A Digital Imaging Transformation In Radiology Departments

In the near future, institutions will turn to health care IT technologies to deliver the tools needed to produce and distribute information that directs the diagnosis and treatment of patients.

Michael W. Jackman, Kodak Health Imaging Group

Converting the explosion of information gained from modern imaging studies into useful clinical information is one of the key challenges for radiology departments across the nation and the world. New picture archiving and communication systems (PACS) and radiology information system (RIS) platforms promise to harvest and store this data and provide rapid access for referring physicians and specialists. As future imaging technologies introduce increasingly more detailed clinical information, institutions will turn to health care IT technologies and services to deliver the tools needed to produce and distribute the information that directs the diagnosis and treatment of patients.

Dramatic Growth in Image Capture

The medical imaging community is experiencing a dramatic growth in digital image capture, which is being fueled by several factors: 1) an overall increase in imaging volumes due to an aging population, 2) the widespread use of multislice modalities, and 3) increased use of digital image capture for projection radiography.

Health care facilities across the country are seeing 3 to 10 percent annual increases in imaging volumes, and these percentages are expected to rise at most facilities. The number of images captured on magnetic resonance and ultrasound modalities continue to grow exponentially, as do general radiography procedures. One large U.S. hospital conducted 32,000 computed tomography (CT) procedures in 1995. By 2002, the number of CT procedures tripled and now continues to grow at about 10 percent a year.

Another key factor is increased exam information density. CT scans that were once 40 images have ballooned to 4,000 images with multislice CT systems. A routine chest or abdomen CT will generate 300 to 500 images, while a CT angiography runoff study will generate 1,600 to 2,000 images. Current stack mode methods for dealing large-volume data sets are inadequate.

Digital imaging has also entered projection radiography, with placements of both computed radiography and digital radiography (DR) expected to achieve double-digit gains for the near term, with DR placements projected to grow at 30 percent a year for the next several years.

Transforming Data Into Valuable Information

This dramatic increase in information and images needs to be channeled into useful clinical information – therefore an efficient solution to manage, store, and view these images becomes an economic and clinical necessity. This need accounts for increased implementation of PACS. Until very recently, images from many modalities were diagnosed on soft copy but were output to radiographic film for storage or for referring physicians. Now, however, PACS technology has matured and platforms have become more flexible and fully featured.

As a result, PACS adoption is expected to climb from about 10 percent of facilities in the United States to about 75 to 80 percent by 2012. Some industry analysts argue that up to 90 percent of health care facilities will have a PACS platform by 2010.

Outlining An Efficient New Digital Workflow

Let's examine how capture, networking, archiving, and output technologies work together in an efficient new digital workflow.

1. An order is prepared by the hospital information systems (HIS)/RIS and sent to the PACS server. The PACS server software includes many functions, such as auto-routing, data-

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base management, online storage management, Web server, and workflow management.

2. Once the order is received at the PACS server, the server will use search parameters to look for relevant prior studies. Relevant prior imaging studies are pre-fetched (if stored in long-term storage systems) and loaded onto the PACS server. Alternatively, the reading physician can fetch current and prior radiology reports and imaging studies from the PACS server once the patient's name appears on his worklist.
3. The modality worklist is prepared by the HIS/RIS and sent to the relevant modalities.
4. The patient arrives in the hospital the next day for a head scan. The image data is pushed to the PACS server, backed up on the long-term storage, and pushed to the diagnostic workstation. The radiologist views the imaging study using electronic hanging protocols, other digital tools, 3D tools and even computer-aided detection. She marks key images and dictates a report.
5. These key images are automatically pushed to the PACS server, and the report goes to the RIS. The RIS, in return, sends a copy of the final report to the PACS server. The PACS server backs up the report and key images onto long-term storage. Radiology reports and imaging studies are available immediately to physicians throughout the hospital.
6. The next step is to make the report and images available to referring physicians. The PACS server can create an automatic, encrypted email containing both the report and key images and send it to the referring physician.
7. The referring physician views a one-page summary of the radiology report as well as key patient images.
8. A referring physician can view either the entire case or key images in full resolution by clicking on the "entire case" or "key images" link in the email. Patient identification data is

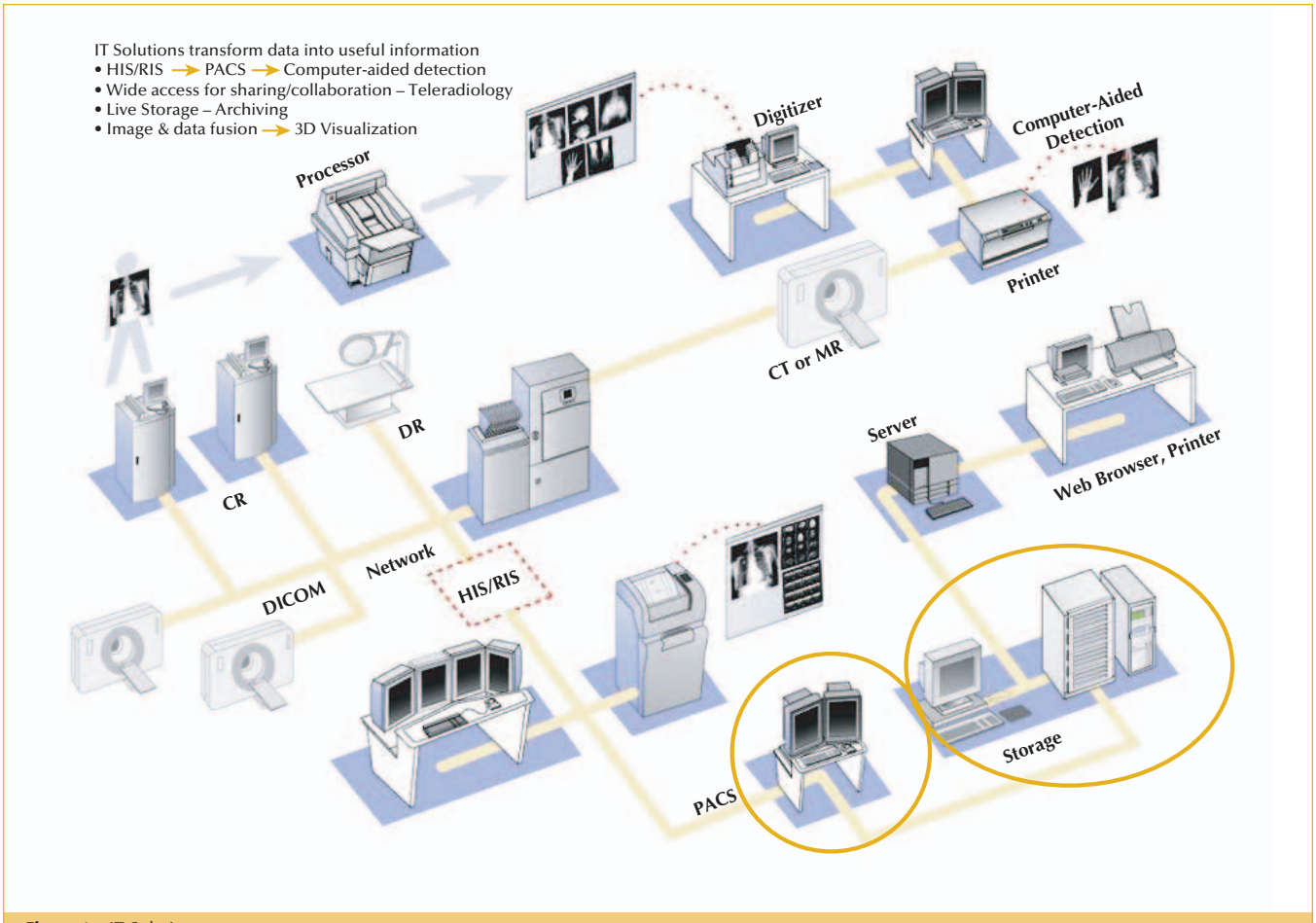

Figure 1 IT Solutions

automatically transferred to the Web server portion of the PACS server, and the Web server starts streaming the whole study (or key images) to the referring physician.

9. The referring physician can now study the case with the tools of an advanced radiology workstation. If he has a question for the radiologist, he can attach the relevant image to an email, annotate it, and email the question to the radiologist. If the referring physician is not online, the data (study, report, previous reports, and key images) can be delivered on a self-playing CD.

A Digital Workflow Enables Many Benefits

This efficient digital workflow enhances radiologists' productivity because current and prior imaging studies are available instantly for side-by-side viewing. Accurate electronic measurement tools can be used. Customized hanging protocols automatically bring the images up in correct order for review on workstations.

In addition to efficient review, storage, and distribution of images, a digital imaging and information platform enables new clinical tools such as computer-aided detection to be efficiently employed. Computer-aided detection can enhance efficiency and accuracy, especially in screening efforts. Computer-aided detection systems for use with digital and film mammography systems are currently available, and the application of computer-aided detection to lung cancer detection is close to commercialization.

PACS also enables teleradiology capabilities. Health care facilities can employ follow-the-sun services to use radiologists in different time zones or even overseas for nighttime reading.

3D viewing is also being integrated into PACS platforms and is an extremely powerful means of transforming vast amounts of data into useful information.

Consider a case with two original, cross-sectional images (out of 200 acquired CT slices) and one 3D rendered image of 200 slices of the heart. The patient had a triple coronary artery bypass surgery. An aneurysm has developed in one of the bypasses. While detecting the aneurysm from the original 200 slices alone is a difficult and time-consuming task, the 3D-rendered image provides the diagnosis to the cardiologist at a glance. The original slice data (200 images) consumes 100 MB. The volume of the email with the referring physician's report is only 100 KB. This is an example of transforming data (the CT slices) into useful information (the 3D-rendered image). The volume-rendered image in the email represents a compression of approximately 1500-to-1 of the acquired data.

A cardiologist who receives an envelope with 15 films containing the 200 slices and a paper report will have to spend a considerable amount of time to visualize the situation of this patient (three bypasses and an aneurysm). On the other hand, an email can deliver the diagnosis at one glance. If he wants to view individual slices, he can click the "entire case" link on the email and have the whole set of data delivered to his computer.

This proliferation of new digital technologies creates an urgent need for providers of IT services to design, link, and implement health care IT solutions. A variety of services, from site preparation to project management and integration services are now available to help health care facilities implement PACS/RIS and handle integration with new or existing information networks. Outsourcing services are also available for data management (either onsite or offsite) and secure email systems.

Mark Thornberg
2.18.04

Patient: Mark Thornberg DOB: 9.7.48
Sex: M
Patient Loc: IN20
Patient Status: O
Physician: Dr. J.B. Pierce
Wa17261-51 02.18.04 10:05 a.m.
Requested by: Dr. Wallace

CT Thorax/Abdomen
Diagnosis: H.A.
History: H.A.

Findings: *Aortocoronar venous bypasses to the right and the left coronary artery, and the ramus circumflexus.*

Impression: *The bypass connecting the aorta and the right coronary artery has developed an aneurysm.*

Entire Case

Key Images

Radiologists: J.B. Pierce, M.D.
Transcribed on: 02.18.04 at 10:15 a.m.

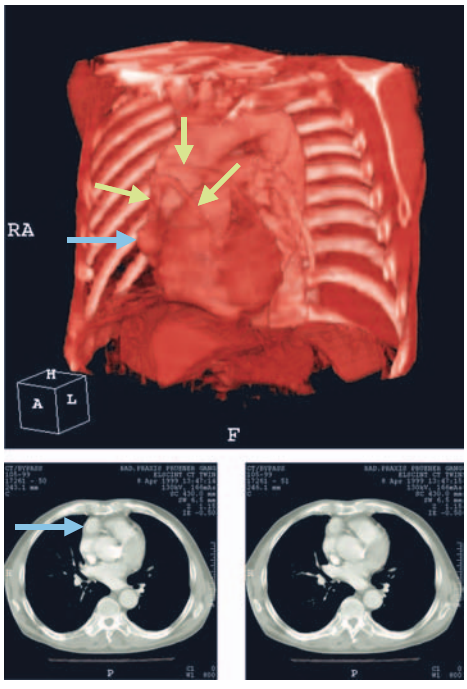

Figure 2 Referring Physician's Report

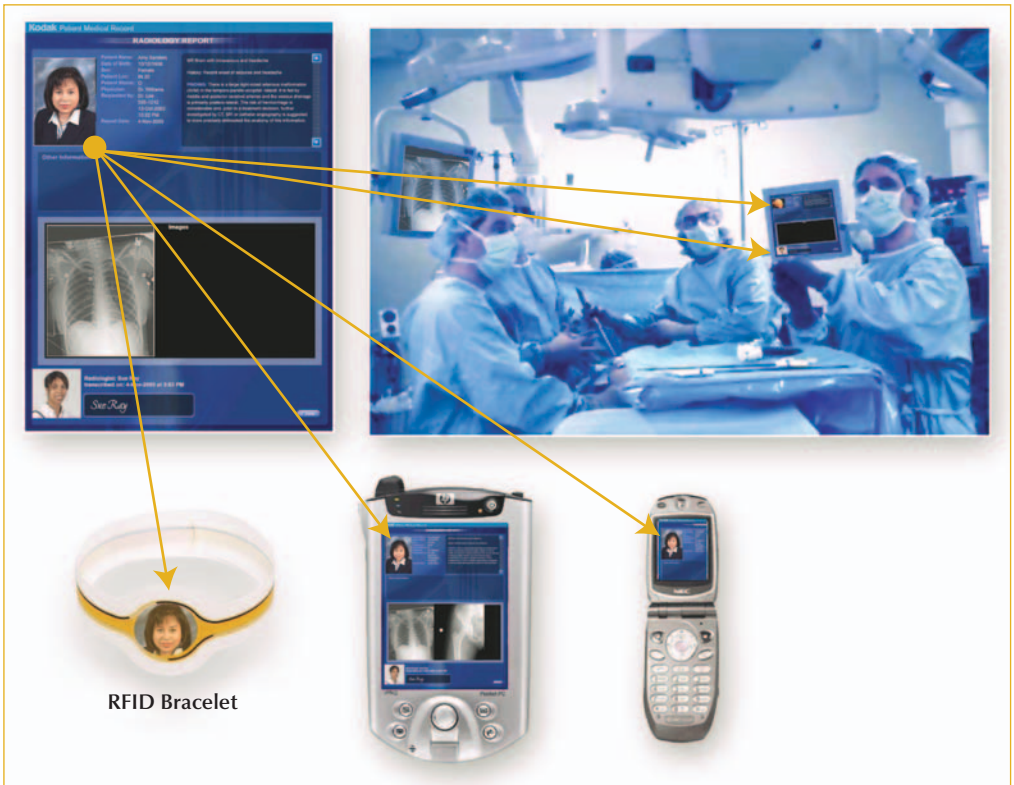

Figure 3 Networked Health care

Looking Into the Future

A look at the future reveals electronic health records where all the information is digital, accessible through the Internet (with secured wireless access) and can be efficiently used by medical professionals, insurance companies, and patients.

Tomorrow it may be possible for surgeons in the operating suite to have on demand video conferencing with other specialists to solve unexpected issues that arise during a procedure.

In order to combat medical errors, patients will soon have bar coded identification bracelets and RFID bracelets with a patient's photograph is also on the horizon. Hospital communications with government agencies and health care participants will also be improved. Inefficient communications via phone, fax, or EDI (electronic data interchange), will be replaced with automatic sharing of data across a secured interconnected network, allowing multiple authorized participants to access information at the same time.

Hospital communications with payers, government agencies, and health care participants will also be improved. Inefficient communications via phone, fax, or EDI will be replaced with automatic sharing of information and images across a secured interconnected network, allowing multiple authorized participants to access information at the same time.

In summary, the medical imaging community is experiencing a dramatic growth in digital images – due to image-intensive imaging modalities and a widespread conversion to digital image capture for projection radiography. Radiology departments will increasingly turn to health care IT technologies and services to manage these new technologies and harvest the expansive clinical information that they represent. ■