Providing Complete Multimedia Patient Data to Consulting Radiologists, Other Specialists, and the Referring Clinician

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IMAGE STORAGE and communication is very important in the practice of medicine. A wide variety of images are used in treating patients, including xrays and other radiology images, drawings, photographs, endoscopic pictures, and graphical data such as electrocardiograms. Images are an important part of the medical record of the patient, but they are not normally stored in the patient's chart. With today's technology, the VA is digitizing, storing and distributing medical images along with the patient record using workstations located throughout a hospital and across the wide area network.^{1,2}

The major goal of the VA's Integrated Imaging System is to provide complete patient data in an integrated manner that facilitates the clinician's decision making. Images and associated text data are available at any time throughout the hospital on windows-based workstations that are interfaced to the main hospital system in a client-server architecture. The system handles high quality image data from many specialties including cardiology, pulmonary and gastrointestinal medicine, pathology, radiology, hematology, and nuclear medicine, as well as textual reports from the hospital information system, scanned documents and electrocardiograms. The system improves the quality of patient care, enhances clinicians' communication, and is used routinely at conferences, morning report, and during ward rounds.

SYSTEM ARCHITECTURE

A local area network connects imaging workstations to multiple magnetic and optical disk image file servers, to the VA's hospital information system, and to commercial systems. The local area network uses Ethernet (10 or 100 mb/sec) and conforms to the EIA-TCA 568 structured wiring standard. The multimedia workstation platform

used in the VA is based on PCI-bus Pentium Pro systems containing video display boards with at least four megabytes of memory. Digital image capture may be performed directly using the workstations. Workstations are located in a number of departments and patient care areas.

The VA uses a hospital information system (HIS) called Veterans Health Information Systems and Technology Architecture (VistA) that was developed internally. A client server architecture allows clinical workstation clients to communicate with hospital information system servers. Windows-based software on the workstations communicates with HIS servers using VA's "Remote Procedure Call (RPC) Broker" software. All messages are processed through the broker software that performs the requested operations on the HIS and returns the results to the workstation via a TCP/IP message. Security logon and server connection is also handled by the broker software. With the proper security privileges, a workstation user may connect to any HIS server on the wide area network. Workstations currently run the Microsoft Windows 95 or NT operating system. Software running on the workstations is written in Borland's Delphi or Microsoft Visual Basic, except for integrated off-the-shelf products. The V.A. toolkit and the broker software allow the integration of multimedia data.

Images are accessed and displayed on the workstation client from Windows NT servers or via calls to an API for electrocardiogram waveforms. Images are acquired using frame capture boards in the workstations, TWAIN or SCSI interfaces, or via DICOM interfaces. The HIS stores the information about the patient's images and their association with other patient record data. Image servers may be purchased as off-the-shelf commodity items, or provided as part of medical equipment. Windows NT magnetic and optical disk storage is automatically handled by the HIS image management software and is indistinguishable to the user except for differences in image display times.

All VA facilities are connected by a wide area packet-switched network consisting of 23,000 miles of fully digital optical fiber network with four backbone nodes and twenty-two tributary nodes.

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Frame relay running at 1.544 megabits/second connects a large number of VA medical centers. Additional T1 or ATM communications lines have been installed between centers that share a large amount of data. The wide area network carries TCP/IP traffic to all sites, thus moving images, HIS communications, and DICOM messages.

USER INTERFACE FOR DATA DISPLAY

The clinical workstation allows users to view the multimedia electronic medical record, a record which goes far beyond the paper chart in functionality and readily available information. It serves both treating clinicians and consulting specialists, and provides display, capture and telemedicine functionality. The workstation's user interface displays integrated data from different sources, including:

- HIS components such as laboratory, radiology, pharmacy, health summary, discharge summary reports

- a variety of images from the VA's VistA imaging system
- images from commercial image systems such as Radiology PACS
- other multimedia systems such as electrocardiogram systems

Users sign onto the workstation with their hospital information system security logon codes. They select a patient and then view the patient's multimedia longitudinal medical record. A number of windows are used to display the patient's image and text data (Fig 1). A menu of small thumbnail images allows the user to select images for more detailed viewing. Special windows are provided for color images, grayscale images, and document images. Procedure reports pertinent to the image are available with another click of the mouse. This "visual chart" capability is typically used by treating clinicians reviewing the patient's course, assessing progress, and determining treatment plans. Specialists often review data related to a particular

Fig 1. A patient's multimedia medical record includes images and hospital information system reports displayed in multiple windows.

clinical procedure or a patient's medical condition when dictating their reports.

ABILITY TO CAPTURE IMAGES

Images may be captured using workstation hardware (via frame grab, TWAIN or SCSI interface), they may be transmitted from independent systems (via a DICOM or other interface), or they may be accessed by the workstation's display software via a vendor-provided API. Workstation image capture within the V.A. is done in a number of locations (Table 1). Consulting services generally collect images during a medical procedure for diagnostic or follow-up purposes. After logging into the workstation, the user identifies the patient and the study being performed. Image capture requires only the click of a mouse button. The user then enters any pertinent descriptive information related to the image, and clicks a button to save it to the patient's record. This simple procedure takes less than thirty seconds, and the result is more informative than a textual description of the image.

Typically, the clinician who performs the procedure selects images that are significant to the patient's diagnosis or treatment course. Most images are linked to the procedure report in the hospital information system. The number of images captured per procedure varies by the specialty and is determined by the users themselves. Radiology and nuclear medicine images are best obtained across DICOM standard interfaces in digital form. With such automatic modality interfaces, all images are generally captured, including negative exams and those images that may not be clinically significant. The VA has interfaced several commercial radiology PACS systems with its hospital information system using the DICOM standard.

Table 1. Typical Image Input Workstation Locations

Cardiology
Gastrointestinal Endoscopy
Bronchoscopy Examination Room
Surgical Pathology Reading Room
Hematology Laboratory
Dermatology Clinic
Emergency Room
Rheumatology Clinic
Operating Room
Cystoscopy Suite
Radiology Department
Nuclear Medicine Department
Dental Clinics
Ophthalmology Clinic

These interfaces send patient data to the PACS and deliver images to the VA's imaging system.

BENEFITS OF A MULTISPECIALTY IMAGING SYSTEM

Clinicians find that the Imaging System provides a number of benefits to care providers and patients including:

- it improves the quality of patient care by providing all patient data
- it reduces the possibility of error based on lack of data or nonstandard terminology used to describe images;
- it increases communication among clinicians, improving continuity of care when multiple specialists are involved
- it reduces physician time spent searching for data;
- it aids patients in understanding their problems;
- it allows consultation with physicians at other sites;
- it assists in physician education;
- it reduces costs by avoiding film printing

Clinicians use the Imaging System during conferences, rounds, in the emergency room, operating rooms and intensive care units, on wards, in clinics, and in their offices. For consultation and medical record access for patients at distant locations, clinicians connect to systems across the VA's wide area network. Most recently, the system has been tested for home-based care.

The availability of a full range of patient data from a single source—the clinical workstation—is a key factor in system efficiency, usability and user acceptance. Because the system is integrated, data that is entered into any part of the system serves all users. This results in a system that contains a "critical mass" of information. Users are more likely to find what they need from the system, therefore they look first to the system, and find it cost effective to place information in the system. Reaching this critical mass is essential to achieve the maximum benefits from an integrated patient record system.

REFERENCES

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