WE WANT OUR MPEG2

THE EVOLVING DIGITAL ECHO LAB

As digital echo labs continue to use technology that is nearly a decade old, such as VCRs, some innovators are trying to get medicine up to speed with the latest advancements—MPEG2 technology.

By Dan Harvey

Dennis D. Roscoe, PhD, founder of Motion Picture Archiving and Communications Systems (MPACS), LLC, in Madison, Wisc., is helping to pioneer the latest direction in the development of digital echo laboratories. Driving his efforts is the recognition that echocardiography is, essentially, a multimedia event. That's why he believes that digital echo labs should take advantage of available broadcast industry standards. After all, echocardiography and home entertainment vehicles both deal in moving images and sound. To that end, he has introduced MPEG2 (Moving Picture Expert Group) technology into echocardiography—it represents the cutting-edge standard for DVD movies and satellite television.

"I wish I could say MPEG2 was designed for medical applications," says Roscoe, "but it was designed so we could see Monday Night Football via satellite with as much resolution as possible."

No matter what it was originally designed for, Roscoe wanted to take the technology where it would do the most good. "We thought it was time to bring that kind of horsepower to the medical arena," says Roscoe.

Previously, digital echo labs were—and still are, to a great extent—employing VCRs as well as JPEG (Joint Photographic Expert Group), MPEG1, and other decompression techniques; however, MPACS is trying to get medicine up to speed. It might seem odd to apply pop-entertainment phraseology to the imaging field but, when you consider that the development of the echo lab closely follows the recent history of entertainment media advances, it becomes appropriate—even if the medical world follows a few steps behind.

"We tried to go with the best quality and were pretty much driven by whatever video recording devices manufacturers put on the machine," recalls David Adams, RDCS, of Duke University Medical Center in Durham, N.C., where a digital echo lab evolved over the years. "They went from Beta to VHS to Super VHS, trying to achieve the best imaging quality. We followed along with them."

DIGITAL DEFINED

To understand the development of a digital echo lab, one must first understand one fundamental concept—the difference between analog and digital. In his paper, "The Digital Echo Lab," Adams explains that digital involves converting information by computer into codes comprised of ones and zeros. Everything that is digitized—letters, numbers, drawings, sound, and pictures—is coded into long strings of these two digits. Because computers communicate digitally, processes and procedures can be easily automated. Conversely, analog data (video) is stored in continuous waveforms.

Digital provides distinct advantages over analog. Digital images don't degrade

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the way video images do. Video degradation is inevitable, and it occurs even when a videocassette sits on a shelf—that includes those old movies you taped off American Movie Classics. As Adams notes in his paper, image quality with digital is preserved because the original numbers are saved. Further, image quality is not only preserved, but it is also better than video.

Another advantage involves data review. Video only allows for a linear review of data. Consider entertainment videos. With DVD, the push of a button can take you anywhere within a movie. In the digital lexicon, this is called random access. With a videocassette, you're limited by the spooling of the tape. Sure, you can accelerate the process with the fast-forward or rewind button, but you're still moving in a linear fashion.

Moving away from the home entertainment center and into the medical arena—specifically echocardiography—the benefits of digital technology, according to Adams, include more accurate storage and retrieval of information with greater speed, better echo information management, higher quality and reproducibility of images, and a decrease in time and money spent with an increase in accuracy and quality.

THE DIGITAL ECHO LAB

Defined simply, a digital echo lab is a facility in which echocardiography is performed with digital technology. According to Adams, in a digital lab, "all information, including images, is captured in or converted to a digital format for analysis, transmission, and storage."

Digital echocardiography, as we know it today, started emerging in the early 1990s. Although it wasn't as technologically advanced as today, it offered better, real-time images of the heart. However, as Adams notes, digital methodology first came into play in the late 1960s and early 1970s, when it was used to maintain log books, record echocardiographic data, and store and retrieve images. As far as images were concerned, these early systems provided a snapshot of a video field from videotape that could be stored on a floppy disk. When stress echocardiography was introduced, loops could be digitized from videotape. Still, because the images were first stored in a video format, there was degradation of image quality. The digital method allowed for the direct storage of original data to disk, thus preserving original image quality.

At first, videotape provided an advantage because it was inexpensive and could store a large amount of real-time data. But, as Adams explains, sometimes it was hard to find a patient's existing study on videotape; therefore, few echocardiograms were viewed by anyone other than the physician rendering the interpretation.

The evolution that culminated in digital echocardiography, says Adams, basically follows the advancements in videotape.

Duke University Medical Center experienced that evolution firsthand. In the late '60s and early '70s, Duke employed M-Mode recorders, first using Polaroid prints and then strip chart recorders. "In the early days, when we needed to store motion images, the only technology available were big, reel-to-reel video machines," Adams recalls.

In 1975, Duke went to 1-inch and then 0.5-inch reel-to-reel tape. Two years later, it switched to 0.75-inch Beta video. In 1980, it was using an 8-track Sanyo. In the early 1980s, Duke went from 0.5-inch Beta video to 0.5-inch VHS. In 1993, it graduated to 0.5-inch Super VHS. Finally, in 1995, Duke had an all-digital laboratory. Now, it uses videotape to temporarily back up digital studies. Once the echo studies are interpreted and archived, the videotapes are reused.

DIGITAL BENEFITS

More benefits of digital technology became apparent, especially for physicians. The fact that studies can be stored online results in the following benefits:

- time is saved during interpretation and image quality is improved;
- patient studies can be viewed in remote locations;
- clinical files and images can be easily shared;
- telediagnosis is made possible;
- digital images can be kept in high-density optical disk drives, and diagnostic information is available from a PC; and
- reports can be electronically generated, reviewed online, and disseminated electronically via e-mail and fax.

Reflecting on his own experiences, Adams considers the alternative. "In most places, during interpretation, it's always a battle," he says. "It's a pain to try to find the old videotapes for a patient who had a previous study. Then you have to queue it up correctly, hoping that it hasn't been taped over. It is critical when doing a good interpretation to review the old images along with the old report, and it is so much easier to do that with a digital system."

Specific technical benefits include the following:

- image reproduction without degradation;
- unlimited dubs and edits;
- side-by-side comparison of the current study with prior studies;
- off-line quantification, analysis, and image postprocessing;
- a variety of display formats for the image, including single, dual, or quad screen;
- inclusion of digital images integrated with an echo report and patient demographics in the patient record; and
- random access and thumbnail icons for quick review.

CONVERTING TO DIGITAL

Going all-digital is more complex than just changing your recording media, Adams explains. The conversion process at Duke, for instance, spanned a seven-year period that saw the installation of a program that created an electronic log and generated reports, the networking of computers into the program, and the installation of multiple servers, jukeboxes, and workstations.

Obviously, conversion requires substantial investment in new hardware and software. More importantly, physicians, sonographers, and administrative staff need to rethink how echo labs are managed and how patient care is provided. The change in the day-to-day operations of the reading physicians is not that big, explains Adams, because reading in digital format is faster for them. However, the challenge is greater for sonographers, specifically in adjusting the way they scan. With video, sonographers tried to capture all of the necessary images by simply letting the videotape run.

"They're used to turning on videotape and letting it record, so it's almost like a safety net," says Adams. "Even if they don't recognize some sort of abnormality, the videotape is there to pick it up."

With digital, Adams notes, the editing is more of a front-end process. "You don't have that video safety anymore," he says, "so the sonographers really need to know what it is they're looking at and looking for."

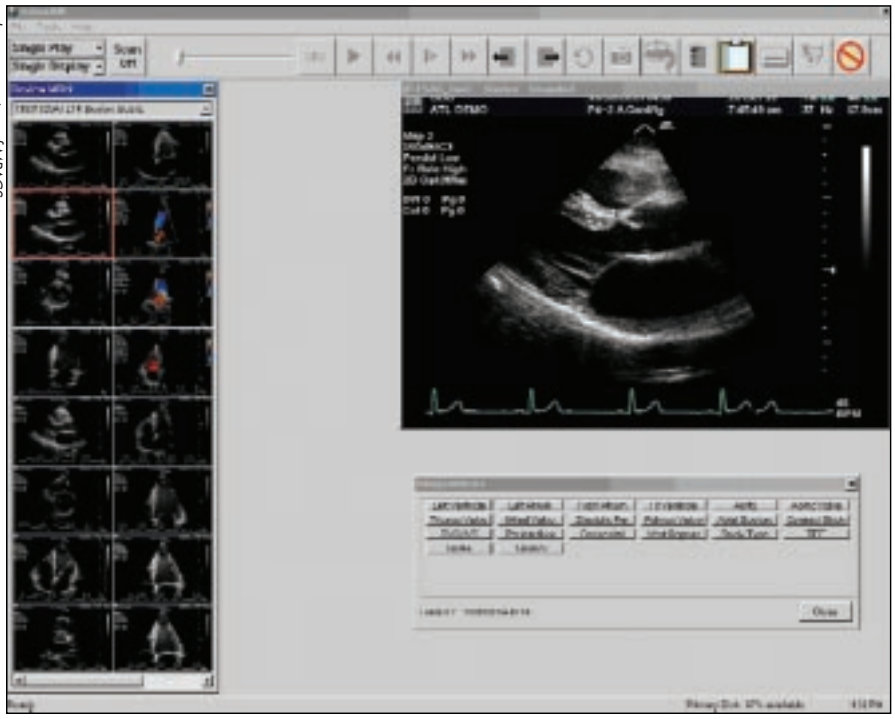
Sonographers now rely on documenting the presence or absence of abnormalities in multiple beat loops instead of long videos. This documentation is important, Adams indicates, because physicians aren't often available for consultation at the time of the exam in labs where sonographers perform the scanning.

One of the biggest challenges with conversion involves standardization—or lack thereof. Despite Digital Imaging and Communications in Medicine (DICOM) standards, not all equipment interfaces. In his paper, Adams indicates that, because of inconsistent standards, installing a digital network becomes a technical endeavor with problems arising in systems integration and communications among computers. The inconsistency can often create a technological Tower of Babel. "One manufacturer's DICOM compatible piece of equipment may not interface with someone else's," says Adams.

RESISTANCE TO CHANGE

Because of those issues, there is still much resistance to digital conversion. Also, some administrators are reluctant to pay for the technology. "A new recording methodology does not translate into an additional charge to a patient," says Adams. "So, it's not only the physicians you must convince. You have to convince the administrators that this is something that is going to be better for patient care."

Some resistance arises from misconceptions about the technology. Roscoe believes that the early history gave digital a "black eye" that hasn't quite cleared up yet, and obtaining acceptance remains an uphill battle.



— Images courtesy of MPACS

A screenshot of MPACS's thumbnail-based physician's echoLINK Review Station

"At first, the technology was driving the pathology," he says. "In other words, you could use digital for certain studies but not all studies. You don't want to make life worse for the sonographers, but, at first, life got worse instead of better. They could study some patients digitally; however, with other patients, sonographers still had to rely on videotape." This inconsistency resulted in "hybrid" labs, with sonographers having to manage both video and digital technology.

Another problem involved the image standard. "Early on, it was JPEG, which is somewhat inappropriate," says Roscoe. "JPEG is essentially a photographic standard for a still picture. It's great for many radiology applications that deal with still frames, but cardiac ultrasound is about motion and sound. Cardiologists believed that a radiology standard was being shoved down their throat."

Roscoe explains that while JPEG provides good pictures, it limits the number of compression while trying to maintain image quality. The only way to get motion with JPEG is to use a process that can best be described as the penny arcade "movie-ola" or the "cartoonie," where you collect a lot of still photographs and flip through them to create motion. "Unfortunately, when you do that on computer, it consumes a tremendous amount of space," says Roscoe.

Video frees people from some of the limitations of JPEG. With the VCR, they can capture as much or as little as they need or want. But, video has its own limitations. The introduction of digital advanced the capabilities. However, at first, it was cost-prohibitive. Also, it forced a change in the way echoes were performed. "You need to have your sonographer pick one or two cardiac cycles per digital view, and that would be what the doctor looks at," says Roscoe.

Many were uncomfortable with what was being asked of them. "The entry level into digital was pretty steep," Roscoe explains. "Sonographers not only had to face a new technology, but they also had to become sharper at spotting pathologies. With digital, only the most skilled sonographers could find the one cardiac cycle that shows that pathology in one try. The fact is, most sonographers need two, three, or even 10 cardiac cycles because of breathing cycles and patient movement. So, from that standpoint, there had been resistance."

Adams has found that the older sonographers were most uncomfortable with the change because they tend to be more "computerphobic." Younger sonographers, born in the Computer Age, "think it's cool," he says. "They don't have as big a mental obstacle when it comes to computers. They could see the benefits of digital far outweighing the disadvantages."

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FUTURE DIRECTION: MPACS AND MPEG2

By introducing MPEG2 into the digital echo lab, Roscoe, through MPACS, is addressing key concerns and problems currently encountered in many digital labs. Concerns include the following:

- Single clips and short loops — For certain studies, Roscoe believes single clips or short loops aren't enough. Many physicians feel the same way. The brief capture lengths of the clips are limited by JPEG storage requirements.
- VCR dependency — Despite the advantages of digital technology, many labs still need the VCR, a device that Roscoe wants to render obsolete.

It's the old case of someone who looks at a new technology and asks why, while someone else looks at the new technology and asks why not? "MPEG certainly is not an oddball technology," Roscoe says. "So why not use it for echocardiography? Why isn't it a part of the DICOM standard? That has been the battle."

The trouble with moving toward an MPEG2 standard, Roscoe explains, is that it meets resistance from vendors who still have products in the JPEG world.

"It's an operability issue," explains Roscoe. "If DICOM accepts or incorporates new technology, such as a different compression technique, then they must be able to accommodate that technology. Right now, PACS companies are struggling just to work with motion JPEG. Frankly, they don't want to have another compression technology in the standard until what they are currently working on is stable."

It's a matter of keeping up with changes in technology. That, in itself, can be a struggle—technology cycles keep getting shorter and shorter. "Manufacturers haven't come all that far in shortening their turnaround and design cycles," says Roscoe.

Roscoe believes that it's imperative to put the major PACS issues aside—those that involve legacy and profitability—and determine what is best for the DICOM standard, which would open the door to having the broadcast industry standard included in the medical standard.

The MPACS product line includes the echoLINK Image Acquisition Unit that, according to the company, employs an image compression technique that allows echo labs to quadruple the amount of acquired digital image information while preserving the original image quality. MPACS is the first company to employ the MPEG2 video compression. "The acquisition units essentially replace the VCR on an ultrasound machine," explains Roscoe. "These convert your ultrasound image into an MPEG2 image."

He adds that sonographers need not be so apprehensive about finding the right cardiac cycle anymore. "We went into this trying to mimic the use of a VCR, which makes the digital transition simpler," he says.

echoLink also provides a thumbnail-based review station and archiving devices, as well as an integrated reporting system. "While looking at their images online, physicians can enter their interpretations and build their final report without transcription and outside services," says Roscoe.

The advantages of the digital echo lab have become increasingly apparent as both the concept and the technology have evolved in the past 40 years. As Adams explains, conversion to digital technology is a significant step toward the integration of information and images both inside and outside of a facility's cardiology department. He envisions expansion into areas such as patient billing, inventory management, continuous quality improvement, scheduling, and other administrative tasks. Further, with companies like MPACS embracing technological advancements and applying them to the concept of the digital echo lab, the diagnostic effectiveness of digital echocardiography should reach heights never dreamed as recently as 10 years ago. When misconceptions are finally invalidated and when technical issues such as standardization are worked out, its full potential can be realized.

— Dan Harvey is a staff writer at *Radiology Today*.