Electronic Imaging and Clinical Implementation: Work Group Approach at Mayo Clinic, Rochester

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Electronic imaging clinical implementation strategies and principles need to be developed as we move toward replacement of film-based radiology practices. During an 8-month period (1998 to 1999), an Electronic Imaging Clinical Implementation Work Group (EICIWG) was formed from sections of our department: Informatics Lab, Finance Committee, Management Section, Regional Practice Group, as well as several organ and image modality sections of the Department of Diagnostic Radiology. This group was formed to study and implement policies and strategies regarding implementation of electronic imaging into our practice. The following clinical practice issues were identified as key focus areas: (1) optimal electronic worklist organization; (2) how and when to link images with reports; (3) how to redistribute technical and professional relative value units (RVU); (4) how to facilitate future practice changes within our department regarding physical location and work redistribution; and (5) how to integrate off-campus imaging into on-campus workflow. The EICIWG divided their efforts into two phases. Phase I consisted of Fact finding and review of current practice patterns and current economic models, as well as radiology consulting needs. Phase II involved the development of recommendations, policies, and strategies for reengineering the radiology department to maintain current practice goals and use electronic imaging to improve practice patterns. The EICIWG concluded that electronic images should only be released with a formal report, except in emergent situations. Electronic worklists should support and maintain the physical presence of radiologists in critical areas and direct imaging to targeted subspecialists when possible. Case tools should be developed and used in radiology and hospital information systems (RIS/HIS) to monitor a number of parameters, including professional and technical RVU data. As communication standards improve, proper staffing models must be developed to facilitate electronic on-campus and off-campus consultation.

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AS MANY DEPARTMENTS begin the implementation of picture archiving and communication systems (PACS), radiology information sys-

tems (RIS), and hospital information systems (HIS), new strategies and policies will need to be developed with regard to clinical practice patterns in order to take advantage of improved quality and efficiency of electronic imaging. Many publications have addressed specific areas of clinical practice, such as soft-copy versus hard-copy interpretations, report image turnaround times, and worklist management.¹⁻⁵ Little has been published concerning the reengineering of radiology departments in order to maintain practice goals and improve quality and efficiency.^{1,6-7}

After thorough review of current technology and experience in PACS implementation in our practice, a recent decision was made within our Department of Diagnostic Radiology and our institution to become a completely digital and electronic radiology department. Technical modeling plans and equipment purchasing plans are currently being developed. However, additional strategies and policies needed to be developed with regard to potential impact and changes to our radiology and clinical practices. An Electronic Imaging and Clinical Implementation Work Group (EICIWG) was therefore established in our department to address the unique and challenging reengineering needs of electronic imaging.

The EICIWG was formed with members from our Electronic Imaging Informatics Lab, Finance Committee, Management Section, and Regional Practice Group, as well as several organ and modality subspecialists of the department. Their charge was to study and develop strategies regarding electronic imaging in clinical practice.

MATERIALS AND METHODS

The electronic imaging coordinating group responsible for PACS implementation in our practice submitted a list of significant issues regarding electronic imaging and our radiology practice. In addition, our radiology departmental Clinical Practice Committee submitted a number of key issues to be address. All of the input was distilled into a list of specific issues to be explored by the EICIWG. The issues to be studied were as follows:

- (1) electronic worklist organization;
- (2) how and when to link images with reports;
- (3) how to redistribute technical and professional relative value units (RVUs);

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- (4) how to integrate teleradiology with our regional and non-Mayo practice partners;
- (5) how to facilitate future radiology section goals regarding unique manpower and work redistribution models; and
- (6) how to develop new and future strategies under the current electronic imaging implementation timeline.

The EICIWG divided their efforts into two phases. Phase I included a thorough review of current practice patterns regarding hard-copy image report turnaround times, RVU allocation, practice goals within the various sections in the radiology department, and current off-campus teleradiology practice patterns. After phase I was completed, phase II was implemented, which included the development of policies and strategies for current and future electronic imaging implementation for the next 5 years.

RESULTS

Phase I efforts of the EICIWG turned first to establishing a clear understanding of the electronic imaging timeline for the next 5 years. The electronic imaging oversight group presented a clear, concise timeline of when and what will be converted to digital imaging and then PACS integration over the next 5 years (Fig 1).

Worklist Organization

The next issue evaluated was the concept of electronic worklist organization. Worklists and folders are software concepts designed to subdivide the

huge collection of imaging examinations within a PACS system into clinically useful subgroups.⁴ In the medical environment, worklists are means of subdividing work to be done (ie, unreported examinations) into radiologically meaningful groups. Folders, on the other hand, subdivide work that has already been done (ie, reported examinations) into different subgroups suited to particular clinical needs.

The corollary to an electronic worklist in radiology is similar to a pile of films or a radiology rolloscope or alternator that is loaded with films from a number of examinations. A radiologist approaches the pile of films or rolloscope as a group of examinations to be interpreted. Similarly, electronic worklists are ways to organize the work electronically into particular types and relevant groups of examinations. The key difference between electronic worklists and physical piles of film is the opportunity to move and mix examinations into a variety of worklists without the limitation of geographic transportation or physical presence of film.

The concept of electronic worklists, therefore, can open new and unique opportunities for organizing the radiology workload. A number of unique

Tasks	Year 1	Year 2	Year 3	Year 4	Year 5
Begin a dual image archive by maintaining film production and archiving as well as storing all digital images into a common digital archive					
Complete computed radiology replacement of all film/screen bone and chest imaging					
Install remaining DICOM gateways for all digital imaging acquisition devices (CT, US, MR, Angio, fluoroscopy)					
Implement a common PACS system department-wide					
Begin operating without primary reliance on film in some areas of the department (i.e., ICUs, ultrasound)					
Begin digitizing film-based outside exams and remaining inside film-based exams, if necessary (i.e., mammography, angiography)					
All or most of film production ceases					

Fig 1. Proposed electronic imaging installation timeline.

opportunities were identified with the concept of electronic worklists. These are as follows:

- (1) potential improved quality of interpretation by directing the images to the radiology specialist;
- (2) improving the efficiency of practice by making more of the radiology workload available to more of the radiologists (when one radiologist is busy with a procedure, another radiologist in another location can access new images arriving on the worklist);
- (3) opportunity to identify and separate emergent studies from routine studies to facilitate proper turnaround times for each examination; and
- (4) worklists can enable teaching institutions to separate resident-read examinations that need to be approved by the supervising radiologist.

Linking Images With Reports

The next item the EICIWG addressed was the concept of linking images with reports. In our current practice, images are not released until a report is available with the examination. However, in the electronic format, images could possibly be instantaneously available to both the referring physician and to the radiologist; and the desire of the referring clinician to view images before a report is generated has arisen. A policy and recommendation, therefore, was needed regarding image release with or without a radiology report.

To evaluate the issue further, a study of current practice patterns was undertaken. Using computer-assisted software engineering tools (case tools) built into our RIS, we were able to evaluate current film/report delivery times (Table 1).⁸ The current average time from technologist's completion to radiology report generation (TC-RRG) for a large group of examinations is approximately 105 minutes. This turnaround of 1 hour and 45 minutes appeared to be reasonable for report generation. Image release without reports within this small time frame did not appear to offer much advantage. In addition, clinical care issues and potentially legal issues could arise when releasing images before a report is generated.

Finally, a survey was performed in our department as to whether or not images could be released without reports in the electronic format. The virtually unanimous response from our radiologists was

Table 1. Technologist Completion to Radiology Report Generation Time*

Selected Types of Radiology Exams	Average TC-RRG Time	No. of Examinations
Skeletal x-rays	81 min	4,199
Chest x-rays	76 min	6,292
Body CT—clinic	138 min	1,381
Body CT—hospital†	174 min	805
Neuro CT—clinic	140 min	655
Neuro CT—hospital†	76 min	983
Ultrasound clinic	70 min	1,728
Ultrasound hospital*†	85 min	762
Body MR—clinic	154 min	380
Neuro MR—clinic	113 min	1,020
Mammography	45 min	2,720
Nuclear medicine	106 min	740
Average of all exams	105 min	21,665

Abbreviations: TC-RRG, technologist completion to radiology report generation; CT, computed tomography; MR, magnetic resonance.

*Selected areas of practice, June 1998.

†St Marys Hospital.

that images should not be released without reports in order to maintain quality of patient care and to avoid potential legal liabilities that might result from releasing images without diagnostic reports.

Relative Value Units

The EICIWG next addressed the work management tool of RVUs. A discussion of RVUs was deemed important in that productivity measurements no longer will occur according to geographic boundaries in the electronic imaging world. Although radiology images may be performed on a patient in one location, the radiology examination may be interpreted by another radiologist in another geographic location. Issues and problems stemming from productivity measurements could arise when the examination is performed at one site and interpreted at another site; specifically, who gets credit for what. Because productivity measurements in radiology are currently centered around tools such as RVUs, a more in-depth look at RVUs was necessary. Productivity tools, such as RVUs, are a work measurement based on examination complexity and are divided into three components in our practice: professional (radiology effort), technical (allied health staff and equipment related), and malpractice. Together these three components are termed a global RVU. RVUs are currently used for three processes.

RVUs are recognized as measuring tools for the annual planning process and provide information to

the institution's planning process regarding the needs for personnel and equipment for the upcoming year. The second use for RVUs is procedure costing. RVUs can be used as a pricing mechanism for managed care and other contract service bid-dings. Each RVU component has a recognized reimbursement rate associated with it. Finally, RVUs have been used to track individual productivity. Professional RVU values are assigned to the radiologist for each report generated and can be tracked in the RIS system. In the same manner, the RIS system database can also track the productivity of technologists, transcriptionists, and machine utilization. Therefore, it might seem logical to just reassign professional RVUs to the location where the radiologist interprets the examination in order to provide an appropriate level of coverage in a staffing model. However, scheduling radiologists to certain geographic locations depends on other significant factors, such as physician physical presence needs, clinician consultation, hospital versus clinic needs, and patient care urgency needs. Therefore, remote interpretation of a radiology examination and the reassignment of professional RVUs is complicated by the complex scheduling needs of any radiology department.

In summary, remote interpretation of electronic images acquired at a different location may lead to improved efficiencies in some areas, as well as improve the specialty interpretation. However, electronic transfer of imaging and remote interpretation could lead to a redistribution of RVUs, which can complicate the process of practice structuring and modeling. Accurate case tools will be needed to aid in the process of departmental planning processes as they relate to electronic imaging and remote interpretation, RVUs, and staffing models.

Remote Interpretation

The final issue the EICIWG addressed was remote interpretation of teleradiology images from off-campus Mayo practices and non-Mayo practices. The Mayo Clinic practice in Rochester, MN, has expanded to include affiliated practices in smaller towns and cities in a 150-mile radius. This includes affiliated hospitals and clinics in these smaller areas. In addition, the Mayo Group Practices in Scottsdale, AZ, and Jacksonville, FL, are also linked to the Mayo Rochester practice via electronic means. Potential sharing of the workload in the departments of radiology among all of these

practices will become a possibility in the electronic imaging age. A thorough understanding of current practices and future potential practice patterns was necessary before policies and strategies were recommended.

A thorough review of Mayo Health System practices was outlined. In addition, the current status of RIS, HIS, and PACS system implementation in these practices was identified. It was determined that none of the affiliated Mayo practices used similar HIS and RIS information systems. Because of this, current transferring of information was not possible. However, future plans include common, unique identifier numbers for patients and patient examinations such that networking of image examinations could occur over standard communication lines. Fortunately, the Mayo Group Practices in Jacksonville, Scottsdale, and Rochester all share a common RIS system. The potential for sharing electronic imaging worklists among these three Mayo Group Practices is close to reality and could be implemented soon. Interpretation of off-campus non-Mayo imaging is currently limited by proprietary teleradiology systems and by legal and licensing issues across state lines. However, although primary interpretation of teleradiology images does not occur, some consultation with teleradiology systems is occurring and could expand in the future.

After further exploration, the complex issues of image compression, RIS, and HIS communication standards, as well as legal and licensing difficulties, will continue to make remote interpretation from off-campus imaging difficult well into the future.

CONCLUSIONS

After complete review into the aforementioned issues, the EICIWG recommended the following strategies and policies to enable a smoother implementation of electronic imaging into our current practice patterns.

- (1) Maintain the policy of releasing electronic imaging only when a report has been generated and is connected to the radiology images. In doing so, the contribution of radiology interpretation as well as the contribution of high-quality imaging will remain a complete product; and quality, safety, and reduced liability for all physicians will be maintained.

- (2) Establish electronic imaging worklists in a

manner that will enhance current preferred methods of physician staffing with the introduction of improvements where possible providing greater flexibility among the radiologists, as well as improve quality of interpretation. Physical presence by radiologists in certain radiology departments will be necessary for urgent patient care, physician interactive examinations, and clinician consultation. Electronic imaging worklists should facilitate radiology staffing models that maintain physical presence in critical areas and allow for workload dispersion to the radiologists at the variety of physical locations they need to practice.

(3) Develop case tools within HIS and RIS systems to study and evaluate professional RVU and technical RVU data in order to provide an accurate means of following physician and departmental productivity. Global RVUs can no longer be

assigned to specific geographic radiology locations in the electronic imaging age, because images may be obtained in one location and interpreted in another.

(4) After thorough review of current and future opportunities, the EICIWG felt that some off-campus image consultation and primary interpretation could occur within state boundaries in the near future, if standard patient identifier numbers and RIS standards are developed. Teleradiology will be more difficult over state boundaries. However, when these technical legal issues are resolved, proper staffing and RVU allocation will be needed to account for off-campus remote interpretation. Appropriate case tools must be in place to study performance and report turnaround times to assure and maintain the quality of practice at the off-campus imaging location.

REFERENCES

1. Siegel EL, Diaconis JN, Pomerantz S, et al: Making filmless radiology work. *J Digit Imaging* 8:151-155, 1995
2. Strickland NH, Hons (Oxon) MA: Review article: Some cost-benefit considerations for PACS: A radiological perspective. *Br J Radiol* 69:1089-1098, 1996
3. Williams SC, Contreras M, McBiles M, et al: The impact of a picture archiving and communication system on nuclear medicine examination interpretation. *J Digit Imaging* 10:51-56, 1997
4. Reiner BI, Siegel EL, Hooper FJ, et al: Effect of film-based versus filmless operation on the productivity of CT technologists. *Radiology* 207:481-485, 1998
5. Stirling B, Weatherburn G, Watkins J, et al: Radiology report times: Impact of picture archiving and communication systems. *AJR* 170:1153-1159, 1998
6. Williamson B Jr: The electronic transformation of radiology. *Radiology* 209:606-614, 1998
7. Spencer BG, Sobel AH, Young LQ, et al: Processes involved in reading imaging studies: Workflow analysis and implications for workstation development. *J Digit Imaging* 10:40-45, 1997
8. Taira RK, Breant CM, Chan HM, et al: Architectural design and tools to support the transparent access to hospital information systems, radiology information systems, and picture archiving and communication systems. *J Digit Imaging* 9:1-10, 1996