Radiologist's Clinical Information Review Workstation Interfaced With Digital Dictation System

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Efficient access to information systems integrated into the radiologist's interpretation workflow will result in a more informed radiologist, with an enhanced capability to render an accurate interpretation. We describe our implementation of radStation, a radiologist's clinical information review workstation that combines a digital dictation station with a clinical information display. radStation uses client software distributed to the radiologist's workstation and central server software, both running Windows NT (Microsoft, Redmond, WA). The client system has integrated digital dictation software. The bar-code microphone (Boomerang, Dictaphone Corp, Stratford, CT) also serves as a computer input device forwarding the procedure's accession number to the server software. This initiates multiple queries to available legacy databases, including the radiology information system (RIS), laboratory information system, clinic notes, hospital discharge, and operative report system. The three-tier architecture then returns the clinical results to the radStation client for display. At the conclusion of the dictation, the digital voice file is transferred to the dictation server and the client notifies the RIS to update the examination status. The system is efficient in its information retrieval, with queries displayed in about 1 second. The radStation client requires less than 5 minutes of radiologist training in its operation, given that its control interface integrates with the well-learned dictation process. The telephone-based dictation system, which this new system replaced, remains available as a back-up system in the event of an unexpected digital dictation system failure. This system is well accepted and valued by the radiologists. The system interface is quickly mastered. The system does not interrupt dictation workflow with the display of all information initiated with examination bar-coding. This system's features could become an accepted model as a standard tool for radiologists.

WHILE CLINICAL information systems may be readily available to the radiologist, they are often underused due to a variety of factors, including inefficient user interfaces and computer terminal location not in proximity to the interpretation station. In our own institution, clinical information was available through several nonintegrated computer terminal interfaces. However, it was generally accepted that these terminals were underused given the inefficiency of information access through nonintuitive, nonintegrated display screens.

MATERIALS AND METHODS

radStation is an application designed to support radiologists while they dictate results. A computer-attached microphone is used in place of the usual telephone-based dictation device. A Dictaphone Boomerang (Stratford, CT) microphone was chosen because it closely resembles the traditional radiologist's microphone with the slide control and an integrated bar-code reader. This microphone was integrated into a program that allows radiologists to dictate their report and store a digital copy on the computer. The digital report is transferred to a Dictaphone Enterprise Express voice server for transcription and access for the referring physicians.

This basic functionality is supplemented by a graphical user interface that provides additional information, and functionality, to the radiologist (Fig 1). When the radiologist bar-codes an accession number to identify the examination he/she is reading, radStation displays the patient's name, medical record number, and the name of the procedure the radiologist is dictating. In addition the patient's schedule, historical radiology examinations, historical laboratory tests, film jacket location, and procedure tracking details are displayed. The most recent radiology result of the same type that is currently being dictated is also displayed. In examinations without acute findings, in most instances, the radiologist never has to touch the computer's keyboard or mouse.

The information displayed comes from four different commercial products from three different vendors. The radiology information comes from Shared Medical Systems (SMS, Malvern, PA), Radiology Management System, version 25. The scheduling information comes from the SMS Invision hospital information system. The laboratory results come from the Cerner (Kansas City, MO) laboratory information system. The dictation information comes from the Dictaphone Enterprise Express dictation system.

The radiologist can use radStation to view a patient's medical history as it resides in several different vendor's medical information products, without sacrificing the simplicity of

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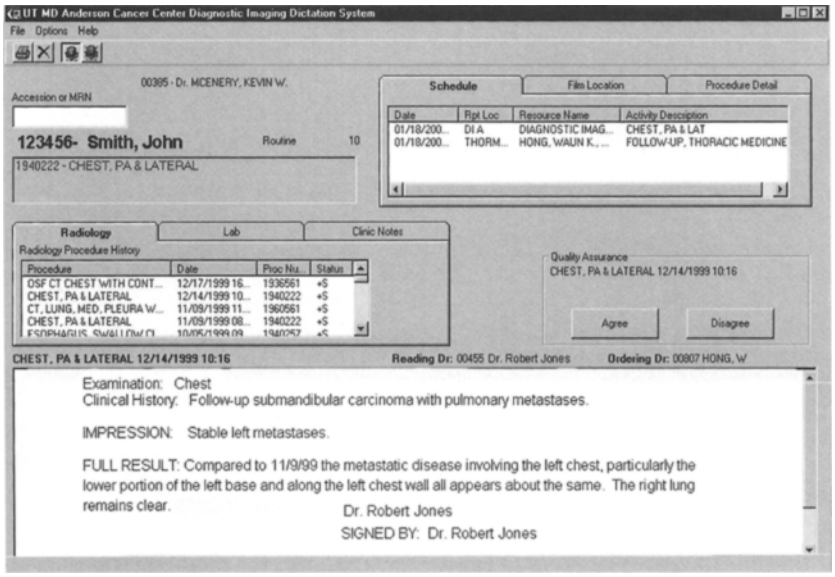

Fig 1. radStation's main screen. Upon bar-coding a requisition, radStation displays the patient demographics, examination for dictation, list of prior reports, display of prior comparison report, including date of dictation, and patient's schedule. Lab, Clinic Notes, Film Location, and Procedure detail can be reviewed by clicking the appropriate tab.

the interface of the traditional radiologist's microphone. All of the different information stores are queried and presented to the radiologist simply from interactions with the microphone. The mouse and keyboard are available to backup the bar-code reader and to allow the radiologist to switch views or type comments to colleagues.

radStation employs a three-tier system architecture. The radStation Presentation Tier runs on the radiologists desktop computer, a Pentium III (Intel, Santa Clara, CA) 500-MHz, 128-Mbyte RAM, 8-Gbyte hard drive connected to the main server via a 100 base-T switched Ethernet connection. The Business Rules Tier runs Windows NT server software (Microsoft, Redmond, WA) on a dual 600-Mbyte Pentium III server. This server processes all queries from the client and then initiates queries and receives responses from the legacy databases. The Data Tier consists of five databases installed on four different machines. Two of the databases are local copies of the data, and are fed by interfaces to the actual clinical system. Two of the databases are the actual clinical databases used by the original production application. The final database, the quality-assurance database, is maintained separately to ensure that professional quality-assurance information does not mix with clinical information.

Available clinical systems include the radiology information system (RIS), which encompasses all prior diagnostic imaging reports with automatic display of anticipated comparison report, and completed and scheduled diagnostic imaging examinations. The hospital information system (HIS) databases include patient clinical contact information and clinic schedules for outpatients. The laboratory information system data includes all chemistry, culture, and pathology results. Clinic notes system data include clinic progress notes, presentation history and physical, discharge summaries, radiotherapy treatment plans, and operative reports.

radStation has warning messages built in to its architecture. A warning will display if the report status of the bar-coded requisition is already at "films read." This prevents duplicate dictations. In bar-coding several examinations in sequence, the first one dictated is considered the master and the system will not accept a subsequent accession number if it does not correspond to the master patient. If a radiologist decides to cancel a dictation, this can be done by clicking the designated icon. The status of the procedure remains at "films unread." If the central dictation server is unavailable, the report is stored on the desktop PC until the central server becomes available.

DISCUSSION

The radStation system represents what we believe to be a benchmark in the evolution of radiologist's information access, as well as the communication of those results to clinicians. Previous authors have noted the need for integration of clinical databases to aid the radiologist.[1,2] Much of the integration focus has been on picture archiving and communication systems (PACS)-RIS-HIS interfaces.[3] These efforts often focus on making the PACS system more technically functional, but do little to address the radiologist's information needs. To our knowledge, no electronic medical record specifically targets the informational needs of a dictating radiologist in as efficient a manner as deployed in radStation.

In many respects, the system emulates what could be considered a model for a virtual electronic record. In our own institution, the information displayed was available to the radiologist by signing onto the HIS, entering the patient's hospital number, and navigating through several screens of data to retrieve pertinent information. This process, while capable of obtaining the needed information,

interrupted the workflow and made the radiologist less efficient in rendering interpretations.

We acknowledge the commercial availability of dictation systems that are interfaced into RIS systems with a bar-code displaying prior radiology reports. However, we are not aware of commercially available systems designed for radiologists that provide access to multivendor legacy databases in the context of a dictation system. The current system provides for display of clinical information (data) regardless of its origin. The use of a dictation microphone as an interface to a clinical information system is also unique.

A goal of radStation was to be an extremely easy system to master. Much effort was spent designing a simple yet elegant interface to available information. The automatic display of the comparison examination report obviates the need for the radiologist to click any buttons. For many dictations, the only interactions with the radStation system will be entirely with the dictation microphone. A normal follow-up report only requires a barcode swipe, manipulation of the microphone controls, and pressing on a button on the microphone to advance to the next report. However, the radiologist is able to read the prior report, observe a list recent examination, and view schedule information. The system anticipates in-depth information retrieval for the most complex case, as all radiology reports, operative notes, and pathology reports information are a click away, allowing for instant fulfillment of informational needs.

Perhaps the greatest feature of the radStation is the speed at which reports and other information are displayed. Once bar-coded, information display is complete within approximately 1 second. A report from the presumed comparison examination is automatically displayed. Additional radiology reports are initially retrieved as a set of pointers to reports that otherwise remain in the RIS. In benchmark testing, a selected report is displayed in approximately 1 second. This is certainly more efficient than paging through a stack of unorganized printed reports. The performance is similar to radiology reports retrieved directly with the RIS client. The radiologist is not precluded from using the RIS client for radiology report retrieval. However, with the availability of the other clinical information sources, the radStation has become the preferred method of report display.

The system also displays data regarding the patient's examination and appointment schedule. In our oncology practice, it is not unusual for a patient to be scheduled for a series of examinations to determine current disease status. This becomes important in several scenarios, including the observation of an unexpected nodule on a chest radiograph. If the patient is already scheduled for a chest computed tomography (CT) scan, the issued report could reference the scheduled CT scan rather than recommend that a CT scan should be ordered. This prevents the referring clinician from becoming confused by a chest radiograph report recommending a CT scan which he thought was already ordered.

Many information retrieval systems being deployed today use a web-based, specifically a browser-based method, of information retrieval.[5] Although we had initially envisioned a web-client system, this proved impractical given the digital dictation component of the system. The robustness of information display would be difficult to implement with a browser. The radStation use of information tabs to designate different data would be cumbersome to implement using an HTML-based interface. An often noted advantage of a web-based systems is the ability to change program features without having to distribute new client software to desktop. However, Windows NT architecture allows automatic distribution and install of updated client versions on remote desktops.

The system also contains an integrated peer review module. This module is discussed in an accompanying presentation.[6]

The radStation system makes our dictation system architecture more robust than our current telephone-based system. The telephone-based system will remain because a limitation of the radStation system is the lack of functionality to digitally edit submitted but nontranscribed reports. With the current architecture, if a radiologist needs to digitally edit a report, this must be accomplished with the existing telephone-based system. The telephone-based system consists of dictation station, telephone lines, and central dictation server. The radStation system consists of Boomerang microphone, desktop computer, Internet protocol network connections, and the central dictation server (same as a telephone-based system). In the telephone-based system, if the central dictation server disk archive fails, radiologists cannot dictate. With radStation, if the central server disk fails, the

reports will remain in a que on the desktop machine until the central archive has been restored. The hard drive on the desktop can store several days of dictation. It is unlikely that both the telephone and server connections will be disrupted. The dictation server and radStation server are in different locations. If a radiologist's PC fails, only that radiologist will be affected until that unit can be swapped out with an available spare. The telephone-based system can be used in the interim.

In our own institution, a question often raised is, "Will this system be able to render voice recognition?" The answer is yes. The digital file now sent directly to the dictation server is saved in .wav audio format. Most commercially available voice recognition packages accept .wav audio files as input. We envision implementing a change in workflow where copies of the audio file will continue to be sent to the dictation server, but a copy will also be sent to a voice recognition process and the processed text output sent directly to the RIS.

The system as currently deployed will continue to make available more efficient access to clinical information for patient management. As radiologists continue to use the system, specific suggestions are welcome to improve the usefulness of the system. As an example, in our institution, physicians are issued alphanumeric pagers capable of message display. As pager numbers are available for the referring physician, a button will allow the message to be sent directly from the application, rather than having to access another program. An interface to a teaching file application is also a priority. With the expansion of features, we intend to be vigilant against "featuritis," which could eventually diminish the application's performance and usability. As most suggested feature enhancements involve interfacing to existing systems, we will make a determination of whether the feature is best handled by the existing method or should be incorporated into the application.

CONCLUSION

The radStation system has been well accepted by staff radiologists. The system's training requirements are minimal: usually less than 5 minutes of instruction is required. This is in large part due to the system design, which relies on existing workflow, and requisition bar-coding as the major system interface. In automatically displaying the prior report and the patient's scheduling information, this fulfills the informational requirements for a major percentage of examinations. Further experience and study with the system will be needed to identify additional informational requirements. We anticipate that clinical systems that incorporate similar functionality to the described system will become commonplace in the future.

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