Implementation and Evaluation of Workflow Based on Hospital Information System/Radiology Information System/Picture Archiving and Communications System

Masakazu Osada and Eitaro Nishihara

The purpose of this presentation is to review and evaluate computerized workflow of selected sites that have integrated systems of the hospital information system (HIS), radiology information system (RIS), and picture archiving and communications system (PACS). We then focus on some essential points of integration of those systems, such as avoiding multiple entries of patients demographic data, prefetching current and previous images to the correspondent workstations, and workflow management. To realize them by integrating multiple subsystems such as HIS/RIS/PACS integration, there must be exchange of the workflow control information, and consistency of the information between subsystems.

Copyright © 1999 by W.B. Saunders Company

WE HAVE IMPLEMENTED several integrated systems consisting of hospital information system (HIS)/radiology information system (RIS)/picture archiving information system (PACS) since the early 1990s. When those systems were introduced, the following items were commonly discussed and implemented in various ways: (1) entry method of patients' demographic information into modalities; (2) display method of examination status, such that users know whether the examination is done whether the examination is wet reading; (3) display method of reading status (being read or not read); (4) cancellation/change/merge of examination and its reflection to worklists of modalities and diagnostic workstations; and (5) migration and prefetch method of previous images from jukeboxes to workstations. These are all related to workflow for users, and in many cases they have already realized it manually using papers, messenger persons, and telephones. Thus, their concern is to improve it by introducing the systems.

Some of the integrated systems are so-called health screening systems (HSS). The HSS is a computerized workflow support system of the yearly health checkup procedure that Japanese and local governments promote. The system is similar to the HIS/RIS/PACS integrated system, which includes reception and reservation support, as well as on-line data acquisition from modalities including images, data archive, and data retrieval by diagnostic workstations and consultation/review workstations. Large hospitals usually establish

health-screening centers as an annex. If any abnormality is found, patients can receive continuous and detailed medical services at the main hospitals.

The purpose of this presentation is to review and evaluate the computerized workflow of selected sites that have integrated systems of HIS, RIS, and PACS. We then focus on some essential points of integration of those systems.

METHODS

We chose three typical HIS/RIS/PACS installation sites and reviewed how they managed their workflow by using the systems. Site A was a general hospital, private, with 300 beds and 220 examinations per day. There were three computed radiology (CR) modalities one film digitizer, one digital fluorography (DF), one computed tomography (CT), two magnetic resonance imaging (MRI), and one nuclear medicine (NM). Systems were a HIS, RIS, report management system (RMS), and PACS provided by Toshiba, Tokyo, Japan. Site B was a general hospital, city-owned, with 600 beds and 350 examinations per day. Modalities were seven CRs, one film digitizer, three DRs, one digital subtraction angiography (DSA), three CTs, one MRI, and two NMs. Systems were RMS and PACS provided by Toshiba, and HIS and RIS provided by NEC (Tokyo, Japan). Site C was a HSS annexed to a university hospital, with 30 visits per day. Modalities were one CR, two DRs, seven ultrasounds, and one CT. Systems were HSS (including RMS) and PACS provided by Toshiba.

At all selected sites, the PACS receive ordering information from the HIS/RIS or HSS prior to the examination and start prefetching the previous images from the images archives (usually jukeboxes) to PACS workstations. Proprietary communication protocols are used to exchange ordering and result information between systems, as Digital Imaging and Communications in Medicine (DICOM) modality worklist management (MWM) and modality performed procedure step (MPPS) were not widely available at the time of installation.

RESULTS

Examination Workflow Support

At all selected sites, examination worklists and detailed information are provided by RIS or HSS

From the Image Management Systems Department, Medical Systems Division, Toshiba Corporation, Tokyo, Japan.

Address reprint requests to Masakazu Osada, Medical Systems Division, Toshiba Corp, 1-1-1 Shibaura, Minato-ku, Tokyo 105-8001, Japan.

*Copyright © 1999 by W.B. Saunders Company
0897-1889/99/1202-1030\$10.00/0*

terminals. At site A and B, where the HIS and RIS are integrated, the RIS acquires ordering information from the HIS. Examination status (examination priority, interrupt/resume control) is provided and managed by HIS/RIS or HSS terminals. For example, examination cancellation is managed by RIS terminals at site A and B, and by HSS terminals at site C. Also, merging multiple orderings from HIS to one examination is managed by RIS terminals at site A. Those results show that RIS or HSS is responsible for workflow management on examinations at all selected sites, and PACS is designed to be controlled by those systems.

When users start examination without multiple entries of patients' demographic data, they are transferred from the RIS to modalities at site A and B. At site C, where temporary ID cards for each patient are created by the HSS, modalities read the ID cards, which contain patients' demographic data.

Sometimes users review previous images before or during examination. To shorten the response time for retrieving images, the PACS receives ordering information from the HIS and prefetches previous images from jukeboxes to PACS workstations at all sites. Examination result information is transferred from modalities to the HIS through the RIS at site A, whereas users have to enter information into the RIS or HSS at sites B and C.

Diagnostic Workflow Support

Results show that the RMS or HSS is responsible for workflow management on diagnosis at all selected sites, and PACS is designed to be controlled by those systems. At sites A and B, the RMS manages diagnostic workflow. At site C, the HSS does the management. Users view examination lists on RMS terminals or HSS terminals, where the status of the diagnosis and a detailed description of the examination are provided. At sites A and B, handwritten clinical information is scanned at reception if needed and is displayed at the RMS terminals.

Users start one reading session by selecting an examination from the lists on RMS or HSS. At all selected sites, RMS or HSS terminals send the selected examination information to PACS diagnostic workstations, then the correspondent current and previous images are displayed automatically on the workstations. Again, to shorten response time for retrieving images, the PACS receives

ordering information from the HIS or HSS, then prefetches current and previous images to PACS workstations before the diagnostic sessions at all sites.

DISCUSSION

There is no doubt that avoiding multiple entries of patients' demographic data is one of the key issues of workflow improvement. Multiple entries could happen at examination, at diagnosis, and possibly during the consultation and review process. Passing demographic data between subsystems by integration not only reduces users' workload, but also decreases human typing errors that result in potential confusion towards patient care.

Prefetching current and previous images to the correspondent workstations is also crucial for the image viewing process. By doing this, they can review previous images for reference at examination, and can read images at diagnosis with an acceptable response time. Before the introduction of PACS, users had difficulty accessing previous images during examinations. By reviewing those images online, they are not only able to improve efficiency of the image retrieval, but also to improve procedures by referring and comparing the images.

There are two reasons why the RIS or HSS does workflow management. First, users require enough information, such as examination priority, examination history for patients, and examination worklists, including finished/not finished status information, to perform appropriate procedures. Second, the control and status information should be consistent among integrated subsystems, although there is no interaction between modalities and the RIS or HSS to keep the examination status information consistent. On diagnosis, the RMS or HSS also does workflow management because users require information such as reading status. These results suggest that, in order to implement workflow management function on modalities or PACS workstations, it is important to support the control information mentioned above, and to interact with other subsystems for data consistency.

CONCLUSIONS

In a computerized environment, it is important to provide the capability for workflow management such that users are supported by workflow control

information such as priority control information and to-do lists, in order to improve efficiency. To realize this by integrating multiple subsystems such as HIS/RIS/PACS, there must be exchange of the

workflow control information and consistency of the information between subsystems. Further research is needed to evaluate workflow control customization and user interface customization.

REFERENCES

1. Nishihara E, Sakamoto Y, Kura H, et al: Integrated RIS/PACS architecture for daily practical reading (utilization of HIS/RIS information for image distribution). Proc SCAR 219-226, 1994

2. Osada M, Toshimitsu A, Takayanagi T, et al: Impact of user interface visualization on endoscopy department mini-PACS and its integration to health screening system. Proc CAR'98 398-402, 1998