Introduction

The availability of accurate information and its efficient management is crucial for quality patient care. Organizing and communicating the vast amounts of information generated in radiation oncology presents a great challenge. During the last two decades, radiation oncology has witnessed great technological advancements. Nowadays, we deal with huge amounts of diagnostic information, complex treatment planning, accurate dose calculations, and very complicated treatment delivery information. For precise treatment in radiation oncology, a comprehensive information management scheme has become essential for the storage and rapid retrieval of the enormous amounts of information.

The need for management of medical information to provide better patient care, effective medical education, and research has given rise to a new subject known as medical informatics. Medical informatics deals with the acquisition, storage, retrieval, and optimal use of medical information for problem solving and decision making. Information data sets and interfaces between different disciplines are combined by medical informatics. It also involves understanding the evolving technology and relationships and standards by which this information can be managed. Radiation therapy treatment incorporates many facets of modern medical informatics. Medical professionals work closely together, using computer-controlled equipment, and use large amounts of patient and machine data for optimization of the complex techniques in treatment planning, delivery, and verification. The information system (IS) provides the main base for communication, documentation, and quality control by integrating all necessary data/images in a seamless, reliable, and efficient manner. The IS also provides the capability for numerical and statistical analysis of this wealth of data. Modern electronic IS are built on networks of computers connected in complex arrays, running sophisticated software, to ensure transparent and seamless information availability to the users. Investment of human and capital resources in...
IS and networks is an essential and continuing process for improving patient care in radiation oncology.

**INFORMATION COMPONENTS IN RADIATION ONCOLOGY**

Radiation oncology consists of following information components:

**Patient information**
- Patient profile
- Patient history
- Disease status
- Diagnostic (D) data
- Treatment plan
- Simulation data
- Treatment planning data
- Physics data
- Treatment (T) data
- Treatment verification data
- Radiation biology data
- Follow-up information
- Record/billing/discharge

**People**
- Radiation oncologists
- Radiological physicists
- Radiation therapy technologists
- Nursing staff
- Receptionists

**Equipments**
- Diagnostic equipment
- Simulation equipment
- Treatment planning system (TPS)
- Treatment equipment
- Treatment verification equipment

In networking, hardware and software provide a medium through which systems and individuals can communicate. A complete IS for radiation oncology manages information through data acquisition, presentation, communication, storage, and retrieval. The IS must guarantee that all the resources will be available as and when necessary for the delivery of effective, efficient, and compassionate patient care. The IS comprises various information objects.

**Information objects**

There are a large number of information objects involved in radiation oncology. These objects can be grouped into different categories according to the major task or event they are related to. Availability of these information entities may be required at various stages of the radiation therapy process. Each of these objects could be further subdivided into basic information pieces of patient events.

Figure 1 highlights the specific information objects used in radiation oncology. Diagnostic data may include volumetric and spatial data sets from magnetic resonance imaging (MRI), computed tomography (CT), positron emission tomography (PET), radiography, mammography, etc.; it also includes report data in text form and laboratory results. This massive amount of information is required to localize target volume and organs at risk (OAR) to develop a treatment strategy that will deliver the prescribed therapeutic dose to the target, while restricting the dose to the OAR to the minimum. Patient information includes patient profile, history, disease status, and the management plan derived from interaction of the patient with the consulting radiation oncologists and referring physicians; this is necessary for the selection of the appropriate patient-specific treatment approach. Therefore, the patient data may have many sources, including those outside the department of radiation oncology. A qualification test to determine which therapy technique best meets the patient’s need is also part of the record. Using all this diverse information, the treatment regimen is then defined. The simulation step may include combining diagnostic and patient data with specific geometry goals and the constraints of the therapy delivery system. Adequate information is gathered for the treatment planning as per the ICRU-50 recommendations.\(^{[9]}\)

Treatment planning brings the simulation and imaging information objects together with treatment machine/device characteristics. This allows the therapy team to develop a computer-based treatment plan with optimized distribution. Whether it involves forward or inverse planning and fixed or dynamic technique, the planning system must aim to realize the treatment goal and must specify all treatment and reference information related to the accurate and safe delivery of the desired radiation dose.

Whether the treatment delivery method is traditional physical compensation, custom micro-collimation, tomotherapy, dynamic collimator, or dynamic multi-leaf collimation, detailed information must be provided accurately and efficiently to the treatment machine/device. The new treatment techniques like intensity-modulated radiation therapy (IMRT), image-guided radiation therapy (IGRT), etc., are completely dependent on computers for planning, treatment, and verification. However, even simple conventional radiation therapy based on wedges or tissue compensators requires detailed information for compensator design and orientation. In every case, the treatment plan must be verified for its accuracy and safety. This includes verification of the treatment devices (record and verify), the radiation field geometry (portal imaging), and dosimetry. The computer-controlled treatment delivery must be fail-safe. Finally, dose record, details of treatment, and billing information must be captured in an organized manner. All personnel related to the treatment delivery are components of the information needed to complete a successful treatment. In radiation oncology, the active involvement of all the staff is required and must be incorporated in the IS. Quality control and quality assurance remain critical components of each step of the process. As therapy becomes more complex and intensive, data integrity, clear communication, and accurate...
devices become more important. The scheduling component must be able to reconcile complex schedule data from multiple sources, so that all information and personnel are available when needed to deliver the best possible patient care. Thus, the availability of coordinating staff, treatment machine, and all patient-specific data must be integrated.

Information integration
The pieces of key information objects, as described in Figure 1, exist in most radiation oncology facilities, but they are rarely integrated. The goal of the IS is to integrate all of these objects in an effective manner as indicated in Figure 2. This figure shows the integration of each component to form a perfect and regular information geometry. Any missing key information object or a misfit key can distort this perfect information geometry and shape. The organization of these information objects, their definitions, the communication formats, and connecting pathways forms the IS.

The simplest version of the IS is the manually movable paper patient file. This IS contains each of the information objects mentioned above, usually separated into sections. Pen, paper, and sneakers represent the communication web and all data relevant to the patient treatment is available in the patient chart. Manually movable patient file systems have the following limitations:

• Time consuming
• Require large amounts of human resources and space
• File retrieval process is not unique
• Information entries are nonuniform, individual dependent
• Messy
• Difficult to maintenance
• Possibility of unauthorized handling
• Information can often go missing
• Can not be operated remotely
• Chances of destruction of information

Electronic IS have been developed to reduce error, increase efficiency, automate recording, and organize large amounts of data.[5] The rapid advancements and decreasing costs in computer technology have boosted the use of IS in radiation oncology for patient care. Computer-controlled radiation therapy systems have been described by Fraass et al. and Burman et al.,[7,4] but these systems only encompass a portion of the informatics problem. The IS must integrate and communicate all data/information necessary for the radiation oncology patient to receive a complete treatment. Many of the issues related to IS in radiotherapy have been discussed partially in PACS,[5,6] electronic medical record,[7] and IS.[8,9] Whereas, the complete IS should have all the jumbled pieces of information integrated together in an organized fashion. Anderson has described the social, ethical, and legal aspects of e-health.[10] Bakker explored the need for possibility to reconstruct electronic medical data for health care professional at a specified moment in the past.[11] He has also described the differences between digital patient data and paper records. Linden et al. described the aspects of a multidisciplinary electronic health record system.[12] Andrade et al. explored the strategies to access digital imaging and communications in medicine (DICOM)–compliant medical data on mobile devices.[13]

DESIGNING AND DEVELOPMENT OF A RTPIS
A radiation oncology patient information system (IS) has been developed using open source software. PHP and JAVA script have been used as the programming language, MySQL database, and HTML and CSF as the design tool. This system runs through typical web browsing technology using a WAMP5 server.

DESCRIPTION OF THE RTPIS SOFTWARE
Opening the system
The radiation oncology patient management system can be accessed by clicking on the Internet Explorer icon on desktop and then entering the http address of the server.

Log in
Once the system is opened the log-in page will be displayed [Figure 3], where any authentic user (having a unique user ID and password issued by the administrator) can access the RTPIS software.

User library
The user ID and password are issued separately for the administrator, radiation oncologist, radiation physicist, and radiation technologist according to their respective job responsibilities and accountability. Thus, users have limited ability to access or enter data in the IS, which is strictly decided by their job responsibilities.

Administration overview
The administrator provides the user ID and password to the new user. Administrator can also limit/edit/delete any user’s access by using the ‘User Management Button’ [Figure 4]. The special icons are also described.

Patient profile
The data on the patient profile can only be entered by the radiation oncologist. The patient profile form will be displayed by clicking on the ‘Create Patient File’ button. The name, age, sex, occupation, address, department no., consulting radiation oncologist, radiological physicist, date of first visit, referring hospital, diagnosis, and stage of the disease can be entered in this form [Figure 5].

Patient history
After submitting the patient profile, the patient history form will be displayed [Figure 6]. Only the radiation oncologist can enter the information in this form. Patient history and
Figure 1: Key information objects in the radiation oncology department

Figure 2: Integration of key objects in the radiation oncology department

Figure 3: Log-in page

Figure 4: Administrator overview

Figure 5: Patient profile input form

Figure 6: Patient history input form
examination findings, such as general condition, pulse, temperature, blood pressure, information regarding the primary, lymph node, metastasis and treatment management are entered in this form.

**View patient profile and patient history**
Once the patient profile and patient history has been entered properly, only then is the patient registered in the system.

The patient list can be displayed by clicking the 'View Patient' button [Figure 7]. The patient profile and patient history of any patient can be viewed by clicking the 'Click Here' button against the particular patient.

**Investigation**
This form will appear by clicking the 'Create/Manage Investigation' button [Figure 8]. This form is exclusively

![Figure 7: List of the patients](image1)

![Figure 8: Investigation input form](image2)

![Figure 9A: Simulation information input form](image3)

![Figure 9B: View simulation page](image4)

![Figure 10A: Dose prescription messages](image5)

![Figure 10B: Dose prescription input form](image6)
entered by radiation oncologist. Biopsy, x-ray, CT scan, and MRI investigations reports, along with the relevant dates, are entered in this form. Similarly, routine blood investigation results are entered after clicking on the ‘Create Blood Picture’ button.

**View investigations**

Investigations can be viewed in tabular form by clicking on the ‘View Investigation’ button and, similarly, the blood picture by clicking the ‘View Blood Picture’ button.

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**Simulation**

Simulation information of patient is incorporated by opening the ‘Create Simulation’ [Figure 9A]. Simulation images are uploaded in the simulator workstation by simple file browsing. Simulation parameters like field description, technique, collimator angle, gantry angle, and field size are entered as necessary. Simulation images of the final planned portals and related description of the portal are viewed by ‘View Simulation’ button [Figure 9B]. The simulation data can only be entered/edited by the radiological physicist or

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*Figure 10C: View dose prescription in tabular format*

*Figure 11: Physics calculation messages*

*Figure 12: Portion of daily treatment record sheet*

*Figure 13: Brachytherapy information page*

*Figure 14: Radiation biology information page*

*Figure 15: Follow-up details page*
radiation oncologist by using the ‘Create Simulation’ button, but all users can view it in tabular form by using the ‘View Simulation’ button.

**Dose prescription**

The next module of patient management in radiation oncology is dose prescription. A web page displaying the patient information and simulation image is opened by clicking the ‘Dose Prescription’ button, where a ‘Click Here for Dose Prescription’ message is displayed against each simulated final field [Figure 10A]. The ‘Dose Prescription’ button will only be active for the radiation oncologist. In the dose prescription form [Figure 10B], tumor dose, number of fractions, dose/fraction/field, technique, gantry angle, collimator angle, wedge description, shielding description, treatment unit, patient separation, and instruction to the therapy technologist are entered. The dose prescription can be viewed in tabular form [Figure 10C] by any user by clicking on the ‘View Dose Prescription’ button.

**Physics calculation**

This is a typical radiological physicist area in radiation oncology. The radiological physicist opens the ‘Physics Calculation’ web page [Figure 11], which consists of patients’ basic information dose prescription information and message for each field ‘Click here for Physics Calculation.’ In the physics calculation form, the physicist enters the physics parameters such as equivalent square field, output, percentage depth dose/tissue air ratio, tray factor, wedge factor, tumor dose rate, and treatment time. The physics calculation can be viewed in tabular form by any user.

**Daily treatment record sheet**

The daily treatment record is entered specifically by the radiotherapy technologist. This web page is opened by the technologist during treatment by clicking the ‘Daily Treatment Record’ button. This page consists of basic patient information, dose prescription, physics calculation, previous daily treatment information in tabular format [Figure 12], and an empty form for information on the fraction being delivered that particular day. In this empty form the technologist enters the intended and measured tumor dose for each field, the cumulative intended and measured tumor dose, and the number of fractions in days.

**Brachytherapy**

Brachytherapy is a part of the patient management system and the brachytherapy information is entered by filling the brachytherapy form [Figure 13], where the date of application, total dose, dose prescription point, and total treatment time are entered.

**Radiation biology**

Radiation biology information is very useful for assessing the treatment efficacy, to predict the treatment outcome, and for comparison of treatment regimes. The received biological effective doses (BEDs) for acutely-reacting tissues BED (10) and late-reacting tissues BED (3) are effectively calculated and entered in the radiation biology form [Figure 14] by the radiation oncologist or the physicist.

**Follow-up**

Follow-up details are entered by the radiation oncologist [Figure 15], where the date of follow-up, disease status, and normal tissue complications are entered.

**Print summary**

In this system a ‘Print Summary’ option is available. This button will be active only for the radiation oncologist. This option allows the radiation oncologist to get a single-page treatment summary of a patient, which will have patient details, external beam radiotherapy information, brachytherapy information, and follow-up information. This printed summary can be used for referral, documentation, audit, and research purposes.

**CONCLUSION**

We have developed a simple and indigenous radiation therapy patient information system (RTPIS). This system is instantly accessible by any authentic user through a simple web browsing procedure. All types of users in the radiation oncology department will find this system to be very user-friendly. The maintenance of the system does not require large amounts of human resources or space. The file storage and retrieval process is very satisfactory, unique and uniform. By sharing this software through a wireless local area network (LAN), it may be possible to create a clean, smart, and paperless department. There would be very little possibility of accessing the data in this system by an unauthorized person. The information can be stored in a double server, which will minimize the risks of loss or accidental destruction of information. This system can be uploaded on to the internet through a LAN, which will make it possible for an authorized user to operate this system from anywhere in the world.

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**REFERENCES**


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