Impact of an Electronic Chart on the Staff Workload in a Radiation Oncology Department

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Background: In order to improve the efficiency of patient care, we developed an electronic medical record system, named the Comprehensive Radiation Oncology Management System (C-ROMS). C-ROMS was used together with a commercial record-and-verify system, LANTIS (Siemens Medical Systems Inc., Concord, CA, USA). The impact of the C-ROMS/LANTIS system on the staff workload in the Radiation Oncology Department was quantified and evaluated.

Methods: Thirty-four breast cancer patients were divided into two groups based on the method of the charting and the delivery of radiation treatment. The paper chart and manual treatment were used for one group, and the C-ROMS/LANTIS for the other. For each group of patients, the workload per patient for each staff group in the department—nursing/clerical staff, simulation staff, dosimetry/physics staff and technologist staff—was measured and compared.

Results: The average total staff workload with the C-ROMS/LANTIS system was 28.2% less than that with the paper chart/manual treatment method. The workloads for nursing/clerical staff, simulation staff and technologist staff were reduced by 85.7, 61.2 and 20.6%, respectively. The workload for dosimetry/physics staff was increased by 28.4%.

Conclusion: The C-ROMS/LANTIS system significantly decreased the averaged total staff workload, and thus increased the efficiency of patient care.

Key words: Electronic medical record – radiotherapy – information system – record and verify – workload in radiation oncology

INTRODUCTION

The use of computers in radiotherapy has increased rapidly over the last decade. The computerized systems currently used in radiation oncology departments may be categorized into three types. The first is an electronic medical record system (E chart) that replaces traditional paper charts, the second is a record-and-verify (RV) system that verifies all treatment parameters for external beam treatment and automatically controls the linear accelerator set-up, and the third is a computerized treatment planning system. Among the three categories, the E chart and RV system have been integrated into most of the commercial RV systems. However, the electronic chart function in the commercial RV systems has the following limitations: (i) only the English language can be used; (ii) as such, difficulties arise in interfacing with the hospital information network and billing system, which is primarily done in the national language; and (iii) the system does not meet the specific needs of each department, such as statistical support. Therefore, although LANTIS (Siemens Medical System Inc., Concord, CA, USA), a commercial RV system, was implemented in our department, we developed our own electronic medical record system named the Comprehensive Radiation Oncology Management System (C-ROMS) (1–3). This in-house-developed electronic chart system was designed to meet the specific needs of our department while having all of the functions of a paper chart.

During the past 10 years, the validity of computerized information systems for several departments has been widely reported: the impact of electronic medical record systems on primary care, pediatrics, intensive care units and radiation oncology have been analyzed (4–7), and the effects of an RV system have been studied extensively (8–11). However, the reported studies have focused on the qualitative change in radiation treatment, rather than the quantitative measurement of efficacy of patient management, that resulted from the introduction of the electronic chart and/or RV system. A comprehensive analysis of the efficiency of a combined system featuring an electronic chart and a commercial RV, and the resultant change to the department staff workload, has not yet been performed. Therefore, we analyzed and quantified the change in the radiotherapy department staff workload.
for patient care after the introduction of the C-ROMS/LANTIS system. Our results will be relevant to estimate the change of patient treatment capacity after introducing an RV and electronic chart system into radiation oncology departments.

MATERIALS AND METHODS

SYSTEM DESCRIPTION: C-ROMS

The C-ROMS was developed as a subunit of the hospital information system (HIS) in the Samsung Medical Center. The system was programmed using Delphi 3.0 (Borland International, Inc., CA, USA) and was originally developed to operate on Windows 98 (Microsoft Corporation, USA), and later upgraded to operate on Windows XP (Microsoft Corporation, USA). The C-ROMS uses a transmission control/internet protocol (TCP/IP) for communication with the HIS and links all personal computers in our department via a local area network (LAN).

The C-ROMS is composed of five different subfunctions which handle different information: (i) the order communication system (OCS) handles the physician’s prescription, billing and appointment scheduling; (ii) the digital image chart system (DICS) provides all image information, including the patient’s identification photographs, simulation images and set-up images; (iii) the digital radiotherapy record system (DRRS) records all radiation treatment parameters as well as daily dose and accumulated dose, and displays the set-up diagram on a monitor screen; (iv) the tumor registry system handles demographic information (pre-treatment image), disease information and radiotherapy summary; and (v) the quality assurance system verifies the two-dimensional treatment calculation. The above-described functions are depicted in Fig. 1. The OCS interfaces with the central billing system through HIS. The DICS and DRRS access the HIS database and acquire the relevant patient information and laboratory results. The image information, acquired by digital camera or captured on a local terminal window of a Picture Archiving and Communication System (PACS), is entered as Joint Photographic Experts Group (JPEG) format, Graphic Interface Format (GIF) or Windows Bitmap file format (BMP). Access to C-ROMS was restricted to the authorized radiation oncology staff, by the requirement to enter their personal identification number and password which changes periodically.

QUANTITATIVE EVALUATION

The effect of the electronic chart system on the staff workload was evaluated for four different groups of staff: nursing/clerical staff, simulation staff, dosimetry/physics staff and technologist staff. The average processing time per patient was measured for two different methods, C-ROMS/LANTIS and paper chart for two groups of patients, and the results were compared. For that purpose, two patient groups, each composed of 17 breast cancer patients, were selected. The C-ROMS/LANTIS system is routinely used for the treatment of breast cancer. However, for the evaluation, the paper chart method was used for one group, until the first fraction of the radiation treatment. Each group of staff evaluated all the necessary procedures in patient treatment, accessible in both electronic charts and paper charts. Any items that can be processed by only one method, such as drawing a diagram for treatment planning, were excluded in the evaluation.

To each group of staff, a sheet of paper was given that contained the list of all procedures for which staff were required to record the time. The list of procedures given to each group of staff is summarized in Table 1. In cases where all procedures were performed consecutively, the times of starting and finishing whole procedures were recorded and the total elapsed time was calculated. When all procedures were not consecutive, the time taken for each step of the procedures was measured and the total elapsed time was computed. The workload evaluation by the nursing/clerical staff group focused on tasks required for chart preparation for each new patient, such as recording and entering patient’s information, and scheduling appointments. Simulation staff recorded the time required for preparing the simulation such as finding a patient chart, confirming the disease site and recording parameters during simulation. The dosimetry/physics staff group measured the time taken to record treatment plans and to cross-check the records. For manual treatment, the time taken to record the treatment plan data, such as daily dose, X-ray energy, field size and gantry angles, wedge angle and wedge direction, on the patient chart was measured. When electronic charts were used, in addition to entering the data into C-ROMS, the extra time taken to enter the patient’s data into LANTIS was measured separately. The technologist staff group recorded the time taken to treat each patient, i.e. the time from the moment of opening the patient’s paper chart or electronic chart to the moment of beam off. For the paper-based chart group, the linear accelerator was set up manually, while, for the treatment of the electronic-chart group, LANTIS automatically set up the machine. Finally, the total workloads measured in the two groups were compared. Paired t-test was performed to evaluate the statistically significant differences.

RESULTS

The average workload for four groups of staff is summarized in Table 2. As shown in the table, the use of the C-ROMS/LANTIS system decreased the average total workload by 28.2% (from 2147.9 to 1542.9 s). The electronic chart system decreased the workload for three groups of staff. The largest decrease of average workload was observed in the nursing/clerical staff group, which was an 85.7% decrease (from 654.7 to 93.8 s). The average workloads of simulation staff and technologist staff decreased by 61.2% (from 241.5 to 93.8 s) and 20.6% (from 515.3 to 409.4 s), respectively. However, the average workload of the dosimetry/physics staff group increased by 28.4% (from 736.5 to 945.9 s). This increase was due to the extra time necessary to enter the treatment planning parameters into LANTIS (Table 3). In recording and cross-checking procedures, however, the workload was...
decreased by 18.9 and 44.3%, respectively, when using the electronic charts. Therefore, with a Digital Imaging Communication in Medicine (DICOM) import–export function between the treatment planning computers and the RV system, the workload for the dosimetry/physics staff would decrease.

In the C-ROMS, a few additional functions were implemented, such as a patient waiting list, and conditional patient sorting feature for statistical analysis.

DISCUSSION

The introduction of the RV system into radiation oncology departments has increased the accuracy of patient treatment by reducing random errors. Mohan et al. reported that 416 errors in treatment parameters were detected and prevented by using an RV system over 1 year (10). Podmaniczdy et al. studied the pattern of mistakes by analyzing verification error reports of an RV system (11). According to their data, ~150 significant mistakes were detected and prevented per machine over 1 year. Klein et al. evaluated the impact of a commercial RV system on the patient treatment process, and concluded that checking all beam data and related field scheduling helped in reducing errors and misconceptions (12). They also reported a slight decrease in the treatment time and increase of workload for dosimetry/physics staffs, due to the treatment data entry. Barthelemy-Brichant et al. suppressed the interlock function of an RV system, which detects the mismatching of the planned parameters and the treatment machine setting, and observed the error rate, which was ~1.17% during the study period. Their data proved that the use of an RV system could potentially improve the precision of the radiotherapy delivery (13). The introduction of the RV system, however, did not remove the errors related to human factors (14).

Using an electronic chart together with an RV system not only increases the accuracy of patient treatment, but also
decreases the workload of radiation oncology department staff. Our C-ROMS/LANTIS system reduced the staff workload by \( \sim 28\% \) per patient from the moment of therapeutic decision until the first radiation treatment.

These results were obtained for breast cancer patients who were treated by a simple radiation treatment technique of two-opposing tangential ports. If a more complicated treatment technique was employed in the study, a greater improvement could be achieved, since the system’s auto-set-up function would contribute more to treatment time saving. Moreover, if the automatic transformation of the patient treatment plan from the treatment planning system to LANTIS, and to C-ROMS was possible, then a higher saving rate would be obtained. The decrease in workload can contribute to improvements in the quality of patient care by allowing more time for caring for each patient, can increase the capacity of a radiation oncology department, and potentially can promote more sophisticated treatment techniques.

Among the four groups of staff, the greatest improvement was achieved for the nursing/clerical staff. This is mainly due to the electronic system greatly reducing the patient’s registration time by transferring the patient’s primary information from the HIS database, and by eliminating the procedures related to finding or bringing papers and/or other relevant materials. Although not included in this study, a further workload reduction for clerical staff was possible by introducing an automated reception machine (ARM) into our department. From the second day of radiation treatment, the ARM processes all the relevant procedures for the treatment, when a patient’s hospital identification card is read by the machine.

The work efficiency of simulation staff was increased with the convenience of the electronic system in finding the patient’s schedule and recording the simulation parameters. The increased efficiency of patients’ treatment was mainly due to the auto-control of the linear accelerator by using LANTIS. Since C-ROMS does not have an interface with the linear accelerator, the dosimetry/physics staff were faced with an increased workload. All treatment parameters had to be entered manually into LANTIS. This additional work is inevitable as long as two different systems, an electronic chart and an RV system, are used separately without an automatic import of treatment plans from radiotherapy planning computers. With a DICOM import–export function between the treatment planning computers and the RV system, the workload for the dosimetry/physics staff would decrease. Thus, the most efficient system would be the integrated one of both systems, i.e. the electronic chart system and the RV system.

The use of the electronic system not only reduced the workload of the department staff, but also could improve the quality of patient service. This improvement in quality is

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**Table 1.** Summary of procedures whose elapsed time were recorded

<table>
<thead>
<tr>
<th>Staff group</th>
<th>Procedures</th>
</tr>
</thead>
</table>
| Nursing/clerical   | New patient registration  
Making new chart (paper or electronic)  
Entering patient information (excluding treatment permission and clinical history)  
Selecting primary physician  
Recording all information necessary before the simulation  
Scheduling a simulation  
Finding/opening the patients chart  
Confirming the basic information  
Scheduling and recording the simulation date and time |
| Simulation         | Radiotherapy identification number (ID) generation  
Recording (or entering) ID on the chart  
Confirming disease site  
Recording the simulation results  
Recording any information required for the first treatment |
| Dosimetry/physics  | (E chart) Entering treatment parameters into C-ROMS and LANTIS  
(Paper chart) Recording treatment parameters and inserting the treatment plan print outs in the chart  
Double checking the recorded (or entered) parameters  
(E chart) Generating a new patient in LANTIS and entering treatment parameters  
Finding (or opening) the patient chart |
| Technologist       | Confirming treatment parameters  
Setting the machine  
Delivering the radiation |

**Table 2.** Comparison of the average workload of radiation oncology staff

<table>
<thead>
<tr>
<th>Staff group</th>
<th>Average workloads (range) (s)</th>
<th>Average workload reduction (%)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Paper chart</td>
<td>C-ROMS/LANTIS</td>
<td></td>
</tr>
<tr>
<td>Nursing/clerical</td>
<td>654.7 (390–1200)</td>
<td>93.8 (50–160)</td>
<td>85.7</td>
</tr>
<tr>
<td>Simulation</td>
<td>241.5 (170–360)</td>
<td>93.8 (80–120)</td>
<td>61.2</td>
</tr>
<tr>
<td>Dosimetry/physics</td>
<td>736.5 (660–960)</td>
<td>945.9 (900–1020)</td>
<td>-28.4</td>
</tr>
<tr>
<td>Technologist</td>
<td>515.3 (420–600)</td>
<td>409.4 (360–480)</td>
<td>20.6</td>
</tr>
<tr>
<td>Total</td>
<td>2147.9 (1830–2760)</td>
<td>1542.9 (1435–1630)</td>
<td>28.2</td>
</tr>
</tbody>
</table>
attributed to the automatic monitor unit (MU) check function of C-ROMS, and the automatic machine set-up of LANTIS, which also increases the treatment accuracy. The implemented MU check function, which is unique in our system, offers a secondary MU check using the entered treatment parameters and accessing the dosimetry data files of the corresponding machine and energy. A quantitative evaluation of the C-ROMS/LANTIS system on the accuracy of treatment delivery will be performed. Some additional functions in the combined C-ROMS/LANTIS system also can increase the efficiency of patient care. For example, registration at reception automatically informs the therapist of the patient’s arrival, then therapists could prepare the treatment in advance.

The introduction of C-ROMS/LANTIS has many advantages, as mentioned above. However, the security that limits the access to C-ROMS/LANTIS needs to be tightly maintained and the location of the computer monitors used for C-ROMS/LANTIS should be carefully chosen to protect patients’ privacy. Also the C-ROMS/LANTIS computer system should be rigorously maintained to prevent system shutdown.

In summary, we quantitatively analyzed the efficacy of the C-ROMS/LANTIS system for four different groups of staff and proved that this system decreased the total workload of these four groups of staff by ~28%, and thereby improved the efficiency of patient management. With a auto-plan transfer option of a treatment planning system to the RV system and an integration of an electronic chart into the RV system, a higher rate of workload reduction is expected.

References


Table 3. Comparison of the average workload of dosimetry/physics staff

<table>
<thead>
<tr>
<th>Work</th>
<th>Average workloads (range) (s)</th>
<th>Average workload reduction (%)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper chart</td>
<td>400.6 (360–420)</td>
<td>18.9</td>
<td>0.00000</td>
</tr>
<tr>
<td>C-ROMS/LANTIS</td>
<td>324.7 (300–360)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cross-checking</td>
<td>335.9 (240–600)</td>
<td>44.3</td>
<td>0.00000</td>
</tr>
<tr>
<td>LANTIS input</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>736.5 (660–960)</td>
<td>−28.4</td>
<td>0.00000</td>
</tr>
<tr>
<td></td>
<td>945.9 (900–1020)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>