Economic and Clinical Impact of Filmless Operation in a Multifacility Environment

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The transition from conventional film-based to filmless operation at the Baltimore Veterans Affairs (VA) Medical Center has resulted in a large number of clinical and economic benefits. The integration of the Department of VA hospitals in Maryland into the VA Maryland Health Care System has resulted in the opportunity to establish a "virtual" radiology and nuclear medicine department. This integrated department is based on a wide area network in which outlying medical centers use a central hospital information system/radiology information system (HIS/RIS) and a central commercial picture archiving and communication system (PACS), as well as a VA-developed image management and communication system. The creation of this virtual radiology/nuclear medicine department has resulted in additional savings and improvements in clinical care. The benefits of the PACS are made possible, to a large extent, by the high level of integration of the PACS and medical modalities with the hospital information and transcription systems. Our experience suggests that it is absolutely essential to integrate the PACS into the patient's electronic medical record to maximize efficiency and clinical effectiveness of the system.

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ONE OF THE WAYS in which the department of Veterans Affairs (VA) has responded to Vice President Al Gore's challenge to "reinvent government" has been to move rapidly toward a comprehensive electronic clinical patient record system (CPRS). The adoption of this comprehensive electronic medical record (EMR) would permit health care workers to have easy and instant access to all forms of patient information. The data stored in the VA's EMR includes demographic information, allergy and medication data, problem lists, laboratory, admission, progress and discharge notes, and vital signs, as well as multimedia data such as patient electrocardiograms (ECGs), electroencephalograms (EEGs), and audiology studies. This EMR also includes the acquisition of images obtained throughout the health care enterprise, including pathology slides, dermatology, intraopera-

tive photographs, gastrointestinal (GI) endoscopy, bronchoscopy, and so on. Diagnostic imaging studies, including those obtained in radiology, nuclear medicine, cardiology, and the vascular laboratory, are also considered to be part of the patient's EMR. The goal of this transition to the EMR is to increase productivity while improving the quality of patient care. Our last 5 years of experience with filmless radiology in the Baltimore VA Medical Center and our 3-year experience with the multifacility VA Maryland Health Care System have given us the opportunity to evaluate the relative economic costs and benefits of an enterprise and network-wide PACS.

BALTIMORE VA MEDICAL CENTER

The plan to replace an aging suburban VA Medical Center with an ultramodern high-tech medical center located downtown on the University of Maryland Campus presented a unique opportunity. An extensive survey of the technology available in the late 1980s and early 1990s suggested that despite optimistic predictions, there was no system in operation that could meet our requirements. We subsequently wrote a Request for Proposal (RFP) that provided functional specifications that, if met, could provide a viable system. Fortunately, the Department of Defense (DoD) and the Hammersmith Hospital in London also had submitted RFPs for a hospital-wide picture archiving and communication system (PACS) which provided a "critical mass" of interest to encourage the vendor's research and development. All three of the organizations purchased a system from Siemens and Loral that has subsequently changed ownership to General Electric Medical Systems. The PACS uses a "centralized architecture" in which images are stored using a high-speed central server and are routed "on demand" to video memory on Apple (Cupertino, CA) Macintosh workstations, rather than being stored locally on the workstation hard drives.

The PACS, which included approximately 40 clinical workstations, was purchased in September 1991 for \$7.8 million dollars, which included approximately \$7.0 million for PACS and approximately \$800,000 for computed radiography. The

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system was installed and first became operational in June 1993, approximately 5 months after the Baltimore VA Medical Center opened. One of the most important questions in addition to the clinical efficacy of filmless or soft-copy operation was whether filmless operation could indeed be cost-effective using the then "state of the art" PACS technology. Our best guess at the time of initial operation was that a soft-copy department would be somewhat more expensive to operate than a conventional one and that radiologists, but perhaps not technologists, would be slightly (10% to 20%) less productive using this new technology. Both of these assumptions were subsequently found to be incorrect.

Although a few well-written articles were available in the literature, in general these were based on expected or potential savings with PACS or were extrapolated from a specific subset of the hospital such as the intensive care unit. Thus, there was little information to guide our expectations about the cost-effectiveness of PACS in an almost filmless environment.

Baseline data were collected from the hospital and radiology information systems, supply orders, personnel records, equipment procurement records, and other sources both before and after the transition to filmless operation. There was a substantial increase in volume from approximately 34,000 studies per year before filmless operation to more than 60,000 studies per year. This included a twofold increase in the volume of computed tomography (CT) and angiographic studies and the addition of magnetic resonance imaging (MRI), mammography, and bone densitometry, which were not available at the old hospital.

Despite this substantial increase in the volume of studies of more than 70%, the number of attending radiologists only increased from 4.5 to 5.5 with the additional radiologist position used to provide coverage for MRI and mammography. There was no significant difference in the number of technologists despite the increase in the number of studies and the complexity of the studies. The relative percentage of general radiographic studies in comparison to all other examinations decreased from approximately 74% to approximately 67%, resulting in an even larger increase in the weighted work units in the department.

Fig 1. Reduction in unread examinations.

BENEFITS

The benefits of PACS have been previously documented. One of the major benefits has been the virtual elimination of "unread" imaging studies. The 8% unread imaging study rate pre-PACS dropped to approximately 0.3% in 1996. These unread studies can be readily identified in a weekly audit using the HIS/RIS system and are subsequently interpreted (Fig 1).

The combination of the improved dynamic range associated with computed radiography and the ability to modify images using the PACS workstations has resulted in a decrease in the image retake rate from 5% to approximately 0.8%, an 84% reduction (Fig 2).

The transition to filmless operation has resulted in the elimination of a number of steps in the process in which imaging studies are made available for interpretation by the radiologists. This has reduced the interval from when a study is obtained until it is reported from several hours or often the following day to less than 30 minutes (during the normal workday). This "real-time" reporting has had a positive impact on the quality of patient care and perception of radiology services by our referring clinicians. This rapid reporting in conjunction with the purchase of an enterprise-wide digital dictation system has reduced the interval from

Fig 2. Reduction in image retake rate.

Fig 3. Report turnaround times (hours).

when a study is performed until it is dictated from approximately 24 hours to 2 hours.

These benefits have resulted in a strong (92%) preference for PACS versus film (3%, with 5% undecided) among the clinicians at the Baltimore VA Medical Center. Their perception is that the biggest benefit of PACS to their practice is the fact that it makes them more productive. In response to a formal survey, 98% of the respondents indicated that the PACS resulted in more effective utilization of their time.

COSTS

The two major contributors to the cost of the system are the depreciation and the service contract. With regard to the best figure for capital depreciation, the Department of Veterans Affairs uses an 8.8-year depreciation on medical equipment, while computer equipment is often depreciated using a 5-year time period. The other significant contributor to the cost of the PACS is the service contract, which is currently approximately \$500,000 per year. The service contract includes all of the personnel required to operate and maintain the system. It also includes software upgrades and replacement of all hardware components that fail or demonstrate suboptimal performance. This includes replacement of any monitors that do not pass the quality control tests. No additional personnel were required other than those provided by our vendor for the service contract.

SAVINGS

Savings in the radiology department were achieved in a number of different ways. Current film costs are less than \$10,000 and include the cost to print mammograms, and to print films for patients who are sent to other hospitals and outpatient departments and for conferences that are held at the University of Maryland. This is only 5% of the estimated \$200,000 that would have been

required to support our current volume had we stayed in a film based environment.

There have also been other decreases related to the almost complete elimination of film. These include the decreased need for film folders and the decreased need for film chemistry. These savings are relatively modest and total approximately \$15,000 per year.

One of the largest, and to some extent unexpected savings associated with PACS has been the ability to recover space in the radiology department. The current film file room occupies approximately 2,500 square feet and is divided into two halves. The back half has been used for the PACS computer room (although this is more space than is actually required). The front half has been used to store films from the 6 years of operation before June 1993 and a limited number of new films such as mammograms generated during the past few years. Using relatively conservative figures, construction costs are estimated at \$180 per square foot for the file room, and \$20 per square foot per month. Consequently, recovery of this space for other purposes such as a MRI scanner and offices would avert \$230,000 in construction costs and \$307,200 per year in space costs.

The biggest savings associated with PACS at the Baltimore VA Medical Center have been in personnel costs. Given the 76% increase in volume, we have conservatively estimated that at least two additional radiologists would have been required at Baltimore even assuming a major increase in productivity per radiologist. Additionally, we estimate that, using national standards for technologist productivity, we would have required three or four additional technologists to keep up with the volume. For example, we have previously documented¹ a greater than 50% reduction in the time

Fig 4. Effective use of clinician time.

required for a CT technologist to perform a study in a filmless environment.

There has been an elimination of all but one of the film room clerks required to maintain the film library and transport film throughout the medical center. This has resulted in savings of approximately \$100,000 per year.

COST-BENEFIT ANALYSIS

Using conservative estimates of cost savings from the data described above and a depreciation time frame of 5 years, we have estimated that the additional cost of PACS is slightly less than the savings generated by the system. This conclusion has been subsequently supported by a recent study of the PACS at the Baltimore VA Medical Center performed by a group of investigators from Johns Hopkins. This is consistent with a number of authors who have suggested that although PACS may pay for itself, it is unlikely to result in considerable savings in the imaging department itself. These data suggest that our initial guess that filmless operation in radiology and nuclear medicine would be more expensive than conventional film-based operation was, in fact, incorrect.

ECONOMICS OF PACS FOR THE ENTIRE HOSPITAL

The hospital-wide savings associated with filmless operation are more difficult to quantify. The average clinician estimates that he or she saves approximately 50 to 70 minutes per day because of the improved image accessibility associated with the PACS. Our estimates are that they probably save a more conservative 10 to 12 minutes per day. However, when applied across the entire institution, even these more conservative estimates result in savings of approximately two to four clinician

full-time-equivalent positions (FTEs) per year. This represents savings of between \$200,000 and \$500,000 per year just in clinician time. A number of other, even harder to quantify, cost benefits are associated with the PACS. These include decreased waiting times for radiology reports (typed report turnaround has decreased from 24 to 2 hours), which has the potential to impact on length of stay, increased clinician efficiency and accuracy in patient care, decreased medicolegal risks, and savings associated with a decreased rate of lost studies. Even ignoring these latter benefits, the savings of \$200,000 to \$500,000 are considerable.

ECONOMIC BENEFITS FOR A NETWORK OF HOSPITALS

As of June 1995, the four Department of VA Hospitals in Maryland have been combined into a single integrated Health Care Network, the VA Maryland Health Care System. These four hospitals, Baltimore, Ft Howard, Perry Point, and the Rehabilitation and Extended Care Facility, all share a single hospital director, hospital information system (HIS) and radiology information system (RIS). The imaging departments have also been combined into a single "virtual" imaging department that shares the radiology/nuclear medicine commercial PACS located in Baltimore. These additional facilities have added an additional volume of more than 33%, resulting in more than 80,000 studies per year for the combined network.

This integrated imaging service was accomplished by converting the two "higher volume" facilities to 100% use of computed radiography for general radiographic examinations. These studies, in addition to CT examinations, are sent to the commercial PACS at Baltimore for archival and, in many cases, for primary interpretation. The integration of radiology services has resulted in the ability to provide subspecialist expertise to supplement the general radiologists located at those sites. This centralization of imaging studies in Baltimore has permitted a decrease in radiologist coverage by 50% at those outlying facilities without an increase in turnaround times for reports. Patients can be more easily triaged before they are referred to the tertiary referral center (Baltimore), and when those patients are transported, their images have already been reviewed before their arrival. The use of the PACS has resulted in a significantly improved ability to provide back-up and subspecialty cover-

Fig 5. Decrease in CT technician examination times (minutes).

age for the radiologists at the other three Maryland VA facilities.

The resources required to add an additional facility to the PACS network have been relatively small, with the costs being less than 20% of the cost of a separate system at those facilities. The major cost thus far has been in the computed radiography equipment, which in addition to the networking equipment has represented an investment of approximately \$200,000 to \$250,000 per institution. The costs saved at those institutions are estimated at approximately \$200,000 per year despite the fact that they have not yet made the transition to filmless operation.

VISTA IMAGING

The VA's VISTA PACS is currently used within the VA Maryland Health Care System for nonradiology/nuclear medicine images such as pathology, GI endoscopy, and dermatology. However, given the fact that it uses standard Windows 95 and Windows NT workstations, which are already deployed throughout the enterprise, it has the potential to play a major role in the distribution of imaging studies throughout the enterprise. This is particularly true for the facilities outside Baltimore, which do not have the commercial PACS. In these medical centers, the VISTA imaging system has the potential to provide most or all of the functions of the commercial PACS at Baltimore for the clinicians using affordable desktop PC's that are already being used for office automation and the electronic medical record.

The VA's VISTA imaging system developers are currently working on software and hardware systems that would be optimized for the radiologist to make primary diagnosis. These two- to four-monitor $2,500 \times 2,000$ pixel workstations with the new software designed for radiologists are being tested in the Wilmington, Baltimore, and Washington VA Medical Centers. The potential advantages of such an internally developed PACS would include an extraordinarily high level of integration with the remainder of the electronic medical record, as well as relatively low costs for the software and minimal mark-up on the required hardware and software costs. The biggest challenges of such an internally developed PACS will be in the maintenance and support of the system, as well as the development of a system sophisticated enough to

meet the demanding requirements for speed and usability of radiologists.

IMPORTANCE OF INTEGRATING PACS INTO THE HEALTH CARE ENTERPRISE

The integration of the PACS and our medical equipment with our existing information systems has been essential to the success of the project. The HIS/RIS interface to the PACS results in the ability to transfer electronic ordering information and radiology reports so that the radiologists are not constrained by waiting for the paper imaging request forms and can operate in a more efficient paperless environment using automated worklists. The interface also permits automatic "prefetching" of examinations from the slower long-term archive to the much faster short-term storage at the time a study is ordered so that it can be available to radiologists and referring clinicians immediately. The interface between medical modalities such as computed radiography, CT, and MRI has resulted in substantial improvements in speed and accuracy of the patient demographic data entered by the technologists. An integrated transcription system permits transcriptionists to work at home, listen to digital dictations, and transcribe them directly into the RIS with automatic transfer of these reports into the PACS. The interface between the commercial PACS and the HIS PACS permits automatic transfer of radiology and nuclear medicine images across the wide area network to relatively inexpensive personal computers located in clinical and administrative areas. This integration of the PACS and other medical imaging and transcription equipment with the hospital's information systems has been a critical element in the success of the system.

DIGITAL IMAGING AND THE DEPARTMENT OF VETERANS AFFAIRS

The VA has, within the past few years, reorganized into 22 geographic networks throughout the country known as Veterans Integrated Service Networks (VISNs). These Integrated Health Care Networks are in a particularly good position to take advantage of the potential benefits associated with digital radiology. One major factor is the fact that VA facilities are considered to be located on federal rather than state property. This permits sharing of images across state lines without worrying about issues of state licensure. The medical centers within

the VISNs are being encouraged to minimize duplication of services. For example, in our VISN, the Baltimore VA Medical Center has a particularly strong neurosurgery and neuroradiology program while the Washington, DC VA Medical Center has an excellent cardiac surgery department. This encourages the development of "centers of excellence" within each VISN, with sharing of patients and their electronic medical record among the facilities. Teleradiology and PACS technologies have been used to increase image accessibility and to maintain or improve the quality of care while keeping costs low. The short-term plans of many of the VISN's include major acquisition of digital imaging equipment, including large-scale teleradiology and PAC systems.

In the medium and long term, the VA will continue its trend toward the use of teleradiology and PACS to improve image accessibility and access to expert radiologic services. Although sharing between VISN's is currently limited, this will likely increase in the future. To prepare for this, the Department of Veterans Affairs will need to begin to formulate a plan to maximize the interoperability of the various commercial PAC systems. During the next few years, the relative role of the VISTA imaging system and commercial systems will become clearer. It is likely that in the

next couple of years, these systems will act synergistically to provide a combination of the relative strengths of the commercial and internal VA systems. It is also likely that there will be much greater sharing of radiology services and digital imaging equipment between the various government health care organizations. These include the VA, the DoD, the Indian Health Service, the National Institutes of Health, the Immigration and Naturalization Service, and the Federal Prison System. PACS and teleradiology technologies, combined with improved national network infrastructure, will result in continued reinvention of the practice of diagnostic imaging within the Federal Health Systems. This will undoubtedly lead the way toward changes in the practice of radiology and nuclear medicine in general.

The promising results at the Baltimore VA Medical Center and in the VA Maryland Health Care System need to be further studied. Other large scale PACS projects that are hospital, outpatient, and network based in both academic and community settings need to be analyzed to determine the relative costs and benefits of the technology in other settings.

REFERENCE

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