A Radiation Oncology Based Electronic Health Record in an Integrated Radiation Oncology Network

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ABSTRACT

Purpose: The goal of this ongoing project is to develop and integrate a comprehensive electronic health record (EHR) throughout a multi-facility radiation oncology network to facilitate more efficient workflow and improve overall patient care and safety.

Methodology: We required that the EHR provide pre-defined record and verify capability for radiation treatment while still providing a robust clinical health record. In 1996, we began to integrate the Local Area Network Treatment Information System (LANTIS®) across the West Penn Allegheny Radiation Oncology Network (currently including 9 sites). By 2001, we began modifying and expanding the assessment components and creating user-defined templates and have developed a comprehensive electronic health record across our network.

Results: In addition to access to the technical record and verify information and imaging obtained for image-guided therapy, we designed and customized 6 modules according to our network's needs to facilitate information acquisition, tracking, and analysis as follows: 1) Demographics/scheduling; 2) Charge codes; 3) Transcription/clinical documents; 4) Clinical/technical assessments; 5) Physician orders 6) Quality assurance pathways. Each module was developed to acquire specific technical/clinical data prospectively in an efficient manner by various staff within the department in a format that facilitates data queries for outcomes/statistical analyses and promotes standardized quality guidelines resulting in a more efficient workflow and improved patient safety and care.

Conclusions: Development of a comprehensive EHR across a radiation oncology network is feasible and can be customized to promote clinical/technical standards, facilitate outcomes studies, and improve communication and peer review. The EHR has improved patient care and network integration across a multi-facility radiation oncology system and has markedly reduced the flow and storage of paper across the network.

Keywords: Electronic health record, radiation oncology
Disclosure: The authors declare no conflicts of interest.

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doi :10.5166/jroi-3-1-16
ISSN: 1663-618X, J Radiat Oncol Inform 2011;3:1:3-11

1. INTRODUCTION

Radiation Oncology is a discipline that is heavily dependent on advanced technologies. Historically with this technology, a need for more accurate monitoring and recording of daily radiation treatments arose. Computerized record and verify systems were first introduced approximately 30 years ago to ensure the accurate and safe delivery of radiation therapy (1). Record and verify systems allow for the verification of proper dosing of patients at the linear accelerator and have become the backbone of modern radiation oncology departments. Over the years, numerous publications have validated their importance and necessity in the efficient and safe function of a modern radiation oncology practice (2-6). Traditionally, these record and verify systems have been unique to radiation technical information and contain only limited patient data such as demographics and scheduling. Specific patient clinical data such as pathology reports, laboratory results, nursing assessments, and consultation/progress notes have not usually been part of these systems.

Several perceived or real obstacles exist when implementing an EHR. In addition to the initial cost, a perceived lack of reimbursement for the investment and the potentially challenging logistical and technical issues associated with implementation have been barriers (7). With the passage of the American Recovery and Reinvestment Act of 2009, and the drive promoting development and use of comprehensive electronic health records, problems unique to radiation oncology have also arisen. Radiation oncology requires integration of a technical record and verify system with the clinical patient information of an EHR. The system must be user friendly, flexible and adaptable to changing conditions and standards within the department. Han *et al.* categorized 3 distinct computer systems used in a modern radiation oncology department. These include a clinical medical electronic record, a record and verify system, and a computerized treatment planning system (6). The challenge is to integrate these platforms into a user-friendly system that not only improves department efficiency but also improves patient safety. Previous reports have suggested that an integrated radiation oncology EHR can improve workflow and communication within a department (8, 9). Furthermore, implementation of an integrated EHR can result in "better organization and standardization of patient data" (10).

It is unlikely than any EHR will meet an organization's needs "out of the box". Our purpose is not to compare data systems but to demonstrate modification and implementation across a large radiation oncology network of one such commercially available record and verify system into a comprehensive EHR with both clinical and technical information. Though the system does not meet all of the desirables for a comprehensive radiation oncology EHR, the innovative approaches we describe have allowed elimination of paper charts, improved network-wide accessibility and remote access to patient and treatment records and have introduced verifiable standards of quality assurance methods.

2. METHODOLOGY

The Local Area Network Treatment Information System (LANTIS® Siemens Medical Inc., Concord CA) (currently in version 8.30R1) provides the radiation treatment record and verify capability, integrates with radiation treatment planning systems and provides for customizable modules allowing integration of patient information to create a comprehensive oncologic EHR. LANTIS stores the accrued information in a relational database.

Implementation of the EHR began in 1996, across the West Penn Allegheny Radiation Oncology Network which comprises 9 sites anchored by Allegheny General Hospital (AGH) in Pittsburgh, PA and includes clinics in southwestern PA and southeastern OH. Approximately 250 cancer patients are treated daily with an array of advanced techniques/modalities including 3-dimensional conformal radiation, intensity-modulated radiotherapy (IMRT), stereotactic radiosurgery and stereotactic body radiotherapy, image-guided radiation therapy (IGRT), and low dose rate/high dose rate brachytherapy. The ongoing need to implement comprehensive cancer care and advanced radiation treatment programs as well as consistent, verifiable and standardized quality assurance programs at AGH and throughout the network has made necessary an expandable EHR that integrates clinical and technical information.

By modifying and expanding the basic interface within the system, we have developed a comprehensive EHR and quality assurance system. An EHR committee that included representatives from the physician group, physics, nursing, therapy, information systems, and management developed six modules to meet specific departmental needs. These were: 1) demographics/scheduling; 2) charge codes; 3) transcription/clinical documents; 4) clinical/technical assessments; 5) physician orders; 6) quality assurance pathways. Specific technical and clinical data are prospectively acquired in a standardized format in each module by various staff within the department. Quality assurance pathways

doi :10.5166/jroi-3-1-16

ISSN: 1663-618X, J Radiat Oncol Inform 2011;3:1:3-11

were also developed via a quality checklist tool resulting in more efficient workflow and improved patient safety and care. Prospective acquisition of these data facilitates data queries for outcomes and statistical analyses.

In order to access the EHR across the network, we have robust connectivity from all our treatment centers. When high band width is not practical, we provide for authenticated access through a Citrix® (Fort Lauderdale, FL) server, thereby allowing access to the EHR at all of our offices and conceivably from any private networked computer.

3. RESULTS

Demographics/Scheduling

Standardized demographic information was defined by the EHR committee. At the time of consultation, the patient completes a demographics form which includes address, emergency contacts, insurance information, referring physicians, etc. This information is entered into the system by trained staff and is updated as needed when patients return for follow-up. Patients are also scheduled for consultations, follow-ups and treatment using customized physician templates.

Charge Codes

Charge panels were developed to ensure the consistency and accuracy of multiple charges for a single procedure. To capture charges, the appropriate staff "click" on applicable charges in procedure-specific charge panels. This system improves accuracy by minimizing missed charges and the use of wrong charge codes and has improved the accuracy and reliability of point of service billing thereby reducing insurance denials. The system also allows for standardization of charge practices across the network, improving network-wide efficiency. **Figure 1** shows the charge panel for a low dose rate prostate brachytherapy procedure.

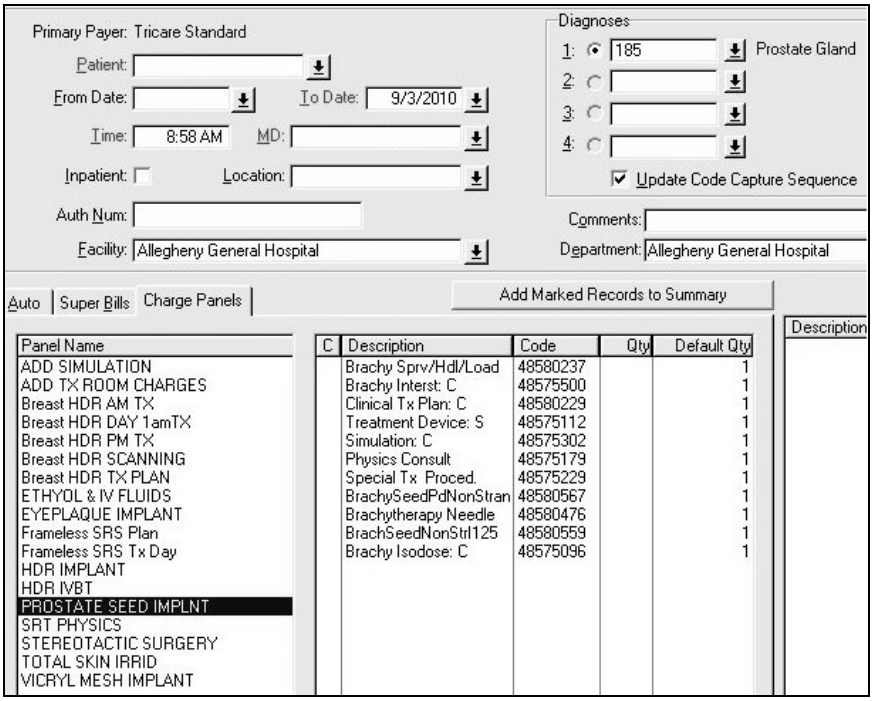

Figure 1. Charge panel for low dose rate interstitial prostate brachytherapy

Transcription/Clinical Documents

Transcription templates for documents such as consultations, follow-up notes, simulation notes, brachytherapy procedure notes, etc., were developed to merge previously entered data (such as birth date, medical record number, etc.) from the system and populate these documents automatically. The templates contain specific drop down boxes that are selected by appropriate staff members. Once approved, they become permanent documents within the patient's electronic health

doi :10.5166/jroi-3-1-16

ISSN: 1663-618X, J Radiat Oncol Inform 2011;3:1:3-11

record. Notification statuses such as "dictation required" and "edit required" allow involved staff to track the progress of documents as they pass through dictation, editing, etc. These templates are standardized throughout the network and can be modified as a whole if necessary. **Figure 2** is an example of a simulation note with drop down boxes. The simulation template allows the therapist to create a document specific to the physician orders and the specific simulation that was performed including such things as the type of immobilization, use of contrast media, full/empty bladder, etc. These documents are ultimately approved by the physician, and become a permanent part of the EHR.

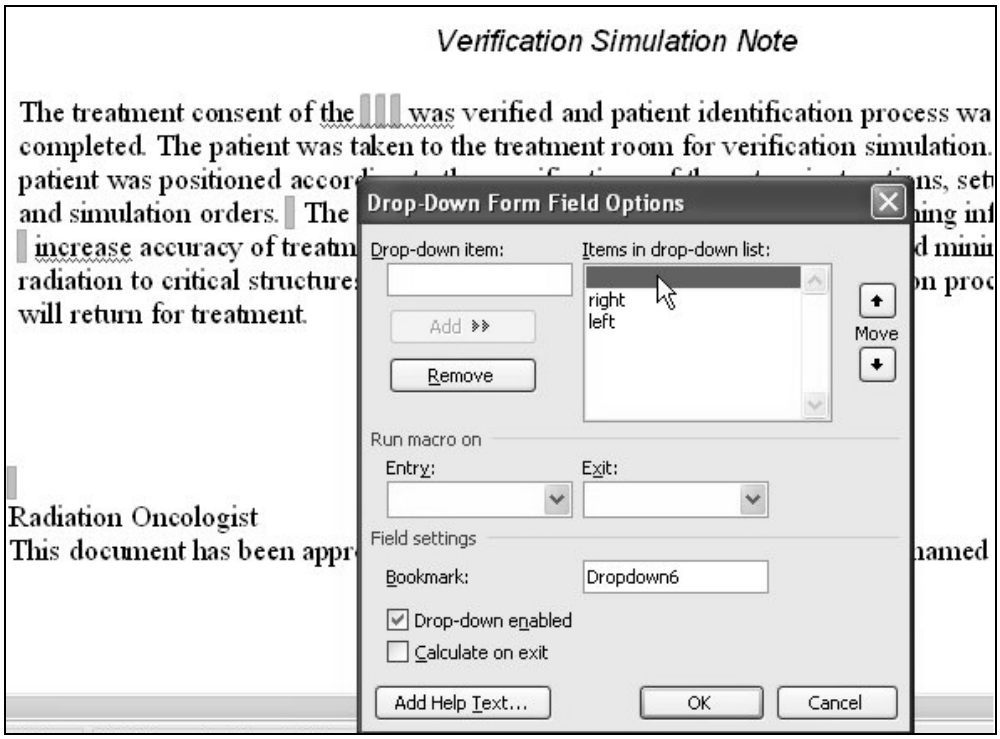

Figure 2. Simulation note with drop down boxes.

The use of such customized dictation templates has facilitated timely documentation and streamlined the overall transcription process. These templates also comply with standardized quality and billing guidelines which can be changed as regulations and/or standards change. The improved efficiency translated into one less full time employed position for transcription.

Clinical/Technical Assessments

Disease site-specific clinical and technical assessments were designed allowing for the prospective, real time collection of data (toxicity profiles, efficacy of treatment, quality of life, dose volume histograms, etc.) and for outcomes analysis. Disease site-specific clinical assessments are performed at the time of weekly on-treatment visits and are used to record acute toxicity (based on National Cancer Institute Common Criteria Toxicity) and treatment tolerability. Different follow up assessments were also developed to quantify subacute and chronic morbidity as well as oncologic outcomes such as overall survival and local control. These clinical assessments are performed by nursing staff, residents, and attending physicians and are ultimately approved by the attending physicians, becoming a permanent part of the EHR. **Figure 3** is an example of a thoracic malignancy clinical assessment performed weekly during radiation therapy.

doi :10.5166/jroi-3-1-16

ISSN: 1663-618X, J Radiat Oncol Inform 2011;3:1:3-11

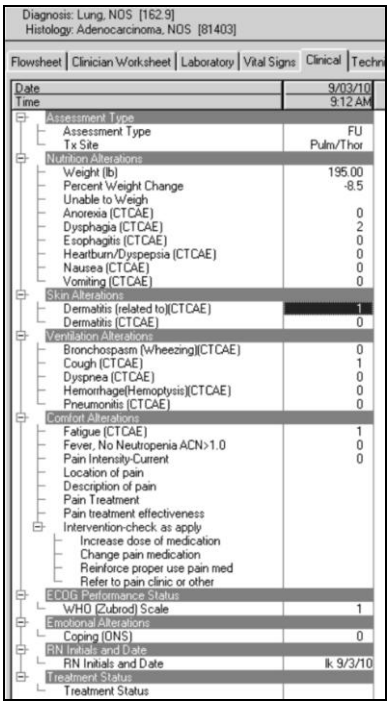

Figure 3. Weekly on treatment clinical assessment for thoracic radiation patients.

Disease site-specific technical assessments were also built into the system. These assessments cover a broad range of topics from pretreatment checklists that include tasks such as "correct patient and site verified" to disease site-specific dosimetric data. **Figure 4** is a screen capture of dosimetric data that are collected for the treatment of prostate cancer with external beam radiation.

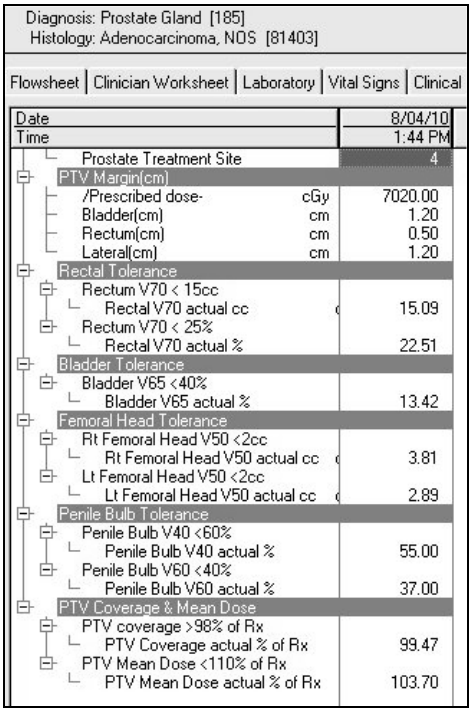

Figure 4. Dosimetric data for prostate external beam radiation.

doi :10.5166/jroi-3-1-16

ISSN: 1663-618X, J Radiat Oncol Inform 2011;3:1:3-11

Physician Orders

Disease site-specific order sets were developed to aid physicians in prescribing/ordering simulation and treatment related items. The order sets follow a general format including: 1) body site of simulation and scanning parameters; 2) treatment planning technique (e.g. 3-D conformal, IMRT, etc.); 3) patient setup information including type of immobilization (e.g. vac bag, belly board, etc.) and patient position (e.g. supine, prone, etc.); 4) contrast media (e.g. IV contrast, bowel contrast, etc.); 5) chemotherapy charges and; 6) type of image guidance (e.g. conebeam computed tomography, port films). These standardized order sets not only improve communication between physicians and the radiation therapists but also serve as documentation to justify charges for the billing of these procedures. **Figure 5** is a screen capture of physician orders for breast cancer patients treated with external beam radiation therapy across the network.

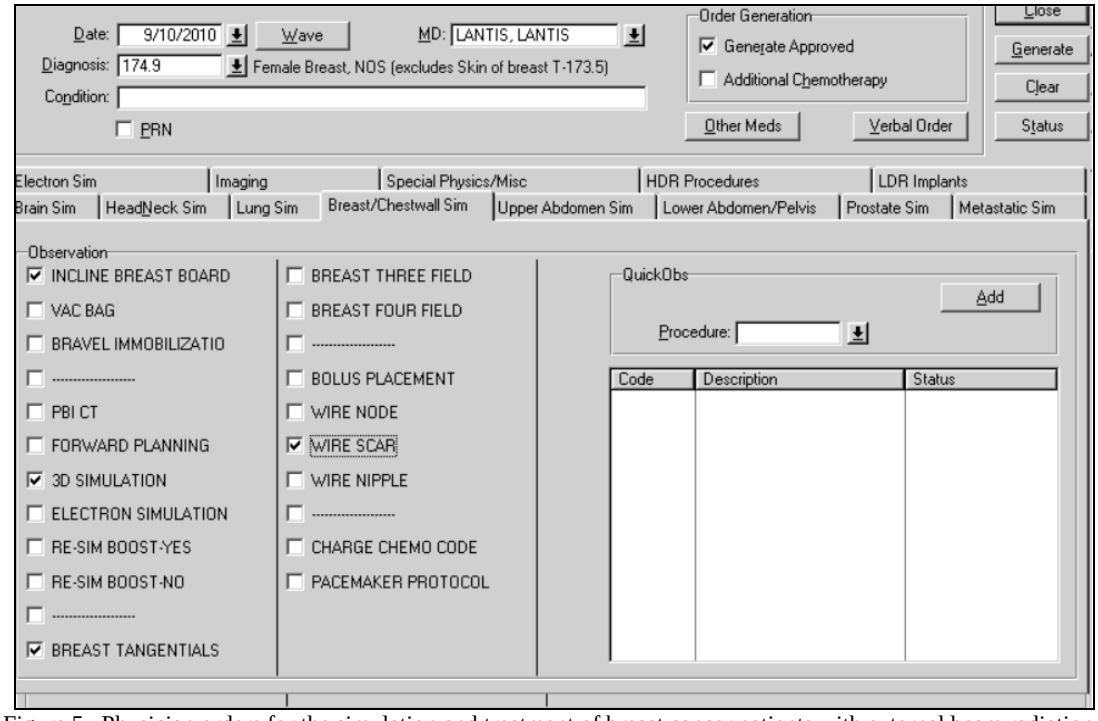

Figure 5. Physician orders for the simulation and treatment of breast cancer patients with external beam radiation.

Quality Assurance Pathways

Quality assurance pathways were developed via the quality checklist tool, resulting in more efficient workflow and improved patient safety and care. With this tool, specific tasks can be assigned to individuals. Completed tasks become part of the electronic health record after the responsible individual identifies it as finished. For example, once a 3D conformal CT simulation is performed, the simulation therapist creates a task for the physician requesting: "please draw volumes". Once the physician completes the volumes, the physician creates a task for dosimetry stating: "volumes completed; please begin planning". Such a process allows for more efficient workflow and minimizes the risk of miscommunication between staff.

An example of improved workflow and ultimately, improved patient care through implementation of an EHR quality assurance pathway was seen in high dose rate gynecologic procedures. Prior to use of this pathway, the average time for treatment of these patients (from time of simulation until treatment completion) was 1 hour. With implementation of the pathway, the average time improved to 30 minutes resulting in a more efficient workflow.

4. DISCUSSION

Implementation of a comprehensive EHR in radiation oncology is a daunting process and there is no perfect system. Electronic health records in radiation oncology must not only address the clinical aspects of patient care but also the

doi :10.5166/jroi-3-1-16

technical component of radiation treatment. Combining both of these components into a "hybrid" EHR is unique to radiation oncology. Nowlan *et al.* reviewed the Emory University School of Medicine Department of Radiation Oncology's experience with the implementation of a comprehensive electronic information system at a busy advanced department (8). They concluded that though transition to electronic records integration effectively streamlined treatment processes, there continue to be challenges as desires and technology advance (8).

Within our network, an EHR committee was formed to implement the EHR in an organized and efficient manner and also to continue to refine and improve it. Six modules were customized to the needs of the network to allow for efficient workflow, improved patient safety and to facilitate access to outcomes data and analysis. Real time data entry encompassing all patient information (from demographics to patient medications) allows for an up-to-date EHR. Proper training of staff to maximize proficiency on EHR use was a key step. Likewise, continued refining/upgrading of the EHR and ongoing training of the staff remain integral components of maintaining a useable, efficient system.

Implementation of this comprehensive EHR has resulted in more efficient workflow and improved patient safety and care. Examples of improved efficiencies include dictations that are reviewed and approved in a timely manner, electronic documents that can be directly faxed from the EHR, treatment plans which can be approved on-line, and access to a multiple user interface minimizing wasted personnel time in tracking paper charts. Standardization of prescription formats based on best known standards within the field and quality assurance processes further result in improved patient safety. Each of these tasks is recorded by the approving physician with time and date becoming a permanent part of the EHR.

The EHR within our network is comprehensive and has resulted in significant improvements in documentation and management **(Table 1)** but needs continued refinement and has some limitations. Barriers to acceptance include initial and ongoing training of department staff and physician buy-in towards more standardized practices/habits with real-time data entry.

Table 1. Results of EHR Expansion

- Incorporate standardized quality guidelines in multiple clinical, technical, education and management areas.
- Capture patient information at consult, during radiation treatment planning and delivery, and in follow-up
- Capture real time patient information related to efficacy, toxicity and quality of life
- Improve patient care by facilitating timely and accurate review of patient treatment information
- Facilitate documentation
- Multiple user interface minimizes tracking of "missing" charts
- Control and improve the transcription process
- Improve accuracy and reliability of point of service billing to reduce reimbursement denials

Furthermore, a significant limitation to our current EHR is the lack of direct interface with the hospital-based EHR, the Picture Archiving and Communication System (PACS) and with our treatment planning system. Currently, the EHR functions as a record and verify system and recognizes beam data at the linear accelerator but does not directly communicate with the treatment planning system for plan review. Only selected screen captures of patient plans from the treatment planning system are placed into our EHR for review and physician approval. However, review or modification of complete plans, can only be performed within the treatment planning software. Similarly, data within the hospital-based EHR and images in the PACS system reside in alternative computer interfaces. Work within our network is focusing on creating interfaces to integrate the radiation oncology EHR with these other databases and is an ongoing issue that has been previously reported (11,12). As these and other similar systems mature, we expect that interfaces to such resources as automatic updates of medicine formularies and the International Classification of Diseases (ICD-9 codes) will be included.

Image storage is an ongoing issue facing all advanced radiation oncology departments. In the past decade as advanced treatment modalities have emerged (such as IMRT and IGRT), there has been an exponential increase in the volume of data sets per patient. For example, over a recent two year period on a single linear accelerator, we accumulated nearly 2 terabytes of patient imaging data from 250 patients and 4,000 scans. Storage and retrieval of these data sets continues to

doi :10.5166/jroi-3-1-16

ISSN: 1663-618X, J Radiat Oncol Inform 2011;3:1:3-11

be an issue. Older techniques of storing on tape or optical disc are impractical and inefficient. Future storage solutions will likely revolve around a radiation oncology-specific PACS system allowing for efficient storage and retrieval of images with large amounts of storage capacity that communicates with the radiation oncology EHR.

There are currently no international standards for a specialty specific EHR such as that required in the practice of Radiation Oncology. The unique demands for a record and verify system, control of treatment machines, access to the treatment planning system, customizable real-time data acquisition, ease of data base accession and integration within the hospital-wide EHR make a comprehensive radiation oncology EHR difficult to achieve. While several commercial radiation oncology EHRs are available and offer improvements over the extended LANTIS footprint that we have developed, there does not yet appear to be an EHR in this specialty that addresses all of the issues we have raised.

The International Organization for Standardization has published recommended Health Informatics standards (Technical Committee 125) but these deal principally with a hospital wide EHR that does not address with the specifics relating to radiation oncology practices and integration with the hospital EHR (http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_tc_browse.htm?commid=54960). Recently, the Commission for Health Information Technology, a nonprofit organization recognized by the United States government as an official organization for health information technology, has begun work on a comprehensive oncology EHR certification program but its initial focus will be for medical oncology rather than a comprehensive process involving radiation oncology as well (personal communication, July 14, 2010, EDW).

5. CONCLUSIONS

Development of a comprehensive EHR across a radiation oncology network is feasible and can be customized to promote clinical/technical standards, improved patient safety, facilitate outcomes studies, and improve communication and peer review. Despite its shortfalls, the development of this comprehensive electronic chart has enhanced patient care and network integration across a multi-facility radiation oncology system. Current challenges include providing a direct interface with other databases/systems (such as the hospital-based PACS system and the radiation treatment planning system) and providing an efficient, expandable image storage system (likely in the form a of radiation oncology specific PACS system) that is linked to the EHR.

Acknowledgements
The authors would like to acknowledge Linda Meyer, RN for her work on the EHR.

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doi :10.5166/jroi-3-1-16
ISSN: 1663-618X, J Radiat Oncol Inform 2011;3:1:3-11