Radiation Oncology Digital Image Chart System (RO-DICS) at Samsung Medical Center

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Samsung Medical Centerの放射線腫瘍デジタル画像病歴システム

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われわれはオーダーエントリシステム(order communication system: OCS)電子カルテシステム(electronic medical record system: EMRS)腫瘍登録システム(tumor registry sysytem: TRS)の3つの主要なシステムからなる総合放射線治療管理システム(comprehensive radiation oncology management system: C-ROMS)の一部として放射線治療デジタル画像病歴システム(radiation oncology digital image chart system: RO-DICS)を開発した．RO-DICSはSamsung Medical Centerのイントラネット型病院情報システム(hospital information system: HIS)の1構成単位である放射線治療科の21台のパソコンを使って1998年2月より使用してきた．1998年6月まで、468人の患者の2005個のイメージを貯蔵して利用している．RO-DICSの基本コンセプトは治療放射線科内全体でより効率的かつ迅速に必要な画像情報のやりとりをするための放射線治療患者の電子画像データベースを構築することにある．RO-DICSはWindows 95(OS)のデルファイ・システムによりプログラムされており，患者確認のための顔写真，シミュレーション・フィルム，照射のセットアップ，病巣の肉眼所見，放射線診断写真，線量分布図を表示することができる．われわれはRO-DICシステムが放射線治療科内全体に手書きの病歴を運搬することなく容易にかつ瞬時に重要な視覚情報が提供されることにより，時間や資源の節約になるとともに放射線治療のサービスに貢献することを確信している．

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Introduction

The extensive use of computers in routine radiation oncology (RO) practice has created a rapidly increasing need for departmental information and electronic medical record systems (RO-EMRS). Image integration into the patient database is a major requirement in current radiotherapy practice. Several commercialized radiation oncology information systems (ROIS), developed exclusively in Western countries, are widely used. As these foreign systems were not able to accommodate our departmental needs, in 1994 we developed our own ROIS, networked to the Samsung Medical Center (SMC) Intranet and named it the "Comprehensive Radiation Oncology Management System of Samsung Medical Center" (C-ROMS of SMC)[1]. The radiation oncology digital image chart system (RO-DICS) is a sub-system of the C-ROMS, which has three other main sub-systems: 1) an order communication system (RO-OCS), 2) RO-EMRS, and 3) a tumor registry system (RO-TRS). The SMC RO-DICS has been in clinical operation since February of 1998. This system is composed of a picture archiving and communication system (PACS, General Electric Co., Chicago, USA), a radiotherapy information database, and a radiotherapy imaging database. The system is user-friendly and has many advantages over foreign commercial systems with respect to language, culture, developmental concept, pattern of care of radiation oncology service, and medical insurance billing patterns in Korea. This article describes the hardware, system configuration, and clinical application of the RO-DICS.

Structure and System Description of the RO-DICS

The hardware of the SMC hospital information system (HIS) includes 4 main servers and several sub-servers. These systems operate on OPEN-VMS and UNIX systems, a relational database management system (RDBMS), networks composed of a fiber distributed data interface (FDDI) backbone and Ethernet, and more than 2,000 personal computer terminals[2].

The communication protocol used is a transmission control protocol/Internet protocol (TCP/IP). This basic infrastructure serves both the client-server mode and the terminal mode, and the client interfaces are either a graphic user interface (GUI) or a character user interface (CUI), depending on the characteristics of the electronic transactions. The C-ROMS is a unique type of ROIS and was developed by the authors as a subunit of the HIS of SMC. It may be categorized as utilizing a client-server mode with GUI applications. The C-ROMS deals with the complete database pertaining to patients' medical information, including personal identification and demographic information, history of hospital visits and admissions, disease information, physicians' order information, etc. The RO-DICS is characterized as an open system network designed for acquisition, storage, transmission, management, and display of digital images including, not only the diagnostic images, but also various types of images necessary for radiotherapy commencement (Fig.1). This system was programmed using Delphi 3.0 (Borland International, Inc., CA, USA), based on Pascal, and operates on Microsoft Windows 95. There are 21 personal computers linked to the local area network (LAN) in our department, all of which use Pentium-level processors, 32 megabyte (MB) random-access memory (RAM), and monitors of 1,024 x 768 resolution. The speed of image transmission is 10 megabytes per second (Mbps) between the client and server and 100 Mbps between servers. Twenty-one clients in the department are connected by Ethernet (10 Mbps) to the central image server (Sun Ultrasparc 1 workstation) of SMC. The image files are compressed to 0.1x using the Joint Photographic Experts Group (JPEG), the Graphics Interchange Format (GIF), or the Windows Bitmap file format (BMP) and forwarded to the image server. The types of images handled on the RO-DICS include simulation and portal images, patients' set-up photos, relevant diagnostic and other clinical images, radiotherapy planning images, and identification photos (Fig.2). Access to this system is strictly controlled by periodic authorization of identification numbers and passwords to prevent misuse and to protect the privacy of patients.

Clinical Application of the RO-DICS

The RO-DICS and the RO-EMRS have enabled simple and rapid communication of radiation therapy information. Furthermore, the systems can serve as an electronic chart containing an image database and detailed parameters of radiation beams, treatment setup, and scheduling. Diagnostic and radiotherapy planning images can be transferred from the SMC PACS and planning computer workstations to the RO-DICS using a file transfer protocol (FTP), while other images (simulation films, patients' photos for identification, and for setup positioning)

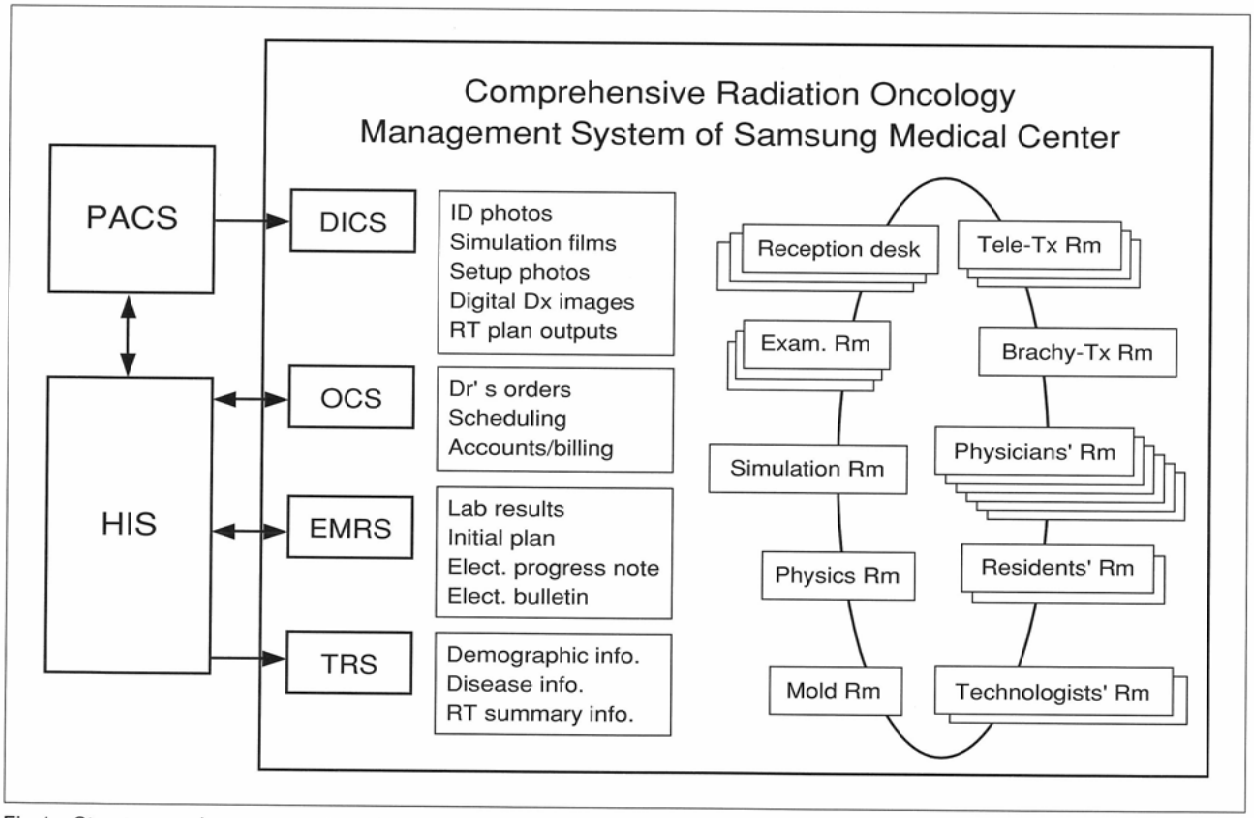

Fig.1 Structure and system configuration of the comprehensive radiation oncology management system (C-ROMS) with relation to the picture archiving and communication system (PACS) and the hospital information system (HIS). The C-ROMS consists of the digital image chart system (DICS), order communication system (OCS), electronic medical record system (EMRS), and tumor registry system (TRS). Twenty-one departmental personal computers are all networked to the HIS, PACS, and C-ROMS.

may be acquired either by digital cameras or scanners. The maximum number of images per patient during one course of radiotherapy is 30. If more than 30 images are necessary, a new folder for the same patient is easily created. Retrieving the RO-EMRS table (containing various text data, including patient position and pillow, source to skin distance, collimator and wedge filter settings, settings of collimator, gantry and table, daily and cumulative doses and monitor units) with the RO-DICS, physicians may organize radiation therapy in a paperless environment (Fig.2). Using this system, we have succeeded in the prompt and accurate communication of patient care information throughout the department, results which significantly decrease waiting time and which provide error-free radiation therapy delivery.

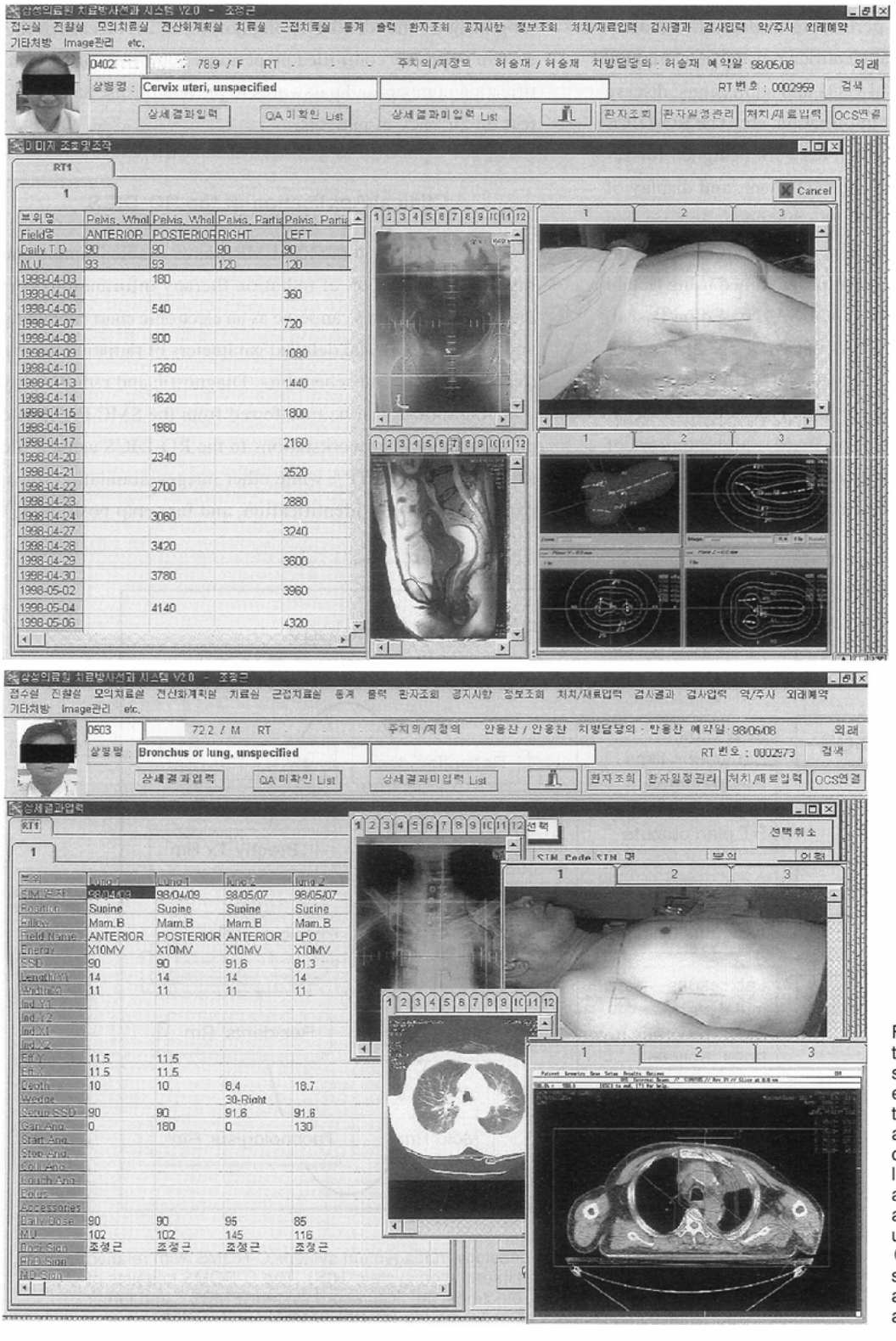

Fig.2 Examples of the radiation oncology digital image chart system (RO-DIC) with relevant electronic records of daily radiation therapy (RT) sheet as well as RT parameters for a uterine cervix cancer patient (A) and a lung cancer patient (B). The images included in the RO-DICS are identification photo (left upper corner), simulation films (left upper), treatment setup position (right upper), important diagnostic images (left lower), and RT plan output (right lower).

We have used the Sun Ultrasparc 1 workstation, which has an optical disk (OD) capacity of 88 disks (Hewlett Packard 120T jukebox), as an image storage server. Each OD has a storage capacity of 1.3 gigabytes (GB). Thus, the server maintains a total of 114.4 GB storage capacity. From the introduction of this system in February 1998 through June 1998, we have accumulated a total of 2005 individual images for 468 patients. Each image requires approximately 0.23 MB of storage space, totaling 460 MB of disk space currently occupied. We estimate an annual requirement of 1.7 GB of storage capacity. Thus, the Hewlett Packard 120T jukebox would be useful for 70 years.

Discussion

The handling and integration of various types of images by a single program for ROIS is the ideal for modern radiotherapy, but its commercial development is still in its infancy[3]. One of the difficulties with image storage and retrieval is that the majority of images are not digital to begin with. Consequently, either a switch to digital data collection (digital cameras, digital fluoroscopy, portal images, etc.) or additional manpower to transform non-digital images into digital formats is required. The authors have overcome this problem by the use of digital files through a file transfer protocol, and the use of digital cameras or scanners. There are only a few commercially available ROIS's, but it would be impractical to use these outside Western countries, especially in Korea, due to the great differences in billing system, language, and patterns of clinical practice. Moreover, none of the foreign systems has achieved adequate and prompt image information handling like ours. Perhaps the most promising advantage of the RO-DICS of SMC is its increased efficiency in handling all kinds of images used in routine radiation oncology. Once stored in the RO-DICS, physicians no longer need to be concerned about a set of hard copy films available for review in decision-making. Use of a digital chart of this kind provides multiple users with instant access to information simultaneously at independent work areas (patient examination room, physician's office, simulation room, control room of linear accelerator, physics room, and conference room). Image information is available whenever and wherever it is needed. Overall, the RO-DICS integrated into the hospital-wide information system has provided the radiation oncology team with an opportunity to increase the efficiency and quality of clinical performance.

The authors discovered that with the use of the RO-DICS system, informed consent from patients was more readily obtained, as image information could be used in helping patients understand their radiotherapy more easily. Additionally, advantages extend to education and training with the use of image databases. Furthermore, this system has several critical advantages over foreign commercial systems with respect to language, culture, development concept, the pattern of medical service delivery, as well as the expense of purchase and maintenance.

Conclusion

Using C-ROMS of SMC and RO-DICS, the authors have achieved decreased waiting time, not only for patients, but also for departmental staff. This increased efficiency has resulted in greater patient satisfaction with radiation oncology services and will provide physicians with the advantages of accuracy and resource savings. The authors strongly believe that the RO-DICS has a positive future in the practice of radiation oncology in Korea and countries with similar medical service environments. In further studies, the authors will analyze the effect of the RO-DICS and C-ROMS on radiation oncology practice compared with other radiation oncology departments of similar activity operating without this system. The authors' final goal is the paperless and filmless practice of radiation oncology.

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