Maintaining Continuity of Clinical Operations While Implementing Large-Scale Filmless Operations

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Texas Children's Hospital is a pediatric tertiary care facility in the Texas Medical Center with a large-scale, Digital Imaging and Communications in Medicine (DICOM)-compliant picture archival and communications system (PACS) installation. As our PACS has grown from an ultrasound niche PACS into a full-scale, multimodality operation, assuring continuity of clinical operations has become the number one task of the PACS staff. As new equipment is acquired and incorporated into the PACS, workflow processes, responsibilities, and job descriptions must be revised to accommodate filmless operations. Round-the-clock clinical operations must be supported with round-the-clock service, including three shifts, weekends, and holidays. To avoid unnecessary interruptions in clinical service, this requirement includes properly trained operators and users, as well as service personnel. Redundancy is a cornerstone in assuring continuity of clinical operations. This includes all PACS components such as acquisition, network interfaces, gateways, archive, and display. Where redundancy is not feasible, spare parts must be readily available. The need for redundancy also includes trained personnel. Procedures for contingency operations in the event of equipment failures must be devised, documented, and rehearsed. Contingency operations might be required in the event of scheduled as well as unscheduled service events, power outages, network outages, or interruption of the radiology information system (RIS) interface. Methods must be developed and implemented for reporting and documenting problems. We have a Trouble Call service that records a voice message and automatically pages the PACS Console Operator on duty. We also have developed a Maintenance Module on our RIS system where service calls are recorded by technologists and service actions are recorded and monitored by PACS support personnel. In a filmless environment, responsibility for the delivery of images to the radiologist and referring physician must be accepted by each imaging supervisor. Thus, each supervisor must initiate processes to verify correct patient and examination identification and the correct count and routing of images with each examination.

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TEXAS CHILDREN'S HOSPITAL is a pediatric definitive care facility in the Texas Medical Center with a large-scale, Digital Imaging and

Communications in Medicine (DICOM)-compliant picture archival and communications system (PACS) installation. As our PACS has grown from an ultrasound niche PACS into a full-scale, multimodality operation, assuring continuity of clinical operations has become the number one task of the PACS staff. As new equipment was acquired and incorporated into the PACS, workflow processes, responsibilities, and job descriptions had to be revised to accommodate filmless operations. Installing PACS in a replacement hospital is a challenge that is well described in the literature.¹ Retrofitting an existing hospital or upgrading an operational PACS involves additional challenges to minimize interruption of ongoing clinical services.²

KEYS TO CONTINUITY OF CLINICAL OPERATIONS

We have identified eight areas that require special attention in maintaining clinical operations during PACS installation, upgrade, and routine filmless operations. Our observations are organized into categories of training, planning, redundancy, accuracy, verification, notification, documentation, and ownership.

Training

Although it may seem obvious, PACS training must be conducted that is appropriate to the job responsibilities and technical background of the individual. We tailor training for radiologists to include fellows and residents, referring physicians, technologists, technologist supervisors, administrative/film library personnel, biomedical engineers, and PACS staff. PACS vendors typically conduct initial applications training, but we have found this to be inadequate. System administrator training is provided by the vendor on a limited basis. We have been able to obtain additional training on our radiology information system (RIS) interface by its manufacturer and on the DICOM standard by a consultant.

Our PACS staff, largely self-taught on-the-job, has developed training programs for the remainder of the hospital staff. We offer initial, refresher, and inservice updates. Initial training needs to be conducted as part of a new employee orientation

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0897-1889/99/1202-1014\$10.00/0*

program. Refresher training is conducted periodically to confirm clinical competency. Inservice updates are required with the introduction of new hardware and software versions, and to disseminate guidance when system or operator deficiencies are discovered. To facilitate communications with our radiologists, we conduct informal biweekly PACS user meetings. These meetings are conducted in a conference room with an image review station and video projector. We encourage lively discussion of system shortcomings, features, and workarounds. We regard all training sessions as an opportunity to uncover issues with filmless operations.

Planning

To deal with newly recognized issues regarding realignment of clinical operations and changes in the process of delivering filmless imaging, PACS operational subcommittees were formed. Each subcommittee includes a radiologist, an imaging service supervisor, a PACS team member, and clinical customers, as required. Decisions are made by the staff affected by the change, who are likewise responsible for implementing it. The service supervisor is the expert on how examinations are conducted, the PACS team member is the expert on how the system accommodates the examinations, and the radiologist who leads the subcommittee is the expert on how the clinical information is used. Clinical customers are included as experts on the unique requirements and procedures of their services. The service supervisor is responsible for making changes in technologist procedures, while the PACS team member is responsible for making changes to the PACS configuration and providing any additional training needed.

To codify changes in procedure, new policies and procedures were developed to restore or continue operations during contingency situations. These include interruptions from IMPAXS service events, power outages, network outages, and unavailability of the RIS or RIS interface. Writing and revising these procedures provides a vehicle for dialog and advanced planning, a ready reference during a contingency, as well as a basis for training new personnel. We have found that these procedures need to be rehearsed and revised to be effective.

When a service interruption can be anticipated for repair, reconfiguration, or upgrade, it is extremely important to coordinate with the imaging

service supervisor. When possible, schedule the outage at period of low clinical workload in the service to minimize the disruption.

Redundancy

By eliminating single points of failure, redundancy is a cornerstone in assuring continuity of clinical operations. PACS without redundancy cannot even tolerate preventive maintenance operations without interrupted service. Redundancy should be considered from several perspectives. The most obvious application involves all PACS hardware components such as acquisition, network interfaces, gateways, archive, and display. Redundancy implies duplication of function, but not necessarily duplication of components. For example, examinations can be stored on the hard drive of the acquisition when the archive server is down, or the examination can be sent to an alternate server.

Redundancy also applies to digital image data. Copies of data may be present in the system on a primary short-term archive, on a long-term archive, on a backup archive, on acquisition stations, or on display stations. Knowing where data resides and for how long is important in planning redundancy.

Redundancy is also accomplished by modularity in PACS design. Modularity accommodates rerouting of images to alternate destinations. Where redundancy is not feasible, spare parts must be readily available. We maintain spare parts onsite for quick replacement of monitors, keyboards, mice, Ethernet cables, external hard drives, and some internal disk drive for the redundant array of inexpensive disks (RAIDs). A sufficient supply of imaging plates and cassettes for computed radiography is maintained to tolerate incidental damage and replacement.

Redundancy in PACS extends to staffing. Round-the-clock clinical operations must be supported with round-the-clock service, including three shifts, weekends, and holidays. To avoid unnecessary interruptions in clinical service, this requirement includes properly trained operators and users, as well as service personnel. Depth in terms of trained personnel must tolerate absences for illness, vacation, training, and personnel losses. We try to accomplish depth by cross-training within the PACS staff and between the PACS staff and the customary imaging staff.

Achieving redundancy is not without economic

cost. We believe that this cost is offset to some extent by the value of uninterrupted services. Some cost is avoided by modularity in the PACS architecture. Building in excess capacity accommodates peaks in workload and growth. The bottom line is that high reliability is an absolute requirement in PACS: redundancy is a component of the cost of doing business.

Accuracy

Human operators are fallible: wherever human input is required, there is a potential for mistakes. PACS images must be associated with correct demographic information, otherwise the images are not viewable by the radiologist or referring physician. The result is a delay of diagnosis. Misidentification of images can result in misdiagnosis. We have tried to minimize or automate steps that require human input, for example, bar coding accession numbers, maximizing reliance on RIS interfaces at acquisition, and implementing DICOM Worklist Management. Errors can still occur. We have to continually reinforce the importance of accuracy and consequences of errors with our technologists and schedulers.

Verification

Because of the potential for human error and the significant consequences, verification is important in PACS operations. A quality-control inspection is performed before transmission of images to correct patient demographics and exam information, as well as to correct image orientation, annotation, and appearance. Another quality-control inspection is performed after transmission to ensure that all images of the examination arrived at intended destination, and to determine whether all relevant prior examinations are available at intended destination(s).

After the examination is transmitted to archive, further verification occurs. The examination may require modification to correct operator input errors, to splitting and merging of exams, and to delete nondiagnostic images. Images that arrive with confusing demographics are sequestered. These "broken" studies must be "fixed," which may involve reconciling demographics between the image database and the RIS. Unusual acquisition conditions can generate other classes of broken studies, such as "unique identifier (UID) conflicts," that may require advanced correction procedures.

DICOM worklist management reduces the frequency of operator input errors, but cannot eliminate the need for verification, because demographic information that is known at the time of the examination, can change, and images can still be associated with the wrong patient.

Verification requires technologist operation of a quality-control workstation, technologist operation of review station, technologist advanced operations with the graphical user interface (GUI), and appropriate user privileges. Coordination between the technologist and PACS console operator may be required for advanced corrections. We have found a number of customized RIS reports (image counts, examination cancellations, demographic changes), and SQL queries of the image database to be helpful in verification.

Notification

Primary and backup systems are needed for notification of the PACS console operator when problems are detected. Provisions include notification of operators and users when network services are interrupted, and also when service is restored.

Documentation

Documentation serves to expedite dealing with service interruptions and to identify recurrent problems. We have compiled site reference information into a "PACS Console Operators Survival Guide" that includes notification information, a network diagram, configuration management information, routine duties, contingency information, and vendor system reference data. We also include a reference set of policies and procedures.

Other documentation provides a history of service events, including vendor field service reports. To assist in the reporting and tracking of downtime, we have developed a maintenance module in our RIS. Technologists record trouble according to the specific device, and the console operator updates the record according to services performed. RIS verification reports, structured query language (SQL) queries, and operator logs, including image count discrepancies and broken study report, provide a history of examination verification activities.

Ownership

Responsibility for delivery of images to the radiologist and referring physician must be accepted by each imaging service supervisor. The

PACS staff must respect the responsibility of the service supervisors to deliver images. That is, they must coordinate planned service interruptions, and provide rapid response to trouble calls. The PACS staff must strive to support, rather than disrupt, services.

CONCLUSION

Maintaining continuous delivery of images while making the transition to filmless operations is challenging. Assuring continuity in image delivery still demands attention after filmless operations are established.

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