front desk) — DATE 6.10.10 — INITIAL emg 2. Check rec'd (Clerical/Cert.) — DATE 6/10/10 — INITIAL [illegible] 3. Check correct (Superv.) — DATE 6/11/10 — INITIAL [illegible] 4. Check logged (Clerical/Cert.) — DATE 6/11/10 — INITIAL [illegible]

SECTION A – NEW CERTIFICATE OF NEED APPLICATION

1. Check statute reference as applicable to CON application (see statute for detail):

____ 19a-638.Additional function or service, change of ownership, service termination.
No Fee Required.

____ 19a-639 Capital expenditure exceeding $3,000,000, or capital expenditure exceeding $3,000,000 for major medical equipment, or CT scanner, PET scanner, PET/CT scanner, MRI scanner, cineangiography equipment or linear accelerator.
Fee Required.

XX 19a-638 and 19a-639.
Fee Required.

2. Enter $0 on "Total Fee Due" line (SECTION B) if application is required pursuant to Section 19a-638 only, otherwise go on to line 3 of this section.

3. Enter $400 on "Total Fee Due" line (SECTION B) if application is for capital expenditure for major medical equipment, imaging equipment or linear accelerator less than $3,000,000

4. Section 19a-639 fee calculation (applicable if section 19a-639 capital expenditure for major medical equipment, imaging equipment or linear accelerator exceeding $3,000,000 or other capital expenditure exceeding $3,000,000 is checked above **OR** if both 19a-638 and 19a-639 are checked):

a. Base fee:	$ 1,000.00
b. Additional Fee: (Capital Expenditure Assessment)	$ _____.00
(To calculate: Total requested Capital Expenditure/Cost excluding capitalized financing costs multiplied times .0005 and round to nearest dollar.) ($_____ x .0005)	$ _____.00
c. Sum of base fee plus additional fee: (Lines A4a + A4b)	
d. Enter the amount shown on line A4c. on "Total Fee Due" line (SECTION B).	

SECTION B. TOTAL FEE DUE: **$ 400.00**

RECEIVED
2010 JUN 10 P 3:1
CONNECTICUT O. HEALTH CARE ACCESS

HARTFORD HOSPITAL
ATTN: ACCOUNTS PAYABLE
PO BOX 5037
HARTFORD, CT 06102-5037

HARTFORD HOSPITAL
Great Doctors Are Just The Beginning

51-57
119

Check Number
420743
FLEET BANK

THE FACE OF THIS DOCUMENT HAS A COLORED BACKGROUND ON WHITE PAPER

Four hundred and 00/100 Dollars

Pay to the order of

TREASURER STATE OF CONNECTICUT
OFFICE OF HEALTHCARE ACCESS
410 CAPITAL AVE
MS#13HCA BOX 340308
HARTFORD, CT 06134

Date: 06/09/2010

Payment Amount: *******$400.00

VOID AFTER 90 DAYS

Elliot Joseph

STATE OF CONNECTICUT

DEPARTMENT OF PUBLIC HEALTH
Office of Health Care Access

June 24, 2010 via fax and email only

Karen T. Goyette
Vice President, Strategic Planning
Hartford Hospital
85 Seymour Street
Hartford, CT 06102-5037

RE: Certificate of Need Docket Number 10-31577-CON
Acquisition of a CT Simulator
Completeness Letter

Dear Ms. Goyette:

On June 10, 2010, the Office of Health Care Access ("OHCA") received your initial Certificate of Need application filing on behalf of Hartford Hospital ("Hospital") for the proposal to acquire a CT Simulator for the Helen and Harry Cancer Center, Hartford campus, with an associated capital expenditure of $999,414.

OHCA has reviewed the CON application pursuant to Section 19a-634-74 of OHCA's regulations and finds that the information submitted is deficient, and that additional information and/or clarification is required as outlined below:

1. Provide the *historical volume for conventional simulation at the Hartford campus location by individual machine:*:

Table 1: Historical Volume for Conventional Simulation – Hartford Campus

	Actual Volume (Last 3 Completed FYs)			CFY Volume*
Equipment	FY 2007	FY 2008	FY 2009	YTD
Philips Simulator				
Simulator 2				
Total				

* Report actual volume year-to-date (YTD).

Regarding the information provided in Table 1:

a) Explain any increases and/or decreases in volume.

2. Please provide an explanation for the slight decline in the Radiation Oncology patient volume in the table submitted on page 6 of the application – from 646 in FY 2007 to 622 in FY 2009.

In responding to the questions contained in this letter, please repeat each question before providing your response. **Paginate and date** your response, i.e., each page in its entirety. Information filed after the initial CON application submission (i.e. completeness response letter, prefile testimony, late file submissions and the like) must be numbered sequentially from the Applicant's document preceding it. For example, if the application concludes with page 100, your completeness response letter would begin with page 101. Please reference "Docket Number: 10-31564-CON" and submit one (1) original and six (6) hard copies of your response. In addition, please submit a scanned copy of your response, in an electronic copy MS Word format and Adobe format including all attachments on CD.

If you have any questions concerning this letter, please feel free to contact me at (860) 418-7001.

Sincerely,

Brian A. Carney

Brian A. Carney
Associate Research Analyst

CAV:bc

****
*** TX REPORT ***
****

TRANSMISSION OK

TX/RX NO	1774
RECIPIENT ADDRESS	98605452127
DESTINATION ID	
ST. TIME	06/24 14:05
TIME USE	00'41
PAGES SENT	3
RESULT	OK

STATE OF CONNECTICUT
OFFICE OF HEALTH CARE ACCESS

FAX SHEET

TO: MS. KAREN T. GOYETTE, VP

FAX: (860) 545-2127

AGENCY: HARTFORD HOSPITAL

FROM: BRIAN A. CARNEY DPH/OHCA

DATE: 6/24/10 **TIME:**

NUMBER OF PAGES: 3
(including transmittal sheet

DN: 10-31577-CON

Comments: PLEASE SEE ATTACHED COMPLETENESS LETTER REQUESTING ADDITIONAL INFO IN REGARDS TO CT-SIMULATOR CON APPLICATION.

PLEASE PHONE IF THERE ARE ANY TRANSMISSION PROBLEMS.

STATE OF CONNECTICUT
DEPARTMENT OF PUBLIC HEALTH
Office of Health Care Access

September 16, 2010

IN THE MATTER OF:

An Application for a Certificate of Need filed pursuant to Section 19a-639, C.G.S. by	Notice of Final Decision Office of Health Care Access Docket Number: 10-31577-CON
Hartford Hospital	**Acquisition of a Computed Tomography Simulator**

Karen T. Goyette
Vice President, Strategic Planning
Hartford Hospital
85 Seymour Street
Hartford, CT 06102-5037

Dear Ms. Goyette:

This letter will serve as notice of the Final Decision of the Office of Health Care Access in the above matter as provided by Section 19a-639, C.G.S. On September 16, 2010, the Final Decision was rendered as the finding and order of the Office of Health Care Access. A copy of the Final Decision is attached hereto for your information.

By Order of the
Office of Health Care Access
Department of Public Health

Kimberly R. Martone
Director of Operations

KRM: bac
Enclosure

Office of Health Care Access
Certificate of Need Application

Final Decision

Applicant: **Hartford Hospital**

Docket Number: **10-31577-CON**

Project Title: **Acquisition of a Computed Tomography Simulator**

Project Description: Hartford Hospital ("Applicant" or "Hospital") is proposing to acquire a Computed Tomography simulator ("CT simulator") to be located at the Hospital's Helen and Harry Gray Cancer Center at Hartford Hospital, with an associated capital expenditure of $999,414.

Nature of Proceedings: On July 21, 2010, the Office of Health Care Access ("OHCA") received a Certificate of Need ("CON") application from the Applicant for the above-referenced project.

A notice to the public concerning OHCA's receipt of the Applicant's Letter of Intent was published on April 19, 2010, in *The Hartford Courant.* OHCA received no response from the public concerning the Applicant's proposal.

Pursuant to Section 19a-639 of the Connecticut General Statutes ("C.G.S.") three individuals or an individual representing an entity with five or more people had until August 11, 2010, the twenty-first calendar day following the filing of the Applicant's CON application, to request that OHCA hold a public hearing on the Applicant's proposal. OHCA received no hearing requests from the public.

OHCA's authority to review, approve, modify, or deny this proposal is established by Section 19a-639, C.G.S. The provisions of this section, as well as the principles and guidelines set forth in Section 19a-637, C.G.S., were fully considered by OHCA in its review.

FINDINGS OF FACT

1. The Applicant is an acute care general hospital located at 80 Seymour Street in Hartford, Connecticut. *(March 25, 2010, Letter of Intent (LOI) Submission, page 1)*

2. The Hospital's Department of Radiation Oncology delivers radiation treatments in the form of Image Guided Radiation Therapy ("IGRT"), Intensity Modulation Radiation Therapy ("IMRT"), Stereotactic Radiation Therapy ("SRT"), and conventional radiation oncology treatments. *(March 25, 2010, Letter of Intent (LOI) Submission, page 8)*

3. The Hospital also provides high dose rate ("HDR") and low dose rate ("LDR") Brachytherapy as well as Simulation and Treatment Planning services at the Helen and Harry Gray Cancer Center in Hartford and Avon. The Avon campus currently utilizes a CT Simulator very similar to the one the Hospital plans to acquire in this proposal. *(March 25, 2010, Letter of Intent (LOI) Submission, page 8)*

4. The Applicant provided the following list of CT scanners currently in use by location:

Table 1: Hartford Hospital's CT scanners

Location	Area	Available Imaging	Utilization
Hartford Hospital, 80 Seymour Street Hartford, CT	Radiology	GE VCT 64 Slice GE Lightspeed Ultra 8 Slice	FY 2009 22,420 scans combined
Hartford Hospital, 80 Seymour Street Hartford, CT	Emergency Department	GE Lightspeed Ultra 8 Slice	FY 2009 27,396 scans
Hartford Hospital, 80 Seymour Street Hartford, CT	Helen and Harry Gray Cancer Center	Discovery LS 4 Slice	FY 2009 1,619 PET/CT scans
Hartford Hospital, 80 Fisher Drive Avon, CT	Helen and Harry Gray Cancer Center	Toshiba Aquilion LB 16 Slice CT	5/1/2009 – 4/30/2010 205 CT simulation scans

(June 10, 2010, Initial CON Application Submission, page 4)

5. The Hospital proposes to replace a conventional Philips simulator[1] with a Toshiba Aquilion 16 slice Large Bore CT Simulator[2] at the Helen and Harry Gray Cancer Center, Hartford campus location. *(June 10, 2010, Initial CON Application Submission, page 3)*

---

[1] Conventional simulation uses machines that are capable of producing similar movements as treatment machines. The images created are essentially two dimensional and produce a limited number of axial slices to provide patient contours and tissue density information. *(Source: Localization: conventional and CT simulation, G R Baker, Kent Oncology Centre, Maidstone Hospital, Maidstone, Kent ME16 9QQ, UK)*

[2] CT simulators produce three dimensional images that can be combined with software to produce virtual simulations. *(Source: Localization: conventional and CT simulation, G R Baker, Kent Oncology Centre, Maidstone Hospital, Maidstone, Kent ME16 9QQ, UK)*

6. The Philips simulator became unusable during the first quarter of FY 2007 and was not repaired due to the equipment's age and technological limitations. *(July 21, 2010, Completeness Response Submission, page 203)*

7. Patients in the cancer center currently receive CT scans in the Radiology Department or the Emergency Department ("ED"). (*June 10, 2010, Initial CON Application Submission, page 3*)

8. The CT scanners in the Radiology Department and ED are heavily utilized for high volume procedures or images during day time hours and therefore, do not always permit as timely a service for cancer patients as would be indicated. The location of the scanners is less convenient and requires transportation of the patient, the treatment records and the treatment devices. (*June 10, 2010, Initial CON Application Submission, page 3*)

9. The Radiology Department and ED scanners are located a significant distance from the cancer center and therefore, require inconvenient travel for cancer center patients, who are frequently debilitated, and staff, including a team of technologists and physicists and at times a radiation oncologist. This causes stress for the patients and presents logistical challenges for the staff. (*June 10, 2010, Initial CON Application Submission, page 8*)

10. Additionally, the bore size of the CT scanners in the Radiology Department and ED limits the scanning of patients in the treatment position due to the size of the devices required and many larger patients cannot be treated in conventional small bore CT scanners. The large bore of the proposed scanner will eliminate these issues. (*June 10, 2010, Initial CON Application Submission, page 3*)

11. The proposed acquisition of a CT simulator in the cancer center will reduce the dependence on the Radiology and ED scanners and eliminate the need to transport patients, treatment records and treatment devices. (*June 10, 2010, Initial CON Application Submission, pages 3)*

12. A dedicated CT simulator in the cancer center will also allow the scan to be performed by radiation oncology staff in the treatment position with the appropriate radiation oncology customized immobilization devices, thus simulating the patient's actual treatment position. (*June 10, 2010, Initial CON Application Submission, page 8*)

13. CT scanning in the treatment position allows the radiation oncologist to contour selected soft tissue targets and avoidance structures so that precise 3 dimensional radiation therapy treatment planning can be undertaken. (*June 10, 2010, Initial CON Application Submission, page 8*)

14. The location and extent of the target volume and position of adjacent organs at risk ("OAR") is necessary for the successful implementation of conformal radiation therapy ("CRT") and IMRT. "The three dimensionality of virtual simulation is essential to visualize the coverage of the target volume and the avoidance of

OARs in the highly complex treatment plans required for CRT and IMRT." (*Baker, GR, "Localization: conventional and CT simulation," British Journal of Radiology, 2006 Sep;79 Spec No 1:S36-49)*

15. Newer CT simulators offer innovative technologies that will aid in the delivery of highly focused radiation techniques such as stereotactic radiosurgery ("SRS"), SRT and gated radiation therapy. *(June 10, 2010, Initial CON Application Submission, page 9)*

16. SRT, SRS and gated radiation therapy utilize images taken in various phases of the respiratory cycle so that tumor tracking can assure accurate delivery of the focused radiation even while the patient breathes in and out resulting in tumor motion. A dedicated CT simulator can have parameters developed which allow individualized settings and protocols for imaging, which would not be possible in a busy diagnostic imaging department. *(June 10, 2010, Initial CON Application Submission, page 9)*

17. Various brachytherapy procedures, including breast brachytherapy and temporary HDR brachytherapy for cervical, endometrial and vaginal cancers, would also benefit from CT simulation for treatment planning. *(June 10, 2010, Initial CON Application Submission, page 9)*

18. An examination of cervical cancer treatment concluded that "CT simulation images more precisely defined the clinical target volume. This more accurate definition of the target volume and individualization of field delineation may potentially lead to an improved therapeutic ratio…" (*June 10, 2010, Initial CON Application Submission, page 8 & 9; Marisa H. Finlay, MD., et al, "Use of CT simulation for treatment of cervical cancer to assess the adequacy of lymph node coverage of conventional pelvic fields based on bony landmarks," International Journal of Radiation Oncology, Biology, Physics, 2006 Jan 1;64(1):205-9.*

19. CT Simulation has also been found to be beneficial in the treatment of breast cancer, as one study concluded that "…CT-based treatment planning generated the most successful plans for proper target coverage…" (*June 10, 2010, Initial CON Application Submission, page 40; Raweewan Liengsawangwong, MD., et al, "Treatment optimization using Computed Tomography-delineated targets should be used for supraclavicular irradiation for breast cancer," International Journal of Radiation Oncology, Biology, Physics, 2007 Nov 1;69(3):711-5)*

20. OHCA finds that a dedicated CT simulator equipped with radiation oncology hardware and software and located in the radiation oncology department will enhance patient care and satisfaction and ensure efficient and effective delivery of health care to patients in the cancer center.

21. The Hartford campus provided treatment to 622 radiation oncology patients in FY 2009 (*see Table 3b*).

22. The proposal will not change the patient population currently being served. (*June 10, 2010, Initial CON Application Submission, page 4)*

23. The Hospital provided historical and projected CT scan volumes:

Table 3a: Hartford Hospital Historical and Projected CT Volume

	Actual Volume (Last 3 Completed FYs)			CFY Volume*	Projected Volume (First 3 Full Operational FYs)		
	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Radiology IP	15,618	15,316	16,848	16,100	16,100	16,100	16,100
Radiology OP	5,129	4,926	5,572	5,100	5,100	5,100	5,100
ED	25,918	25,786	27,396	25,800	25,800	25,800	25,800
Total	46,665	46,028	49,816	47,000	47,000	47,000	47,000

Note: Fiscal year runs from Oct 1st through Sept 30th.
*Based on 7 months actual (October-April)

(June 10, 2010, Initial CON Application Submission, page 5)

Table 3b: Hartford Hospital Historical and Projected # of Radiation Oncology Patients (Hartford Campus)[1]

	Actual Volume (Last 3 Completed FYs)			CFY Volume*	Projected Volume (First 3 Full Operational FYs)		
	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Radiation Oncology Patients	646	642	622	630	630	630	630

Note: Fiscal year runs from Oct 1st through Sept 30th.
[1] Subset of Table 2a
* Based on 9 months actual (October 2009-June 2010)

(June 10, 2010, Initial CON Application Submission, page 6)

24. The slight drop in Radiation Oncology patient volume from FY 2007 to FY 2009 was due in part to a redistribution of patients to the Avon location (opened in late summer of 2008) and is projected to increase in FY 2010. *(July 21, 2010, Completeness Response Submission, page 203)*

25. The Applicant's projections with respect to the number of radiation oncology patients requiring scans are reasonable in light of the historical utilization.

26. Moreover, the volumes on the diagnostic scanners in the ED and Radiology department, as reflected in Table 3a, demonstrate that those are highly utilized scanners.

27. Accordingly, OHCA finds that the acquisition of a dedicated CT simulator in the cancer center will improve accessibility of care for the Hospital's patients.

28. The capital expenditure associated with the proposed acquisition of the CT Simulator is $999,414. *(June 10, 2010, Initial CON Application Submission, page 11)*

29. The Applicant provided a summary of incremental gains/losses projected as a result of the CT simulator acquisition:

Table 4: Hartford Hospital's Financial Projections Incremental to the Project

	Fiscal Year		
Description	**2011**	**2012**	**2013**
Incremental Revenue from Operations	0	0	0
Incremental Total Operating Expense	$99,831	$249,662	$252,662
Incremental Gain/Loss	**($99,831)**	**($249,662)**	**($252,662)**
Gain/(Loss) from Operations (with CON)	**$19,030,169**	**$29,770,338**	**$47,631,338**

Note: Hartford Hospital's fiscal year runs from Oct 1st through Sept 30th.
(June 10, 2010, Initial CON Application Submission, page 15)

30. Incremental losses of ($99,831) in FY 2011, ($249,662) in FY 2012 and ($252,662) in FY 2013 are projected as the result of the simulator acquisition. No additional revenue will be generated and the Hospital will incur depreciation and maintenance contract expenses.

31. Despite the incremental losses due to the CON proposal, the Hospital still projects overall gains from operations of $19,030,169 in FY 2011, $29,770,338 in FY 2012 and $47,631,338 in FY 2013.

32. OHCA finds that although the Hospital is anticipating incremental losses as a result of the proposal, overall gains from operations are still projected for FY 2011-2013.

33. The Applicant reported the following payer mix based on patient population as follows:

Table 4: Current & Three-Year Projected Payer Mix for the Applicant

Payer Mix	**FY 2010**	**Year 1 FY 2011**	**Year 2 FY 2012**	**Year 3 FY 2013**
Medicare*	38%	38%	38%	38%
Medicaid*	21%	21%	21%	21%
CHAMPUS & TriCare	0%	0%	0%	0%
Total Government	**59%**	**59%**	**59%**	**59%**
Commercial Insurers*	39%	39%	39%	39%
Uninsured	2%	2%	2%	2%
Workers Comp.**				
Total Non-Government	**41%**	**41%**	**41%**	**41%**
Total Payer Mix	**100%**	**100%**	**100%**	**100%**

*Includes managed care activity
**Workers Compensation is included in Commercial Insurers
(June 10, 2010, Initial CON Application Submission, page 12)

34. The overall payer mix should not be affected by the approval of this proposal.
(June 4, 2010, Initial CON Application Submission, page 20)

Rationale

The Office of Health Care Access ("OHCA") approaches community and regional need for Certificate of Need ("CON") proposals on a case by case basis. CON applications do not lend themselves to general applicability due to a variety of factors, which may affect any given proposal; e.g., the characteristics of the population to be served, the nature of the existing services, the specific types of services proposed to be offered, the current utilization of services and the financial feasibility of the proposal.

Hartford Hospital is an acute care general hospital located at 80 Seymour Street in Hartford, Connecticut. The Hospital is proposing to acquire a Computed Tomography simulator ("CT simulator") to be located at the Hospital's Helen and Harry Gray Cancer Center at Hartford Hospital, with an associated capital expenditure of $999,414.

The current Phillips simulator at the cancer center in Hartford became unusable in 2007. [Finding 6]. Patients in the cancer center currently receive CT scans in the Radiology Department or ED. [Finding 7] However, the Radiology Department and ED scanners are highly utilized and may not always permit cancer patients to receive as timely a service as indicated. [Findings 8, 23 & 26] Additionally, the existing scanners may not accommodate certain treatment devices or larger patients. [Findings 10] Moreover, the transportation of the patient, treatment record and treatment devices can be logistically challenging for staff and stressful for patients. [Finding 9] OHCA finds that the proposal to acquire a CT simulator will improve access for patients and provide more efficient and effective treatment within the Helen and Harry Gray Cancer center.

A dedicated CT simulator in the cancer center will also allow the scan to be performed by radiation oncology staff in the treatment position with the appropriate radiation oncology customized immobilization devices, thus simulating the patient's actual treatment position. [Finding 12] CT simulation in the treatment position allows radiation oncologists to contour selected soft tissue targets and avoidance structures so that precise 3 dimensional radiation therapy treatment planning can be undertaken. [Finding 13] The location and extent of the target volume and position of adjacent OARs is necessary for the successful implementation of CRT and IMRT. [Finding 17] Additionally, CT simulation has also proven to be beneficial for various brachytherapy procedures, including breast brachytherapy and temporary HDR brachytherapy for cervical, endometrial and vaginal cancers. [Findings 17-19] Accordingly, OHCA finds that the technological advantages provided by use of the CT simulator will positively impact the quality of health care delivery to cancer patients at Hartford Hospital.

Although the Hospital anticipates incremental losses as a result of acquiring the CT simulator, overall operating gain projections remain positive in FY 2011, FY 2012 and FY 2013. The Hospital's utilization volumes and financial projections upon which the operating gains are based appear to be reasonable. Therefore, OHCA finds that the CON proposal is financially feasible.

Order

Based on the foregoing Findings and Rationale, the Certificate of Need application of Hartford Hospital for the acquisition of a Computed Tomography ("CT") simulator, with an associated capital expenditure of $999,414 is hereby **GRANTED**, subject to the following conditions:

1. Hartford Hospital shall submit to OHCA in writing the initial date of operation for the CT simulator acquired for use at the Helen and Harry Gray Cancer Center at Hartford Hospital.

2. Should the Applicant plan to operate the CT simulator at a location other than the Helen and Harry Gray Cancer Center at Hartford Hospital, the Applicant shall notify OHCA of the new location, no later than one month after the equipment's relocation.

Should the Applicant fail to comply with any of the aforementioned conditions, OHCA reserves the right to take additional action as authorized by law. All of the foregoing constitutes the final order of the Office of Health Care Access in this matter.

By Order of the
Department of Public Health
Office of Health Care Access

Sept. 16, 2010
Date

Norma Gyle, R.N., Ph.D.
OHCA Deputy Commissioner

NG:bc

****
*** TX REPORT ***
****

TRANSMISSION OK

TX/RX NO	1990
RECIPIENT ADDRESS	98605452127
DESTINATION ID	
ST. TIME	09/16 13:54
TIME USE	02'00
PAGES SENT	10
RESULT	OK

STATE OF CONNECTICUT
OFFICE OF HEALTH CARE ACCESS

FAX SHEET

TO: MS. KAREN T. GOYETTE, VP

FAX: (860) 545-2127

AGENCY: HARTFORD HOSPITAL

FROM: BRIAN A. CARNEY DPH / OHCA (860) 418-7014

DATE: 9/16/10 **TIME:** 2:51 pm

NUMBER OF PAGES: 10
(including transmittal sheet

Comments: DOCKET 10-31577-CON
STATUS: GRANTED

PLEASE PHONE IF THERE ARE ANY TRANSMISSION PROBLEMS.

User, OHCA

From: Roberts, Karen
Sent: Monday, August 14, 2017 1:17 PM
To: Durdy, Barbara (Barbara.Durdy@hhchealth.org)
Cc: User, OHCA
Subject: 20170814130456318.pdf
Attachments: 20170814130456318.pdf

Hi Barbara – quick question for clean-up purposes on Hartford Hospital's compliance with a Certificate of Need that was issued in 2010. Attached is the last page of a CON Order for Docket Number 10-31577-CON, the acquisition of a CT Simulator for the Helen and Harry Gray Cancer Center. Condition #1 required the submission of notification of the initial date of operation for this equipment. A review of the record for DN 10-31577-CON shows that such notification was not filed. At your convenience, please email that date of initial operation to OHCA@ct.gov and it can be put in the file for this matter. Thanks. Karen

Sincerely,

Karen Roberts
Principal Health Care Analyst
Office of Health Care Access
Connecticut Department of Public Health
410 Capitol Avenue, MS #13HCA, P.O. Box 340308, Hartford, CT 06134-0308
P: (860) 418-7041 / F: (860) 418-7053 / E: *karen.roberts@ct.gov*

Order

Based on the foregoing Findings and Rationale, the Certificate of Need application of Hartford Hospital for the acquisition of a Computed Tomography ("CT") simulator, with an associated capital expenditure of $999,414 is hereby **GRANTED**, subject to the following conditions:

1. Hartford Hospital shall submit to OHCA in writing the initial date of operation for the CT simulator acquired for use at the Helen and Harry Gray Cancer Center at Hartford Hospital.

2. Should the Applicant plan to operate the CT simulator at a location other than the Helen and Harry Gray Cancer Center at Hartford Hospital, the Applicant shall notify OHCA of the new location, no later than one month after the equipment's relocation.

Should the Applicant fail to comply with any of the aforementioned conditions, OHCA reserves the right to take additional action as authorized by law. All of the foregoing constitutes the final order of the Office of Health Care Access in this matter.

By Order of the
Department of Public Health
Office of Health Care Access

Sept. 16, 2010
Date

Norma Gyle, R.N., Ph.D.
OHCA Deputy Commissioner

NG:bc

User, OHCA

From: Roberts, Karen
Sent: Tuesday, November 28, 2017 3:58 PM
To: User, OHCA
Subject: FW: Docket Number 31577 (HH CT Simulator)

From: Durdy, Barbara [mailto:Barbara.Durdy@hhchealth.org]
Sent: Tuesday, November 28, 2017 3:54 PM
To: Roberts, Karen <Karen.Roberts@ct.gov>
Subject: RE: Docket Number 31577 (HH CT Simulator)

Karen,
In response to your compliance inquiry regarding DN:10-31577-CON the Toshiba Large Bore Aquillon CT Simulator was installed in March 2011. The first patient was simulated on March 29, 2011.
Please let me know if you need further information.
Thank you
Barbara

From: Roberts, Karen [mailto:Karen.Roberts@ct.gov]
Sent: Tuesday, November 28, 2017 1:00 PM
To: Durdy, Barbara
Subject: RE: Docket Number 31577 (HH CT Simulator)

Thanks Barbara – we just want to make sure that the record doesn't have any missing required information. Karen

Sincerely,

Karen Roberts
Principal Health Care Analyst
Office of Health Care Access
Connecticut Department of Public Health
410 Capitol Avenue, MS #13HCA, P.O. Box 340308, Hartford, CT 06134-0308
P: (860) 418-7041 / F: (860) 418-7053 / E: *karen.roberts@ct.gov*

From: Durdy, Barbara [mailto:Barbara.Durdy@hhchealth.org]
Sent: Tuesday, November 28, 2017 12:38 PM
To: Roberts, Karen <Karen.Roberts@ct.gov>
Cc: User, OHCA <OHCA@ct.gov>
Subject: RE: Docket Number 31577 (HH CT Simulator)

Karen,
My apologies. I am researching the date for you now,
Barbara

From: Roberts, Karen [mailto:Karen.Roberts@ct.gov]
Sent: Monday, November 27, 2017 4:03 PM
To: Durdy, Barbara
Cc: User, OHCA
Subject: FW: Docket Number 31577 (HH CT Simulator)

Hi Barbara – I don't think we received a response to this August 14th Certificate of Need compliance email. Can you provide a response for the completion of that CON record? Thanks. Karen

Sincerely,

Karen Roberts
Principal Health Care Analyst
Office of Health Care Access
Connecticut Department of Public Health
410 Capitol Avenue, MS #13HCA, P.O. Box 340308, Hartford, CT 06134-0308
P: (860) 418-7041 / F: (860) 418-7053 / E: *karen.roberts@ct.gov*

From: Roberts, Karen
Sent: Monday, August 14, 2017 1:17 PM
To: Durdy, Barbara (Barbara.Durdy@hhchealth.org) <Barbara.Durdy@hhchealth.org>
Cc: User, OHCA <OHCA@ct.gov>
Subject: 20170814130456318.pdf

Hi Barbara – quick question for clean-up purposes on Hartford Hospital's compliance with a Certificate of Need that was issued in 2010. Attached is the last page of a CON Order for Docket Number 10-31577-CON, the acquisition of a CT Simulator for the Helen and Harry Gray Cancer Center. Condition #1 required the submission of notification of the initial date of operation for this equipment. A review of the record for DN 10-31577-CON shows that such notification was not

filed. At your convenience, please email that date of initial operation to OHCA@ct.gov and it can be put in the file for this matter. Thanks. Karen

Sincerely,

Karen Roberts
Principal Health Care Analyst
Office of Health Care Access
Connecticut Department of Public Health
410 Capitol Avenue, MS #13HCA, P.O. Box 340308, Hartford, CT 06134-0308
P: (860) 418-7041 / F: (860) 418-7053 / E: *karen.roberts@ct.gov*

Reminder: This e-mail and any attachments are subject to the current HHC email retention policies. Please save or store appropriately in accordance with policy.