

Contour once. Contour everywhere.

4D multi-modality simulation—made easy. More data. Less work. Now you can do 4D multi-modality contouring in one pass—with AdvantageSIM MD from GE Healthcare. This exclusive software is the first of its kind. It displays the images you need on one screen—PET, CT, MR, even 4D images of tumors in motion—and provides revolutionary tools to help you define the target volume. Trace one image, and you've traced them all. Radiotherapy planning has never been faster or more precise. **Oncology Re-imagined.**

To learn more visit www.gehealthcare.com/re-imagine



GE imagination at work

Picture Archiving and Communication Systems as an Element of Digital Information and Image Management in Radiation Oncology

a report by

Volker Steil,¹ Gerald Weisser,² Frank Schneider,¹ Frederik Wenz¹ and Frank Lohr¹

1. Department of Radiation Oncology; 2. Department of Radiology, University Medical Centre Mannheim, University of Heidelberg

DOI: 10.17925/EOH.2007.0.1.103

After the introduction of stereotactic precision radiotherapy and intensity-modulated radiation therapy (IMRT) on a broader scale in the late 1990s and early 2000s, the complexity of RT treatments has increased dramatically. Contrary to the US, where substantially raised reimbursement covered for the extra workload, in Europe these techniques were introduced with virtually no extra reimbursement. In addition, patient load per machine and department did not decrease, but rather increased at the same time. While computed tomography (CT) images for treatment planning and planar images for position control of the patient have long been a part of clinical RT, volume-based image-guided RT (IGRT) was introduced recently and opens new possibilities. The seamless integration of all this technology into the RT workflow can be accomplished only by an electronic data management system that manages RT data, patient data and image data in a patient-centred fashion, combining features of electromagnetic radiation (EMR), RT record and verify (R&V) systems and, finally, radiology information system (RIS)/picture archiving and communication system (PACS). This review will describe the workflow in a modern RT department, as well as strategies to accomplish a fully paper and film-less environment.

Workflow in a Radiotherapy Department (as Opposed to a Radiology Department)

Workflow in a diagnostic radiology department is a comparatively linear, straightforward process centred on imaging studies. Tools to organise diagnostic workflow electronically are readily available. In essence, three major components are necessary:

- basic scheduling functionality for managing patient appointments based on digital imaging and communication in medicine (DICOM) worklists;
- a PACS for online, near-line and offline long-term storage of DICOM images – otherwise these images are rarely manipulated or processed; and
- an RIS for managing/storing/distributing reports related to the images.

Workflow in an RT department, on the other hand, is a lot more complex and is closer to that of a surgical department than that of a diagnostic department. This is because, typically, a series of more or less invasive procedures have to be planned, performed and documented. Scheduling is more complex due to the need for the patient to undergo a defined series of procedures that have to be performed in a certain timely sequence (DICOM worklists are not 'designed' for these periodically repetitive appointments). The basis for treatment planning is typically a CT data set. These data are further manipulated in the process. DICOM-RT elements such as RT structure set (organ/target structures), RT plan and RT dose (plan data and dose information) are generated – typically in a dedicated treatment planning system – and have to be unequivocally linked to the basic CT image

data and, finally, stored for long periods. After initiation of RT, different classes of data have to be documented and stored, such as machine data directly associated with the treatment – field configurations, applied daily and total dose, any changes to the treatment concept, daily clinical notes (non-DICOM), patient images such as identification (ID) photos or set-up photos (DICOM), images for verification of patient position, incoming reports, new treatment plans, etc. New CT data sets may be acquired or new treatment plans may be generated on initially acquired CTs. In these situations, feedback loops are created that have to be supported by an integrated data management system. Ideally all relevant clinical information is available in such a system, including clinical notes from the wards.

Since such a system has to be patient-centred rather than procedure/study-centred, unequivocal association between each data set and a certain patient is of the essence. Input of primary personal data under control of the leading hospital information system (HIS) is therefore necessary, and manual creation of patient root data should be avoided.

While accessibility of these data within the department is equally important for a diagnostic and a RT department, management of access rights of RT data from outside the department is less important than for a diagnostic PACS system, because most of the RT data are not of interest for other departments. Data that have to be shared can therefore be delivered to and then distributed by dedicated central servers.

As a consequence, disadvantages when using diagnostic RIS/PACS systems in radio-oncology are:

- dispersal of the information to several systems;
- working on different applications for the same patient (difficult data mining);
- session numbers are not created within the radio-oncology workflow;
- DICOM RT objects are stored in a study/examination-related archive structure; and
- it is difficult to match/associate therapy/target-related objects in those DICOM files.



Volker Steil is the Head of the Medical Physicist Group in the Department of Radiation Oncology at the University Medical Centre Mannheim, University of Heidelberg. From 1983 to 1988 he was the Junior Medical Physicist at Hospital Nordwest, Frankfurt. He then moved on to become the Medical Physicist at the Hospital Elisabethen, Ravensburg, in 1988. In 1990 Dr Steil became the Medical Physicist in the Department of Radiation Oncology of the University Medical Centre Mannheim.

Data Classes to be Handled in a Radiotherapy Department

- RT data, generated at/by the treatment machines, in most RT departments, now already handled electronically by an R&V system that is therefore the natural backbone of an RT department information system.
- Patient/clinical data as free text or as quantitative data to be stored in and retrieved from a structured database (functionality typically provided by an EMR).
- External documents provided by the patient, referring doctors or other departments, also handled by an EMR.
- Non-DICOM images, such as patient ID photos, set-up photos at the treatment machine, selected images such as excerpts from radiological studies, histology slides, etc., also preferably handled through an image-enabled EMR.
- DICOM image data such as treatment-planning CTs, including DICOM RT objects, localisation films/images acquired at the accelerator and, increasingly frequently, three-dimensional (3-D) volume image data sets directly acquired at the accelerator.

Legal Requirements with Regard to Electronic Radiation Therapy Data Management

Legal requirements for a PACS in RT or in RT department information systems mostly mirror but typically also exceed the requirements for RIS/PACS systems. While requirements with regard to data integrity, data safety and data storage in general are similar, mandatory storage times for RT data are typically longer than for diagnostic data. In any case, a good strategy to conform with data integrity and readability requirements is to resort to widely distributed data formats such as DICOM for images and portable document format (PDF)/standard Office software files for other data. These formats are likely to survive for the foreseeable future, or appropriate conversion tools will be available should a different standard arise. In addition, the amount of data that

...a fully redundant system with spatially separated mirrored servers is mandated to provide data safety in a fully film- and paper-less environment.

has to be stored is greater, typically including all data that are necessary to fully reconstruct RT treatment. Among these data are treatment planning CTs, treatment plans, documents that provide the basis for the treatment decision, etc. A crucial point is also the approval of different steps of the treatment (treatment plan, patient set-up, completion of treatment, regular checks of patient position with imaging devices) by physicists and physicians. Approval management has to conform to local regulations. A typical requirement for integrated RT department information systems within this framework is the existence of independent logging of all activities within the system and written standard operating procedures clearly defining individual rights, consensus on mode of operation of the system, etc. A critical point not completely resolved is the handling of documents with legally binding signatures that cannot be replaced by access right management. Among these are, above all, informed consent forms for which most legislatures

would require electronic signatures by patient and physician if intended to be stored only electronically, with downstream requirements such as frequent recertification of the database, etc. For the time being, with clear jurisdiction on this issue lacking, it is probably prudent to still store such documents in paper form.

...it is crucial to have all profession groups (physicists, physicians, radiation therapists) participate in designing the system and the workflow.

Possible Hardware and Organisational Architecture of a Radiotherapy Department Information System

As a consequence of the nature of the RT work flow, the data classes to be dealt with and the legal requirements outlined above, it becomes clear that an ideal RT department information system:

- is governed by an HIS as the leading system, providing patient root data and controlling data exchange with other hospital data servers;
- is patient-centred and has a reliable, powerful R&V system recording the most important treatment data at its core;
- has the added functionality of an RIS for patient scheduling and report management;
- has the added functionality of a PACS, including storage and processing of DICOM RT objects, unequivocally linked to a specific patient and a specific treatment;
- has the added functionality of an EMR to link clinical data to image and treatment data; and
- can be accessed by all relevant functional units of the department, such as treatment-planning CT, treatment-planning systems, treatment machines and imaging devices.

As far as hardware is concerned, a fully redundant system with spatially separated mirrored servers is mandated to provide data safety in a fully film- and paper-less environment. To ensure flexibility and scalability of such a system, storage systems that can easily be scaled to the increasing storage need of a department such as storage area networks (SAN) should be considered. Especially when image management represented by a PACS is to be integrated into an existing R&V system, a diligent assessment of existing PC clients with regard to their capabilities to handle large amounts of image data has to be performed, and substantial investments in this part of the infrastructure have to be foreseen. When full EMR functionalities are to be included, the acquisition of several high-speed document scanning devices, to be placed in all parts of the department where documents are received from patients, should be initiated.

With such a system, a paper- and film-less workflow can be established, with data segmentation between databases, where all relevant data created before, during and after an RT treatment can be distributed between an EMR database and a PACS database. This is managed by a control platform integrating these two systems, so that all data can be accessed with unequivocal reference to a single patient everywhere through one system.

Advantages of using such an integrated, DICOM-based system are:

- exploring the real data with DICOM RT viewing capabilities instead of resending the DICOM files back to origin-generated source; and
- recovery of data sets from previously treated patients is not limited by different data formats.

Strategies for the Transition from a Paper/Film-based Workflow to a Paper/Film-less Department

While in a new department all processes can be controlled directly by the electronic department information system without problems, the situation is different for the transition to information technology (IT)-based data management in an existing department. The first step in this situation should be a realistic assessment of the financial and personal resources that could be allocated to such a project, with the consequence of tailoring the timeframe/scope of the transition to the individual means of the department.

To ensure continuity in the daily routine and reduce potentially dangerous incidents due to abrupt changes, whenever possible it is prudent to emulate as closely as possible the previous paper- and film-based workflow that had proven efficient. To shed light on all aspects of the transition as well as to discuss all potential obstacles and prevent

frustration, it is crucial to have all profession groups (physicists, physicians, radiation therapists) participate in designing the system and the workflow. This is a dynamic process that will ideally create enthusiasm for further participation in the improvement and development of the department.

Conclusion

Patient-centred digital data management, including treatment machine data, text data ('patient file functionality') and image data, is one of the major organisational challenges for a modern radiotherapy department. Major emphasis must be put on creating a stable environment that accelerates workflow and conforms to local legal requirements and regulations. In an existing department, a step-wise transition from paper/film-based work flow to a paper/film-less environment involving all professional groups in the department is recommended. Although such a functionality is also possible with different subsystems (RIS/protocol and verify) with a conventional radiology PACS being able to store all DICOM data (including the DICOM objects), a dynamic interaction with EMR and DICOM images during the treatment is not possible unless an integrated system (oncology PACS), as suggested in this review, is used. For long-term storage, all data can ultimately be transferred to a central PACS. ■

<p>1. Schwarz M, Scielzo G, Gabriele P, Implementation of an integrated 'record and verify' system for data and images in radiotherapy, <i>Tumori</i>, 2001;87(1):36-41.</p> <p>2. Nagata Y, et al., Development of an integrated radiotherapy network system, <i>Int J Radiat Oncol Biol Phys</i>, 1996;34(5): 1105-11.</p>	<p>3. Starkschall G, Design Specifications for a Radiation Oncology Picture Archival and Communication System, <i>Semin Radiat Oncol</i>, 1997;7(1):21-30.</p> <p>4. Mansens, JP, L'échange de données médicotéchniques en radiothérapie: les besoins, les méthodes et les limites actuelles, <i>Cancer Radiother</i>, 1997;1:524-31.</p>	<p>5. Van den Berge DL, Ridder MD, Storme GA, Imaging in radiotherapy, <i>Eur J Radiol</i>, 2000;36(1):41-8.</p> <p>6. Maria YY, Law HK, Huang, Concept of a PACS and imaging informatics-based server for radiation therapy, <i>Comput Med Imaging Graph</i>, 2003;27:1-9.</p>
--	---	---

what are you waiting for?

IMPAC combines a complete image enabled oncology medical chart, capable of streamlining advanced therapies regardless of equipment, with fundamental patient administration, workflow management and flexible reporting features. The result is a system that actually increases staff productivity yet still promotes quality patient care.

Patients no longer have to wait, why should you?

MOSAIQTM

management information system



www.impact.com +44(0)1293 654 320

managing the spectrum of cancer care