

## ACC NEWS



### President's Page: Developing Standards for the Digital Age: The DICOM Project

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The American College of Cardiology (ACC) has been committed to developing standards for cardiovascular medicine since the ACC/American Heart Association (AHA) guidelines project was initiated in 1980. As we developed our data base in the late 1980s, it became clear that standard definitions of data elements were vital if communication among data bases was to occur. The same could be said for standardizing cardiovascular images as we moved away from analog technology. Thus, a committee was established to work with manufacturers to develop standards for the new digital technology. Dr. Steven Nissen has been our leader in this effort, and I have solicited his input for this President's Page.

Over the next decade, it seems inevitable that digital storage of coronary angiograms will gradually replace traditional 35-mm cine film. The transition from digital archiving and storage will affect nearly every practitioner of cardiovascular medicine. For the past 3 years, a committee of ACC-appointed physicians and manufacturers of angiographic equipment has been meeting monthly in Washington, D.C., to develop a new worldwide standard for digital communication of images generated in the catheterization laboratory. These software and hardware standards, termed *DICOM* (Digital Imaging and Communication in Medicine), are nearly complete and represent a fundamental advance for cardiovascular medicine.

Before the initiation of this standardization effort, individual manufacturers of angiographic equipment were each planning their own proprietary digital imaging storage and interchange formats. That nonstandardized approach resulted in an unfortunate conundrum—a laboratory with equipment from any particular vendor could not read and display angiograms generated by another site with different radiographic equipment. The DICOM standard provides the capability for review of any angiographic study generated by a DICOM-compatible

catheterization at any other site. Widespread adoption of the DICOM standard will protect cardiology from the very real danger of incompatibility in angiographic data formats—a phenomenon the College has termed the "Tower of Babel" in the catheterization laboratory.

After many months of deliberation and technical analysis, the DICOM committee ultimately selected a recordable form of the CD-ROM (known as CD-R) as the digital medium for exchange of angiography. There were many reasons for this choice, among them the widespread application of this technology in other areas (e.g., multimedia), which improves performance and reliability while reducing cost. At the 1996 ACC Annual Scientific Session in Orlando, Florida, many of you may have seen an exhibition of the potential of this new technology in the "Disc 96" demonstration, which showed that the DICOM standard can enable interchange, not only of angiograms, but also of ultrasound and nuclear studies by the same CD-ROM. To demonstrate the viability of the standard, the ACC and the DICOM committee also developed and distributed a public domain utility program that enabled anyone with a CD-ROM drive and a computer to retrieve and display these images.

The value of a digital medium for storage and exchange of angiograms is manifold. Because digital data can be readily copied, it is possible for each treating physician or surgeon to have his or her own copy of the angiographic study. Electronic transmission of digital angiograms for remote diagnosis and consultation is readily available using current and future technologies. When patients present in the emergency room after previous catheterization, digital technology will enable the treating physician to review previous angiograms within a few seconds. Furthermore, clinical research studies will greatly benefit from the ability to convey a digital copy of the angiograms to a core laboratory rather than mailing bulky films. However, these enhancements to patient care and research are dependent on the nearly universal adoption of the DICOM standard.

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Unfortunately, the conversion to filmless catheterization was already well under way when the DICOM committee began its work. One of the most widely used alternative image storage modalities is the Super-VHS (S-VHS) videotape. This analog recording method is, frankly, a poor substitute for 35-mm film. Under optimal conditions, S-VHS can only record about half the resolution of an angiogram. For this reason, many tertiary care medical centers will not accept S-VHS videotape as a surrogate for cine film and routinely have referral patients undergo recatheterization before surgery or interventional procedures.

It was the awareness of these potential problems that led a subcommittee of the ACC to begin working with the National Electronic Manufacturers Association (NEMA), an organization representing most of the major equipment manufacturers. We were joined in this effort by the European Society of Cardiology (ESC). Accordingly, the DICOM standard will enable image interchange on a worldwide basis. It is crucial to understand that the DICOM committee has created a standard that applies only to the "interchange" of images. For internal hospital storage of angiograms, many different proprietary "archive" systems from various manufacturers will remain and flourish. What the DICOM committee has designed is an extremely portable and accessible digital medium for image interchange that will require no more complicated technology than a CD-ROM player and computer. Manufacturers can still compete by offering a vast array of products for digital archiving of angiograms but remain compatible with the DICOM standard by providing a writable CD-R output in the proper format.

In the near future, using this system, you will be able to call up angiograms from a computer as you talk to a patient on the phone, or send a few images by modem or the Internet to a referring physician or co-investigator. With a home computer, you may be able to deposit a CD-ROM in your briefcase to review cases at home in the evening. Fundamentally, the DICOM standard will permit practitioners to review images whenever and wherever they wish. You will be able to make

additional copies for the surgeon or primary care physician while retaining the original study in your laboratory or "film" library. You will be able to accomplish all this for much less than the \$100 per case required by film, very likely for less than one-tenth of the film cost. Moreover, your computer will allow you to make slides or videos for presentations from these same compact discs.

One of the important features built into this system is an algorithm that compresses the digital data to increase the number of images that can be stored on the compact discs. Significantly, the DICOM committee chose a method of compression that is termed "lossless" because it is completely reversible—when you decompress the file for review, you retrieve exactly the same image originally generated.

Two vendors of X-ray equipment have recently introduced a proprietary extension to the DICOM format that uses a higher extent of compression (termed *lossy*). Lossy compression is not completely reversible; there is some reduction of image quality when decompressed. Before including this approach in the standard, the ACC is now conducting a multi-center study of lossy compression to determine whether we should allow this approach under the DICOM standard. As part of that study, physicians around the country will be asked to make determinations about angiograms that have been compressed with three different lossy compression ratios or uncompressed angiograms. Although this extension to the standard could prove useful, it is important for you to know that lossy compression is not yet part of the angiographic DICOM standard.

For all those eager to eliminate cine film, only one recommendation makes sense for now—demand full DICOM compatibility from your equipment vendor. As we make the transition to the digital era of medicine, our ability to communicate with each other must be fully maintained. If properly managed, the conversion to filmless angiography will offer many new possibilities. If poorly managed, we will live with limitations for decades.