Challenges in the Integration of PACS and RIS Databases

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TEXAS CHILDREN'S Hospital is a pediatric care center that has gradually expanded PACS operations for nearly six years. Modalities now included in our PACS network are CT, MRI, CR, ultrasound, digital fluoroscopy, and nuclear medicine. In an attempt to maximize the integrity of all seven modalities, Texas Children's Hospital (TCH) implemented an interface to the Radiology Information System (RIS) in April of 1997. In the months that followed, we discovered several discrepancies that can occur beginning from the time the exam is requested, through image acquisition, until the final interpretation of the examination, all of which have a significant impact on patient demographic information. These discrepancies arise from exam code modifications, exam cancellation, and missing studies. Discrepancies between the RIS interface and the PACS image database can cause images to be sequestered from the radiologist or to be misidentified, both of which are QI problems.

MATERIALS AND METHODS

Network

Texas Children's Hospital PACS operates on the hospital broadband network. Our segment of the network includes a flat 10 Mbps and 100 Mbps Ethernet backbone using TCP/IP communications that spans three levels of two buildings.

Image acquisition devices

Among the modalities included in our PACS network are CT (GE CT 9800Q), MR (GE MR Signa), three CR devices (AGFA ADC 70), four Ultrasound carts (Acuson Sequoia, Aspen, and two each XP/10 ART, one with a DICOMIT interface, the other performing video capture), and four digital fluoroscopy units (Philips DICOM DSI version 4.2 and 4.3). All image acquisition devices transfer via TCP/IP at 10 Mbps.

Radiology Information System (RIS) interface

The RIS interface operates on a SUN Sparc 5 workstation, known as the Hospital Information System Service Class Provider (HISSCP) developed by MITRA. The RIS interface obtains patient demographic information, patient location, study date, study time, radiology exam code, the name of the referring physician, and radiology reports to our PACS gateways and review stations via an HL7 link¹ to the RIS.

Radiology Information System

The RIS is IDXrad and the Hospital Information System (HIS) is First Data, both of which operate on a DEC Alpha.

Gateways

The PACS image database employed is Oracle. The Oracle database uses Sun Solaris as an operating system. AGFA's gateway package runs on each of three archive servers to manage image workflow, image routing, user profiles, network configurations, and many other functions.

RESULTS

Scheduling the examination

To understand the source of discrepancies, a process flowchart for actions triggered by exam scheduling is displayed in Fig 1. For outpatients, the exam is requested by the child's physician by a phone call from the physician's office staff to the Diagnostic Imaging scheduling office. Patients making their initial visit to Texas Children's Hospital will not have a medical record number (MRN) until registration occurs in the HIS. Examination requests for inpatients are sent via the HIS to the Diagnostic Imaging scheduling office. The request is scheduled in IDXrad.

Once the examination has been scheduled, an event is transmitted by IDXrad to the RIS interface.² If the broadcast event contains an MRN, then the patient's name, MRN, sex, accession number, IDXrad exam code, study date, study time, and modality type are stored in the database of the RIS interface. If the MRN is not contained in the broadcast, then the RIS interface accepts the broadcast, but stores the event in a portion of the database not used in the verification process.

Acquiring the examination

The sequence of events that occur from arrival of the patient through transmission of the study to the PACS gateway is displayed in Fig 2. After the patient arrives in the department, the patient demographic information is either entered manually on the acquisition station's console or a query/retrieve to the RIS interface is initiated from the console. The examination is performed and the study/series is sent to the PACS gateway. As the study/series

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Fig 1. Exam process flow chart for action triggered by exam scheduling.

enters the PACS gateway an association is triggered with the RIS interface. Provided that the incoming study/series contains an event in the RIS interface, and the stored event matches the MRN and accession number of the incoming study/series, the study/series passes verification and enters the public work list of the PACS gateway. Should the incoming study/series MRN and accession number not be contained within the RIS interface, the RIS interface initiates a query of the RIS database for a matching accession number. If the RIS database contains an accession number match, an update event is sent back and stored in the RIS interface. Once the MRN and accession number is stored in the RIS interface, the incoming study/series can successfully pass verification. If the RIS database does not contain the accession number that the RIS interface is searching for, the study/series enters the private area of the PACS gateway, where it is inaccessible to PACS users. If the incoming study/series contains an MRN and accession number other than the MRN and accession number that exist in the RIS interface, the incoming study is also sent to the private area of the PACS gateway.

Discrepancies

Although verification is performed at the time the examination enters the PACS database, exam information changes for nearly 40 percent of the

studies that exist on the PACS database, which presents serious problems for radiologists performing diagnostic interpretation with PACS.³ Moreover, the time frame during which exam information can potentially change is much greater than one day. In pediatric care centers, it is not unusual for the child's demographic information to change. When the patient's name or MRN is changed in IDXrad, the PACS database is not updated with the change. Hence, radiologists performing a query based on the patient's new accession number or MRN will not find prior studies for comparison.

Changes are made to exam codes when the wrong examination is scheduled or the radiologist determines that the requested examination is not appropriate for the child's diagnosis. If the appropriate exam code is not used during the initial scheduling of the examination, the exam code assigned to the study/series entering the PACS database will be incorrect. Moreover, if the routing scheme is designed to route a study/series based on a specific organ type, the study/series will not be routed to the assigned targets if the organ type of the incoming study/series does not match the organ type assigned to the exam code in the routing table.

Two exams that are performed using one accession number presents another problem with exam discrepancies in the PACS database. Though technologists know that two separate exams have been

Fig 2. Flow of events from patient arrival to image transmittal to PACS gateway.

ordered and scheduled in IDXrad, they occasionally perform both exams using one accession, instead of re-entering patient demographic information at the acquisition device. This is a routine practice with CT and MR studies, where a slice from a single examination of the patient needs to be segregated and referred to different subspecialty radiologists for interpretation. Once the patient is registered in the CT or MR console, and the exam is initiated, the technologist cannot modify the acces-

sion number. Therefore, a query from a review station using the erroneous accession number will show nothing.

Study/series transmission failures from acquisition devices to the PACS gateway are occasionally encountered. When an acquisition device fails to send all images in a study/series, there is no automatic way to verify how many images the study should contain at the PACS gateway, which can lead to misdiagnosis.

When exams are canceled in IDXrad after the examination was started, there is no way of identifying the canceled exam on the PACS database. This scenario commonly occurs for children who cannot remain calm during the examination and must be rescheduled with sedation for another date.

At the core of these problems is the issue of delay of diagnosis. If the technologist enters an incorrect accession number or MRN at the acquisition device, the study/series will be sent to the private area of the PACS database until the console operator manually corrects it. Provided that a console operator is available, the time it may take to determine the correct accession number and MRN in IDXrad sometimes exceeds reasonable expectations of turnaround time for a radiologist to view the study. This delay is especially undesirable for emergency care patients.

Verifying exams manually

Figure 3 depicts the flow of events involved in manual verification and updating examinations. Each morning, the RIS database automatically creates a cancellation report, merge report, IDXrad

exam code change report, patient demographic change report, a report with a list of studies sent to the PACS gateway, and a report with the number of images in each study from the previous day. The PACS console operator then manually verifies each report against the PACS database, making certain that everything in the PACS database matches the RIS database. These reports detect changes made to exam information after the exam was transmitted to the PACS gateway, in addition to identifying all studies and images that should have been transmitted. The PACS console operator then manually corrects studies by modifying IDXrad exam codes, MRNs, and patient demographic information. For studies or images that fail to reach the PACS gateway, the console operator either queries the acquisition device and retrieves the missing study or initiates a call to the modality service and requests retransmission of the missing study.

DISCUSSION

In addition to the six IDXrad transaction reports, we installed a bar-code reader on each ID station where technologists enter demographic data for CR

Fig 3. Flow of events for manual verification of studies residing on the public work list.

exams. Now, technologists scan the printed barcode representation of the accession number on the IDXrad exam request. The ID station performs a query of the RIS interface, and retrieves the remainder of the demographic and study information. This has proven to be a valuable investment since it prevents technologists from manually entering incorrect MRN's and accession numbers at the time the exam is performed.

To prevent broadcast events from IDXrad that have a blank MRN field from entering the RIS interface's database, MITRA created a patch that accepts the broadcast event but dumps it into an error log. This patch has drastically reduced the number of studies that enter the private area on the PACS gateway. In addition, MITRA recently introduced a new RIS interface, PACS Broker, which is expected to address deficiencies existing in its predecessor, HISSCP.

In the event that an emergency exam is needed that has not been scheduled in IDXrad or the RIS is out of operation for service or maintenance, technologists have been trained to enter "9999" as the accession number. By entering "9999", or "STAT" as the accession number at the acquisition device, the PACS gateway completely bypasses the verification process described in Fig 2 and allows the study to enter the public worklist of the PACS database. The exam is routed according to the default routing scheme. Even though exam informa-

tion may be incorrect at the time the exam is performed, the PACS console operator later enters the proper accession number and makes any needed changes to patient demographics once RIS operations are restored.

CONCLUSIONS

The discrepancies we encountered clearly demanded manual procedures that must be aggressively performed in order to maintain correct exam information and assure image accessibility for physicians. The accuracy of exam information is vital for diagnostic radiology and necessary to maintain database integrity. The automatic verification system allows exam information to be authenticated only once, therefore RIS and RIS interface providers must develop a method for broadcasting updates to the PACS database after the exam has been transmitted to the PACS gateway.

REFERENCES

1. Health Level Seven: Health level seven—An application protocol for electronic data exchange, in Healthcare Environments (version 2.1). Chicago, IL, 1990
2. Taira RK, Breant CM, Chan HM, et al: Architectural design and tools to support the transparent access to HIS, RIS and PACS. *J Digit Imaging* 9:1-10, 1996
3. Offenmuller W: Expectations and Solutions for HIS/RIS/PACS Dataflow and Workflow. *J Digit Imaging* 10:95-98, 1997 (suppl 1)