Taking the PACS Power to the People

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HENNEPIN COUNTY Medical Center (HCMC) is a public teaching hospital in downtown Minneapolis, Minnesota staffed by approximately 360 physicians and dentist members of Hennepin Faculty Associates who supervise the advanced medical training of approximately 220 resident physicians. Staff physicians are also members of the University of Minnesota Medical School faculty.

Hennepin County Medical Center occupies five city blocks near the Metrodome and also operates primary care clinics in south Minneapolis, in the southern suburb of Richfield, in north Minneapolis, and in the northern suburb of Brooklyn Center. The downtown location has 434 hospital beds (more than 100 intensive care), 16 operating rooms, four primary care clinics, and scores of specialty clinics and outpatient programs. In 1997, these clinics recorded more than 313,600 patient visits and counted more than 124,300 unduplicated patients.

Hennepin County Medical Center was named Minnesota's first Level 1 Trauma Center in 1989. Hennepin County Medical Center's Emergency Department is the most active in the state, experiencing approximately 85,000 patient visits and 48,000 ambulance runs annually.

WHY UNDERTAKE PACS FOR HCMC REMOTE FACILITIES?

The initial objective of the Picture Archiving and Communication System (PACS) project at Hennepin County Medical Center was the automation of the critical care network. The critical care network at Hennepin County Medical Center was primarily comprised of the radiological studies from the Emergency Department (ED) and Intensive Care Unit (ICU) departments. Not only was computed radiography (CR) equipment and PACS workstations placed in these areas, but the building of an optical disk archive was initiated.

As the PACS program began to stabilize and the success of the project in eliminating the problems surrounding the film-based systems gained visibility (lost or mis-filed studies, long delivery times for requested images by the clinicians, etc), the desire to leverage the border-less aspect of the PACS

technology gained in priority. The trend to a higher percentage of outpatient care services in the local healthcare marketplace began to be reflected in the patient population being serviced by Hennepin County Medical Center.

The volume of studies initiated in the three remote facilities affiliated with Hennepin County Medical Center increased to the levels shown in Fig 1 with consumer surveys supporting a continued growth in this area.

In addition, the availability of multiple offsite clinics brought with it the problem of patients being treated at different facilities for different visits. The Hennepin County Medical Center marketing campaign didn't help as it was quick to emphasize the "one healthcare service provider" aspect of its remote clinics. Now it was up to Medical Imaging to operationalize this consumer expectation as far as their imaging records were concerned.

To overcome the consumer assumption that the separation from the main facility could possibly lead to time delays in the care delivery process itself, a "one visit" objective was established as a monitor of the expediency of the offsite care services. This objective could only be achieved with a networking of the remote and main sites to facilitate access to historical patient records and permit timely consultations with specialists, such as radiologists, physically located at the main facility.

RESULTS

Clinic-Hospital Teleradiology

Once the decision to expand PACS to the remote sites was elevated to being a strategic initiative, any economic benefits were considered icing on the cake. The cost of the network expansion had a

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Fig 1. Actual and projected volume studies originated at the remote clinics.

network component cost of between \$25-\$30,000 capital expense and an actual operational expense of \$7500 per location. The PACS devices (excluding Ultrasound) being installed came in at a capital expense just over the \$100,000 mark.

The more important variable being tracked was the improvement in overall turn-around time of radiology reports. A quantification of these turn-around times is outlined in Fig 2.

All medical imaging archives were relocated to the main facility. The main hospital and the largest clinic had started to build separate optical platter-based digital archives on a system from Eltrax Imaging Systems. Following the development of a DICOM interface module for the Eltrax (now Emerald Archiving, Inc) system, the clinic-based historical data was merged into the main facility patient data base. These older studies are now transferred on-demand from the Emerald Archiving System to the PACS system as the patients represent at any of Hennepin County Medical Center's facilities.

Clinicians at the remote sites now have access to all radiographic studies conducted at any of the other facilities. In the event that a very old study is desired for comparison interpretation, a quick phone call to the main file room will result in a "push" of

the study from the Emerald Archiving System or a digitizing of the old film. In either case, the maximum response time for having the requested study on the workstation at the clinic is less than 15 minutes (and more typically 5-7 minutes).

The other patient care benefit of deploying PACS at the remote sites, is in regard to immediate consultation with the radiologist in the event of a STAT case or a pathology suspected by the clinician. Both radiologist and clinician can view the image simultaneously to improve the effectiveness of the dialogue and the expediency of the recommended course of action. The achievement of the "one-visit" objective has been measured since the onset of the PACS expansion. The number of repeat visits saved is estimated at 30 to 36 per annum with the primary beneficiary being the patient him or herself.

MOBILE IMAGING FOR VERY LOW STUDY VOLUMES

Taking radiology door-to-door is not a new concept for Medical Imaging. Conventional Xray, CT and MR all have enjoyed the privilege of being shared by multiple institutions for their imaging requirements. Today, most major equipment vendors are able to outrig an 18-wheeler to partner with

Fig 2. Overall average turnaround time for remote clinic initiated studies. Turnaround time is defined as end procedure time to final report.

a healthcare institution to expand its reach to rural areas. For Hennepin County Medical Center, taking the program on-the-road, meant finding a way to expand its PACS reach for its lower volume study types such as ultrasound.

Similar to its other clinic-based services, patient surveys supported the remote ultrasound concept as a way to keep the healthcare practice in the neighborhoods without a loss of service quality. Installing a separate ultrasound scanner with sufficient capabilities at each location was felt to be cost prohibitive at least at the volumes reflected in Fig 3.

A more formal cost benefit analysis (Fig 4) substantiated this feeling but at the same time it quantified the cost of the non-clinic based solution as being worth the investment even if only for strategic purposes.

Network Addressing for Mobile Devices

Technologically, the mobile ultrasound solution offered some additional challenges to the forefront. Hennepin had installed the Ultrapacs system from ALI Technologies for networking ultrasound at its main facility. Video tape was replaced by digital

archives for almost 100% of the hospital study volume. Even portable studies were captured digitally on a Siemens scanner to a hard disk and then downloaded to the digital archive via DICOM when the tech returned to the department. One hundred percent of the studies were being interpreted "soft copy" and film output was supplanted by the printing of 6-8 images of clinical significance on a color laser printer. If needed, hard copy film was provided to clinicians, primarily the surgeons, via a DICOM interface to the main PACS system to access the Kodak laser imager available on that network. In other words, taking Ultrasound mobile, meant taking the Ultrapacs system mobile as well.

The main technological hurdle to overcome came from the network addressing. As the sonographer's workstation and ultrasound scanner moved to the different clinic locations, the TCP/IP addressing caused the routers in the network to "detect" the workstation coming in through different network paths. This generated router table conflict errors. There were two alternative solutions to address this problem:

Fig 3. Actual and projected ultrasounds originated at the remote clinics.

Fig 4. Cost analysis of clinic-based and van-based ultrasound solutions. Depreciation is based on a 5-year straight line schedule for ultrasound devices and shared network components.

1. Have the workstation be assigned a unique IP address for each location.
2. Use a dynamic IP address server, or DHCP (Dynamic Host Configuration Protocol), server to assign an address to the workstation from a range of numbers it had stored for remote access devices (similar to the dynamic addressing used by Internet Service Providers).

Solution number 1 proved too cumbersome to operationalize. The ultrasound tech would need to make sure that very specific startup and shut-down procedures were followed. If a mistake was made it could mean returning to the previous site to correct it. In addition, the tight client-server architecture of the Ultrapacs system was not conducive to a continual re-assigning of the IP address to the same workstation.

The second alternative brought a different set of problems to light. Hennepin County Medical Center did not have a DHCP server and was just at the beginning of its initiatives to provide any sort of secure remote access to its facility. Implementation of this solution is currently in an alpha testing phase.

As an interim solution, ALI Technologies offered a third alternative. The company would partner with Hennepin County Medical Center in providing some additional sonographer workstations until such time as the DHCP environment would be implemented. The offer was accepted and the mobile ultrasound service came online in September 97.

Rave Reviews in the Community

The program to date has received rave reviews in the local press. With the high utilization of ultrasound with pregnancies, the availability of a neighborhood-based service has become a readily used resource by the local obstetricians and general practitioners. The patients all welcome the reduced travel time and small-scale logistics of the clinic service.

Although the mobile ultrasound program is not an economic windfall, it does accomplish the overall strategic objective of maintaining market share in a very competitive marketplace. The success of the program at the affiliated Hennepin County Medical Center clinics has resulted in a closer look at the possibility of providing these

Services to non-affiliated long-term care and nursing homes in the Twin Cities area. New innovations in the Ultrasound scanners which provide better price performance ratios without a loss in clinical functionality and some new data communications options coming to the forefront, are likely to yield a break-even for the nursing home economic model near a 6-8 studies per day estimate and make the program expansion a "no brainer."

CONCLUSIONS

Hennepin County Medical Center has come to the realization relatively quickly that the patients are the real beneficiaries of the PACS initiative. This being the case, it is important to keep the priorities in the right perspective. Economic returns are definitely achievable through reduced operating costs once the digital environment has stabilized throughout the enterprise. However a short-term return investment for a PACS project would cause it to be under-funded and be limited in its scope. Patient care is moving outside the boundaries of the institution. Medical Imaging services, including remote access to this vital component of the computerized patient record, must extend its reach also.

Recent innovations in data communications products and forthcoming service offerings from the telephone carriers (or their competitors) will provide a high-speed communications infrastructure previously only attainable within the facility or campus. Price performance expectations as outlined in Table 1 will enable electronic health-care applications to grow at a rapid pace in the surrounding community. Competition in this market can be expected to drive the cost factor of the new services (cable modems and XDSL) substantially lower in a relatively short period of time.

Hennepin County Medical Center plans to fully participate in these community-wide healthcare initiatives and to leverage its PACS-driven name recognition whenever possible.

Table 1. Price Performance Expectations

Service	Transmission Speed	Performance Factor	Cost Factor
ISDN	128 Kbps (2-way)	x	y
Cable Modems	6-9 Mbps (to facility)	50-70x	15y
XDSL	6-9 Mbps (to facility)	50-70x	10y