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REPORT

AMERICAN SOCIETY OF RADIATION ONCOLOGY RECOMMENDATIONS FOR DOCUMENTING INTENSITY-MODULATED RADIATION THERAPY TREATMENTS

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Despite the widespread use of intensity-modulated radiation therapy (IMRT) for approximately a decade, a lack of adequate guidelines for documenting these treatments persists. Proper IMRT treatment documentation is necessary for accurate reconstruction of prior treatments when a patient presents with a marginal recurrence. This is especially crucial when the follow-up care is managed at a second treatment facility not involved in the initial IMRT treatment. To address this issue, an American Society for Radiation Oncology (ASTRO) workgroup within the American ASTRO Radiation Physics Committee was formed at the request of the ASTRO Research Council to develop a set of recommendations for documenting IMRT treatments. This document provides a set of comprehensive recommendations for documenting IMRT treatments, as well as image-guidance procedures, with example forms provided.

Intensity-modulated radiation therapy, IMRT, IGRT, Documentation.

INTRODUCTION

Many within the field of radiation oncology have become increasingly concerned about the lack of adequate guidelines for documentation and archiving of dose-distributions from intensity-modulated radiation therapy (IMRT) and other inverse-planned conformal treatments. Numerous sources of information exist that provide guidance on various elements of the IMRT process yet there is no single source that adequately addresses documentation of IMRT treatments in detail. For example, the American College of Radiology (ACR) has published guidelines for IMRT, yet their recommendations for permanent documentation of the dose distributions are brief and nonspecific (1):

> *''Documentation of delivered doses to volumes of target and non-target tissues, in the form of dose volume histograms and representative cross-sectional isodose treatment diagrams should be maintained in the patient's written or electronic record. As noted above, various treatment verification methodologies, including daily treatment unit parameters, films confirming proper patient positioning, and records of physical measurements confirming treatment dosimetry should also be incorporated into the patient's record.''*

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Conflict of interest: none.

Acknowledgments—The American Society for Radiation Oncology (ASTRO) is the largest radiation oncology society in the world, with more than 9,000 members who specialize in treating patients with radiation therapies. As a leading organization in radiation oncology, biology, and physics, the Society is dedicated to the advancement of the practice of radiation oncology by promoting excellence in patient care, providing opportunities for educational and professional development, promoting research and disseminating research results, and healthcare environment. ASTRO will periodically provide practice guidelines and recommendations for the practice of radiation oncology to help advance the science and to improve the quality of service to patients throughout the United States. This recommendation for documenting IMRT treatments has undergone a thorough consensus process in which it has been subjected to extensive review by the relevant Committees within ASTRO. Final approval was granted by the ASTRO Board of Directors. The Working Group would like to thank the following individuals for their contributions to this activity: William Mendenhall MD, University of Florida, Gainesville, FL, W. Robert Lee, MD and David Brizel, MD, Duke University, Durham, NC, and Sylwester Dziuba, MD, St. Agnes Cancer Center, Baltimore, MD.

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A prior ACR practice guideline on communication for radiation oncology provides general recommendations on the elements of a treatment plan that should be included in a treatment summary, yet provides little information specific to a complex IMRT treatment (2). The limited recommendations of this document have also been referenced in other guidelines from ACR and ASTRO (1, 3). The International Commission on Radiation Units and Measurements (ICRU) has published two reports on prescribing, recording and reporting photon beam therapy that provide useful detail on the definition of clinical volumes and recommended nomenclature to be used in modern CT-based radiotherapy techniques like IMRT, yet they provide no guidance on documenting the IMRT treatment (4, 5). The American Association of Physicists in Medicine (AAPM) alone, and jointly with ASTRO, has published guidance documents on implementing IMRT into clinical practice that provide detail on the technical issues of implementing IMRT, yet no specific information on treatment documentation (6, 7). Additional documents have also been published by the National Cancer Institute (NCI) (8, 9), Radiation Therapy Oncology Group (RTOG) (10), and the Advanced Technology Consortium (ATC) (11) that provide guidance on documentation required for development and implementation of clinical trials using IMRT. These latter three references provide useful details relevant to documenting an IMRT treatment that have been incorporated into the present work.

Recently, the field has seen an increasing number of patients referred for treatment of marginal recurrences occurring after IMRT treatment at an outside facility. In many cases, it has been impossible to reconstruct the previous treatment sufficiently to compare the recurrence site to the original dose distribution or to estimate the risk to adjacent critical structures from possible retreatment. Successful re-irradiation depends upon the ability of the radiation oncologist to reconstruct the previous treatment; in the past, this could be done electronically by recreating the original fields. Ironically, although IMRT has proved to be a very useful tool for retreatment, the tight distributions used to give initial treatments may also increase the risk of marginal recurrence, and the complexity of the treatment makes it more difficult to reconstruct previous fields. Of course, this problem has implications beyond the treatment of post-treatment recurrence. As the radiation oncology field develops new technologies, it has a responsibility to evaluate its impact on patterns of recurrence and on treatment-related side effects. Without adequate documentation, it is impossible to follow these relationships in a meaningful way.

At the October 2007 ASTRO Board of Directors Meeting, the Research Council proposed that ASTRO develop a subcommittee to evaluate and recommend guidelines for reporting treatment dose distributions and for the retention of electronic data from inverse-planned radiation treatments. A workgroup was formed within the Radiation Physics Committee and assigned this task with the following objectives:

1. To review current guidelines/recommendations for IMRT documentation published by radiation oncology and related standards organizations
2. To augment these existing general guidelines where needed, taking into account the current state of technology, including paper and electronic forms of documentation
3. To augment general guidelines for IMRT with body site-specific documentation recommendations
4. To recommend areas of future development of IMRT documentation
5. To disseminate these guidelines/recommendations to ASTRO community.

The following recommendations were developed by the workgroup with input from the radiation oncologists cited in the acknowledgements.

IMRT DOCUMENTATION RECOMMENDATIONS

I. Recommendations for Current Practice

It is recognized that IMRT documentation is evolving from a paper record to a digital form as the IMRT modality finds increased support in the electronic medical record (EMR) infrastructure. Nevertheless, at present, paper documentation is the most common form of data sharing between healthcare providers. With this in mind, these recommendations reflect the reality that information such as dose distributions will, in many cases, have to be provided in paper form.

Caveat: In a recent publication, Das *et al*. (12) present a retrospective evaluation of more than 803 IMRT plans:

> *"A total of 46% of the patients received a maximum dose that was more than 10% higher than the prescribed dose, and 63% of the patients received a dose that was more than 10% lower than the prescribed dose.… Substantial variation in the prescribed and delivered doses exists among medical institutions, raising concerns about the validity of comparing clinical outcomes for IMRT. The isocenter dose in IMRT is simply a point dose and often does not reflect the prescription dose that is specified by a selected isodose line encompassing the target volume. This study suggests the need for national and/or international guidelines for dose prescription, planning, and reporting for a meaningful clinical trial in IMRT."*

Consequently, care should be taken in interpreting a prior treatment performed at another institution, because variations in the prescribed and delivered dose can range upward of 10% between institutions. This type of uncertainty should be factored into the retreatment planning strategy.

A. Recommendations for Dose and Volume Specification. The following list summarizes the IMRT Collaborative Working Group's recommendations regarding target volume and dose specification for IMRT for the purpose of correlating them with the clinical outcome (9):

1. Clinicians should specify the gross target volume (GTV), clinical target volume (CTV), planning target volume (PTV), integrated target volume (ITV), organ at risk (OAR), and planning organ at risk (PRV) following the recommendations of ICRU Reports 50 and 62 (4, 5).

2. The PTV must (at least attempt to) ensure proper coverage of the CTV in the presence of inter- and intrafraction variation of treatment setup and organ motion. The conventional approach of assigning a uniform margin around the CTV is generally no longer adequate when IMRT plans are considered.
3. As a minimum, the following information should be reported for the purpose of correlating the dose with the clinical outcome:
   a. Prescribed (intended) dose, as well as the point or volume to which it is prescribed; a fractionation prescription should also be included
   b. D95: The dose that covers 95% of the PTV and CTV volume
   c. D100: The dose that covers 100% of the PTV and CTV volume (*i.e.,* the minimal dose)
   d. V100: The percentage volume of the PTV and CTV that receives the 100% of the prescribed dose
   e. Mean and maximal doses within the PTV and CTV
   f. For each organ at risk, the maximal, minimal, and mean doses, the volume of the organ receiving that dose, and other relevant dose–volume data.

B. Recommendations for IMRT Documentation (Paper Copy or Digital form)

The following list summarizes the IMRT Documentation Workgroup's recommendations for documenting IMRT treatments. In addition to the existing Physician's Treatment Summary, the Workgroup recommends that specific details of the inverse treatment planning and image-guided treatment processes be recorded using an IMRT Treatment Planning Directive, a Treatment Goal Summary, an Image Guidance Summary, and a Motion Management Summary.

1. IMRT Treatment Planning Directive
   Facilities engaging in complex three-dimensional (3D) treatment planning are encouraged to develop site-specific *Treatment Planning Directives* that provide an unambiguous description of the input parameters and information required to create a 3D treatment plan. The information on the Treatment Planning Directive should include:
   a. Prescription—body site/target, total dose, number of fractions, protocol ID if protocol case
   b. Target definition—imaging modality used to define the GTV/CTV and the margins used to define the PTV
   c. Organs at risk—consistent naming convention should be used
   d. Plan parameters—energy, heterogeneity correction, and any inverse planning model-specific parameters (*e.g.,* helical tomotherapy slit width and modulation factor; maximum number of field segments and monitor units per field segment for a Direct Aperture Optimization (DAO)/Direct Machine Parameter Optimization (DMPO) formalism)
   e. Treatment planning goals—treatment plan goals such as acceptable target dose uniformity variation and minimum dose–volume constraint, and dose–volume limits on OARs, should be provided
   f. Physician signature and date
   g. Treatment planner (dosimetrist/physicist) signature and date.

An example Directive form developed by the University of Michigan is provided in Fig. 1.

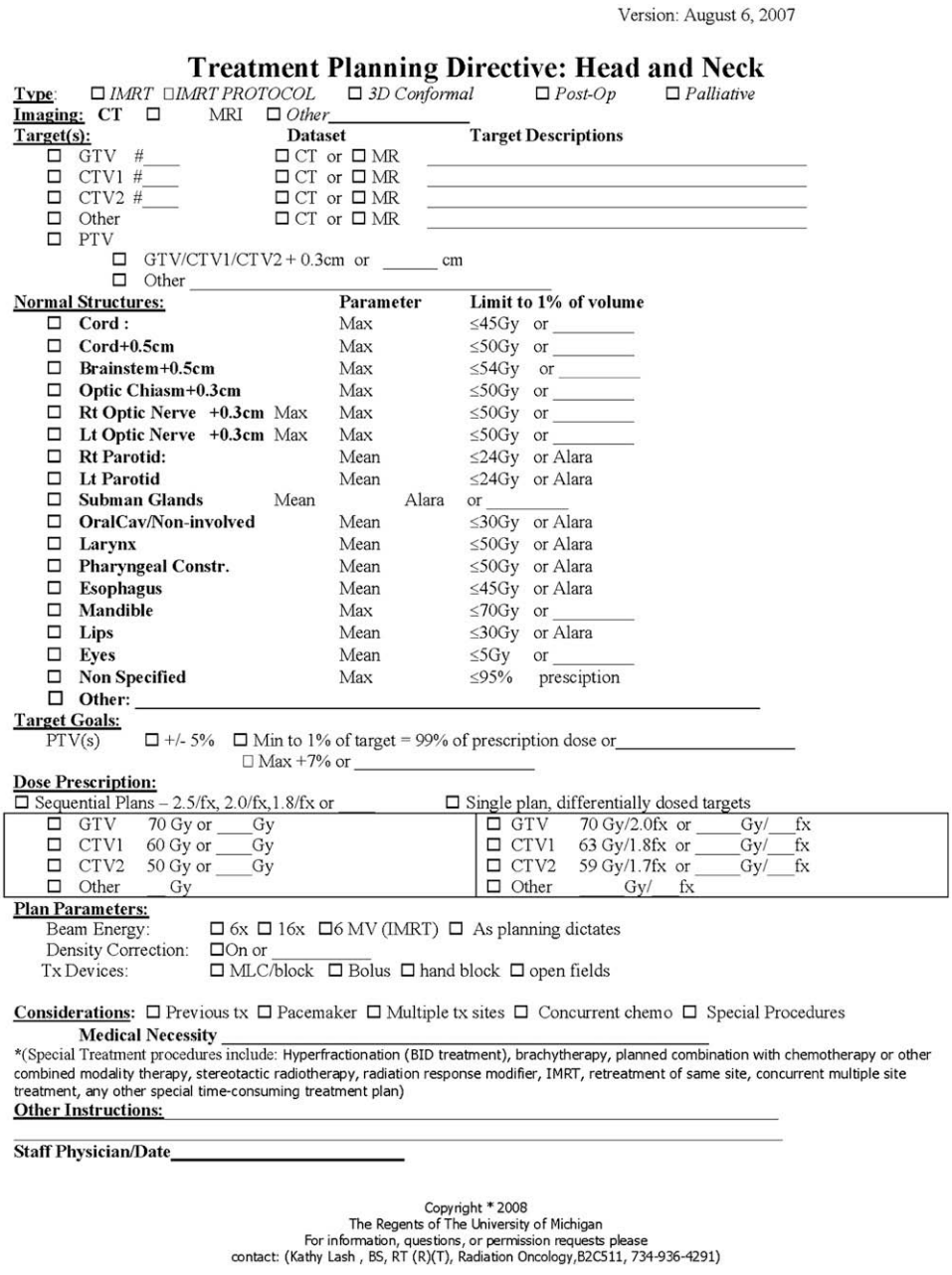
2. IMRT Treatment Goal Summary

Facilities are also encouraged to develop a site-specific *Treatment Planning Goal Summary* for inverse planned IMRT treatments to complement the Treatment Planning Directive described above. An example Summary spreadsheet developed by the University of Florida is provided in Fig. 2.

3. Image-Guidance Summary

Facilities are encouraged to develop a means of documenting the use of image-guidance systems for detecting daily setup errors for IMRT treatments. These errors can be useful in developing site-specific treatment margins for refining the planning process. The summary form should include the type of device (*i.e.,* X-ray, CT, ultrasound, Calypso™, optical system, implanted X-ray fiducials) and the frequency of use. An example Summary form developed by St. Agnes Cancer Center is provided in Fig. 3.

4. Motion Management Summary
   Facilities are encouraged to develop a means of documenting the use of motion-management systems to compensate/correct for breathing motion during treatment of lung and abdominal targets. Information should include:
   a. Body site, including laterality (*i.e.,* right side or left side)
   b. Treatment method (*i.e.,* gated or nongated)
   c. Respiratory management method and device
      i. Nongated delivery using an abdominal compression device, or coordinated breath-hold monitored by an external device such as Active Breathing Coordinator™ (ABC)
      ii. Gated delivery using free-breathing and an external gating monitor such as RPM™.
   d. Expected positioning uncertainty using the motion management system
   e. Method used to define the ITV and PTV:
      i. Four-dimensional computed tomographic imaging (4DCT) with acquisition over multiple breathing-phases
      ii. Slow scan tomographic imaging technique (CT, PET)
      iii. Margins used to create the PTV from the ITV.
5. Physician's treatment summary note, to include:
   a. Disease site and staging
   b. Prescription dose and fractionation
   c. Use of special immobilization, motion management, daily image guidance, implantation of fiducial markers, and any other pertinent information related to the IMRT treatment procedure.



Version: August 6, 2007

Treatment Planning Directive: Head and Neck

Type: ☐ *IMRT* ☐*IMRT PROTOCOL* ☐ *3D Conformal* ☐ *Post-Op* ☐ *Palliative*

Imaging: **CT** ☐ MRI ☐ *Other*_____

Target(s):	**Dataset**	**Target Descriptions**
☐ GTV #____	☐ CT or ☐ MR	_____
☐ CTV1 #____	☐ CT or ☐ MR	_____
☐ CTV2 #____	☐ CT or ☐ MR	_____
☐ Other	☐ CT or ☐ MR	_____

☐ PTV
- ☐ GTV/CTV1/CTV2 + 0.3cm or _____ cm
- ☐ Other _____

Normal Structures:	**Parameter**	**Limit to 1% of volume**
☐ **Cord :**	Max	≤45Gy or _____
☐ **Cord+0.5cm**	Max	≤50Gy or _____
☐ **Brainstem+0.5cm**	Max	≤54Gy or _____
☐ **Optic Chiasm+0.3cm**	Max	≤50Gy or _____
☐ **Rt Optic Nerve +0.3cm** Max	Max	≤50Gy or _____
☐ **Lt Optic Nerve +0.3cm** Max	Max	≤50Gy or _____
☐ **Rt Parotid:**	Mean	≤24Gy or Alara
☐ **Lt Parotid**	Mean	≤24Gy or Alara
☐ **Subman Glands** Mean	Alara	or _____
☐ **OralCav/Non-involved**	Mean	≤30Gy or Alara
☐ **Larynx**	Mean	≤50Gy or Alara
☐ **Pharyngeal Constr.**	Mean	≤50Gy or Alara
☐ **Esophagus**	Mean	≤45Gy or Alara
☐ **Mandible**	Max	≤70Gy or _____
☐ **Lips**	Mean	≤30Gy or Alara
☐ **Eyes**	Mean	≤5Gy or _____
☐ **Non Specified**	Max	≤95% presciption
☐ **Other:** _____		

Target Goals:

PTV(s) ☐ +/- 5% ☐ Min to 1% of target = 99% of prescription dose or_____

☐ Max +7% or _____

Dose Prescription:

☐ Sequential Plans – 2.5/fx, 2.0/fx,1.8/fx or ____ ☐ Single plan, differentially dosed targets

☐ GTV 70 Gy or ____Gy	☐ GTV 70 Gy/2.0fx or _____Gy/___fx
☐ CTV1 60 Gy or ____Gy	☐ CTV1 63 Gy/1.8fx or _____Gy/___fx
☐ CTV2 50 Gy or ____Gy	☐ CTV2 59 Gy/1.7fx or _____Gy/___fx
☐ Other ___ Gy	☐ Other _____Gy/___ fx

Plan Parameters:

Beam Energy: ☐ 6x ☐ 16x ☐6 MV (IMRT) ☐ As planning dictates

Density Correction: ☐On or _____

Tx Devices: ☐ MLC/block ☐ Bolus ☐ hand block ☐ open fields

Considerations: ☐ Previous tx ☐ Pacemaker ☐ Multiple tx sites ☐ Concurrent chemo ☐ Special Procedures

Medical Necessity _____

*(Special Treatment procedures include: Hyperfractionation (BID treatment), brachytherapy, planned combination with chemotherapy or other combined modality therapy, stereotactic radiotherapy, radiation response modifier, IMRT, retreatment of same site, concurrent multiple site treatment, any other special time-consuming treatment plan)

Other Instructions: _____

_____

Staff Physician/Date_____

Fig. 1. Example of an intensity-modulated radiation therapy (IMRT) treatment directive for head-and-neck cancer (provided with permission of the Department of Radiation Oncology, University of Michigan).

6. A copy of the daily treatment record that includes:
   a. Completed treatments and treatment interruptions
   b. Setup photos
   c. Machine information including
      i. Vendor/model
      ii. Beam energy
      iii. MLC type/leaf resolution.
   d. Immobilization/treatment aids (bolus, rectal balloon)
   e. Other (*e.g.*, bladder full or empty, arms over head)
7. Treatment plan printout that includes:
   a. Treatment planning system and version
   b. Date of plan creation
   c. Prescription
   d. Cumulative dose–volume histograms for targets and organs-at-risk
   e. Isodose distributions on CT images located in axial, coronal, and sagittal planes:
      i. Axial planes at interval of 1 cm (or less, depending on the case) extending 1 cm beyond the superior and inferior limits of the treatment fields
      ii. Coronal and sagittal cuts through center of the PTV and any dose-limiting normal tissue such as spinal cord
   f. Dose–volume statistics that include minimum and maximum doses to targets and OARs (note: because the minimum and maximum doses in a structure

Patient Name			John Doe		MRN:	12345		
Site:			Head and Neck					
Plan			Composite					
Prescriptions (Gy)			PTV					
		Total	60					
ROI	Margin (mm)	Volume (c.c)	Goal	Objective Dose (Gy)	Meet Goal			
PTV		100.0						
Plan		95.0	95% Vol > Rx(I)	60.0	YES	95% Vol =	60.0	Gy
		99.0	99% Vol >93% Rx(I)	55.8	YES	99% Vol =	58.0	Gy
		20.0	20% Vol ≤ 110% Rx (I)	66.0	YES	20% Vol =	12.0	Gy
		10.0	%Vol ≥110% Rx(I)	66.0		Vol=	10%	%
Cord(M)	2		0.1 cc Vol ≤ 50Gy		YES	0.1 cc Vol=	30.0	Gy
Brainstem(M)	2		0.1 cc Vol ≤ 55Gy		YES	0.1 cc Vol=	26.0	Gy
Chiasm(M)	0		0.1 cc Vol ≤ 50Gy		YES	0.1 cc Vol=	10.0	Gy
Parotid RT(M)	3	25.0	Mean dose ≤ 26Gy		*	Mean dose=	30.0	Gy
Parotid RT(M)<30Gy	3	12.0	% Vol of 30Gy ≤ 50%		YES	%Vol of 30Gy=	48.0	%
Parotid RT(M)-P	3	10.0	Volume ratio outside PTV		YES	Vol=	40.0	%
Parotid_LT(M)	3	27.0	Mean dose ≤ 26Gy		YES	Mean dose=	12.0	Gy
Parotid LT(M)-P	3	12.0	Volume ratio outside PTV		YES	Vol=	44.4	%

Patient Name			Pedro Prostate		MRN:	23456		
Site:			Prostate					
Plan			Composite					
Prescriptions (Gy)			77.4					
ROI	Margin (mm)	Volume (c.c)	Goal	Objective Dose (Gy)	Meet Goal			
PTV		33.0						
		31.4	95% Vol > Rx	77.4	YES	95% Vol =	77.4	Gy
		32.7	99% Vol >93% Rx	72.0	YES	99% Vol =	77.4	Gy
		6.6	20% Vol ≤ 110% Rx	85.1	YES	20% Vol =	22.0	Gy
		1.0	%Vol ≥110% Rx	85.1		Vol=	3%	%
Rectum Wall(M)	3		10 cc Vol ≤ 70Gy		YES	10 cc Vol=	65.0	Gy
Bladder Wall(M)	0		30 cc Vol ≤ 30Gy		*	30 cc Vol=	32.0	Gy
Femoral Heads(M)	0		0.1 cc Vol ≤ 55Gy		YES	0.1 cc Vol=	41.0	Gy

Fig. 2. Examples of an intensity-modulated radiation therapy (IMRT) dosimetry summary for head-and-neck and prostate cancer cases using a spread sheet with predefined treatment goals (provided with permission of the Department of Radiation Oncology, University of Florida).

volume can occur in single voxels of clinically insignificant volume, clinicians are encouraged to alternatively report the minimum dose as the dose to 1% of the structure volume [*i.e.,* D1], and the maximum dose as the dose to 99% of the of the structure volume [*i.e.,* D99])

g. Optional: Digitally reconstructed radiographs (DRRs) with dose-limiting structure shown in wireframe or 3D surface, and maximum area limit of field segments outlined (note: IMRT is used to increase the dose gradient at a field edge so that dosimetric margins can be reduced; consequently, DRRs for IMRT treatments will appear to have field edges that are closer to the target volume than nonmodulated treatments, and they should always be interpreted with this in mind)

8. Record retention: It is recommended that treatment records (paper and electronic) be retained for a minimum of 5 years. It is preferable that electronic records be archived using standard formats such as DICOM-RT, jpeg, or pdf.

II. Ongoing Development of Electronic Documentation

Several efforts are actively in process to advance the issue of electronic documentation in the field of radiation oncology. This section describes these development efforts, and provides recommendations for future development of tools for electronic documentation, archiving and data sharing.

A. The Advanced Technology Consortium. The Advanced Technology Consortium (ATC) for Clinical Trials Quality Assurance is supported by a National Cancer Institute U24 grant to Washington University (St. Louis, MO). It has grown out of the efforts of Washington University and the Radiation Therapy Oncology Group, beginning in 1994, to create a robust Quality Assurance process to collect and review the image-based planning and verification data for patients enrolled on the 3D Oncology Group (3DOG) prostate dose-escalation protocol (RTOG 9406). The ATC now functions as a ''virtual entity'' made up of the following clinical trials QA Centers:

1. The Image-Guided Therapy QA Center (ITC; Washington University in St. Louis and University of California–Davis)
2. The Radiation Therapy Oncology Group (RTOG) Headquarters Dosimetry Group
3. The Radiological Physics Center (RPC; M.D. Anderson Cancer Center)
4. The Quality Assurance Review Center (QARC).

The ATC strongly believes that advanced medical informatics can create an environment in which clinical

TomoTherapy IGRT Summary

St. Agnes Hospital

Patient name:

MRN

The patient was appropriately positioned on the treatment table using laser lights and a custom immobilization device. An MVCT of the patient in the treatment position was obtained and registered with the planning CT scans. The required shifts to align the image sets were calculated using the TomoTherapy software. The fused images with shifts were verified in orthogonal planes (axial, sagittal and coronal) prior to treatment. After review of the merged images, it was determined that the recorded shifts were necessary to deliver accurate treatment.

Fx	Date	Vert-Z (mm)	Long-Y (mm)	Lat-X (mm)	Roll (deg)	Therapist Review	MD Review
1							
2							
3							
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Fig. 3. Example of a summary record of shifts measured by daily computed tomographic image guidance (provided with permission of Department of Radiation Oncology, St. Agnes Cancer Center).

investigators can receive, share, and analyze volumetric, multimodality treatment planning, and verification digital data. Its ultimate goal is to improve the standards of care in the management of cancer by improving the quality of clinical trials medicine. Its overall mission is to facilitate and support NCI sponsored advanced technology clinical trials, *particularly those requiring digital data submission including IMRT protocols*. This effort includes radiation therapy QA, image and radiation therapy digital data management, and clinical research and developmental efforts.

B. The IHE-RO Initiative. The Integrating the Healthcare Enterprise (IHE) initiative, started in 1998, is an unprecedented international collaboration between healthcare professionals and industry to improve patient care by improving the way healthcare computer systems share information. The goal of seamless integration is accomplished by the coordinated use of established standards to address specific clinical needs. When systems are developed in accordance with standards, they can communicate and share information to improve patient care. IHE, which began in Radiology, has expanded into Information Technology (IT) Infrastructure, Cardiology and now into Radiation Oncology. The latter effort is referred to as Integrating the Healthcare Enterprise–Radiation Oncology (IHE-RO). The IHE-RO includes the

leading manufacturers of imaging, therapy and information systems in the radiation oncology field, as well as the AAPM, ACR, ASTRO, and many other professional radiation oncology societies around the world. This endeavor will allow the radiation oncology field to realize the full potential of computer systems in medical error reduction, efficiency of care, and electronic storage and transmission of clinical outcomes data to processes such as multi-institutional trials and Patterns of Care Studies.

Radiation oncology presents to the IHE process additional layers of complexity because of the multiplicity of treatment machines, treatment-planning, and patient data computers, all of which are constantly undergoing upgrades in the ever-improving paradigm of modern radiation oncology. IHE-RO will provide a detailed framework for the implementation of standards for radiation oncology. The technical framework delineates standards-based transactions (information sharing) among all participants (actors) in a given clinical process at a great specificity to ensure the highest level of interoperability between systems. The process involves the following steps:

1. Identify interoperability problems—Radiation therapy community representatives (clinical physicists and radiation oncologists) identify common integration problems in a radiotherapy facility and/or clinical workflow.
2. Specify integration profiles—Technical experts (physicists and engineers) select standards that address each identified integration need. These experts produce a document describing the proposed IHE Integration Profile for public comment and subsequent revision.
3. Test integration profiles—Once the profiles are finalized, vendors implement these profiles and test their systems with software tools at a ''Connectathon.'' During the Connectathon, vendors of medical equipment demonstrate their compliance with an IHE Profile by testing to ensure that their equipment communicates appropriately with the related equipment from other vendors. Successful completion of the testing requires the vendor's system to receive information from at least three other vendors who support the previous step in the information flow, and to transmit information to three vendors whose applications represent the next step.

In 2007, IHE-RO tested its first profile, the Basic Integration Profile at the 49th Annual ASTRO Meeting in Los Angeles, CA. This profile illustrated a straightforward information flow modeling the radiation therapy treatment planning process. In 2008, an additional profile was added that addressed the interoperability of multimodality image registration tools. This profile demonstrates how multimodality images could be registered and aligned as part of the planning process.

The vendors who pass the interconnectivity and interoperability test for one or more of profiles then have the opportunity to demonstrate that at a national meeting and can publish IHE Integration Statements to document the integration profiles supported by their products. As a result, users can reference integration profiles in requests for proposals (RFPs), simplifying the systems acquisition process. IHE-RO solutions are now available in many of the commercial radiation oncology–related treatment planning, delivery, and information systems. IHE-RO solutions are also implemented in cancer care sites around the world.

C. Recommendations for Future Development of Electronic Documentation. Future technical developments should focus on the creation of solutions for electronic data sharing based on the DICOM standard, standard models and methods for evaluating IMRT treatments, and the development of tools for easily reconstructing prior IMRT treatments:

1. Recommend that radiotherapy treatment planning (RTP) systems support the import of DICOM-RT datasets generated by other vendor's imaging/planning systems so that RTP systems can be used for review of treatment plans generated elsewhere at other facilities:
   a. Axial images (CT/MRI/PET)
   b. Dose volume (grid size)
   c. Regions of interest (ROIs): GTV/CTV, PTV, ITV, OARs, avoidance structures
   d. Dose–volume histograms (DVHs)
   e. Prescription: Total dose to percentage volume, number of fractions
   f. Points-of-interest (POIs): Setup point, isocenter, calculation points
2. Recommend development of a *standard* DVH model for forward and inverse treatment planning applications covering three-dimensional conformal radiotherapy (3DCRT), stereotactic radiosurgery (SRS), stereotactic body radiosurgery (SBRT), and intensity-modulated radiation therapy (IMRT)
3. Recommend that IMRT RTP systems, radiotherapy picture archiving and communication systems (RT-PACS), and electronic medical record (EMR) systems all support the export of DICOM-RT data objects (*i.e.,* axial image sets, dose distribution, plan data, DRRs) to a CD-ROM equipped with a ''data viewer'' to allow the data to be easily archived in a portable format for later review and use if a retreatment is needed
4. Recommend that 3DCRT/IMRT RTP systems support deformable registration of the previously treated dose distribution to the current axial image sets, and furthermore that these systems provide the capability to convert the deformed dose into an avoidance-ROI to assist in planning a retreatment using either forward or inverse planning techniques

DISCUSSION

An objective of this work is to augment the existing literature cited in the Introduction with a detailed list of recommendations for documenting IMRT treatments. These recommendations were drawn from Radiation Oncologists and Medical Physicists with an extensive background in the use of the wide variety of technologies available for

image-guided IMRT treatment. A practical issue guiding this work is the need to provide adequate documentation of a complex treatment like IMRT in the event a recurrence necessitates a reconstruction of the treatment, a task made difficult to impossible to do accurately if the patient obtained the initial treatment from a different clinic. Often this effort has to be carried out manually using printed output from a treatment planning system, record and verification system and localization films. Nevertheless, moving forward, it is recognized that the technology landscape in the radiation oncology field is quickly evolving, and with this evolution will come new ways of documenting treatments electronically in forms that can be easily interpreted to conveniently reconstruct a prior IMRT treatment.

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