

## “Virtual” Radiology – Digital imaging takes on new importance at the University Health Network (UHN)

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With the advent of the 21st century, the tremendous benefit provided by computer systems is clearly apparent in health care. Most recently, the implementation of digital imaging has led to significant changes in the practice of radiology. The development of computer-constructed imaging, such as computed tomography (CT) and magnetic resonance imaging (MRI), initiated the digital age of radiology. Recently, even traditional analog formats, such as plain film X-rays and mammography, have begun to be processed into digital format. This has permitted the development of “filmless” radiology departments in which all images are acquired by computer. The use of high-speed telecommunication has permitted geographically separated health centres to access images at workstations around the world, forming a “virtual” radiology department.<sup>1</sup>

The University Health Network (UHN) in Toronto has recently completed its filmless upgrade. There are several immediate and long-term benefits of such a digital system, as well as potential hurdles that need to be overcome. Given the importance of the UHN as a primary site of medical education in Toronto, the implications of a virtual radiology department for medical education should be addressed. How have these changes affected medical students and physicians?

### The Technology

The core of radiology services at the UHN is the Picture Archiving and Communication System (PACS). PACS is a system that permits the acquisition, storage, retrieval and display of digital information, which also facilitates the communication of such information over a local area network (LAN) connection.<sup>2,3</sup> The end-user interface through which images are accessed is called *eFilm*. This software permits the electronic searching and viewing of almost all imaging modalities at the UHN.

In this system, an image is captured first in a digital format (either immediately digitised during the processing of a radiograph, or via the conversion of an analog film to a digital format). This image is then sent to a modalities server, one of 19 repositories for “current” (within the last 2 to 3 months) images that are accessible from any hospital radiology workstation within the UHN (Toronto General Hospital (TGH), Toronto Western Hospital (TWH), Mount Sinai Hospital (MSH), and Princess Margaret Hospital (PMH)), and from remote locations by individuals who have been granted offsite access to PACS (such as radiologists reading radiographs from home). A copy of each image is also simultaneously sent to an archive server and it is stored permanently within a library of Digital Library Tapes (DLT). The benefit of maintaining two separate server systems is that the modalities server stores only those images generated within the past few months enabling quick image management, while the archive server acts as a permanent home for the entire image library, and thus requires longer retrieval times.

The UHN Hospital Information Systems (HIS) includes *Ulticare* at TGH, TWH, and PMH, and *Cerner* at MSH, which provide computerised storage of patient records and laboratory results. PACS will be fully integrated with the UHN HIS as well as the UHN Radiology Information Systems (RIS) in the near future.

The *eFilm* network provides not only the viewing of digital information via the user-friendly PACS, but also permits a number of technical manipulations of radiological images (see Figure 1). In addition to functions such as image rotation, vertical and horizontal flipping, magnification, colour inversion, and measuring (linear and elliptical), the advanced functions of digital subtraction angiography (DSA), tissue identification and synchronisation of multiple series are possible. (Those interested can visit the *eFilm* website at [www.efilm.net](http://www.efilm.net) where the complete software is

available for free download with sample images for practice manipulation.)



Figure 1. A typical eFilm screen, showing high-resolution CT image of the head.

Through the process of teleradiology, any eFilm image can be accessed from any on-line workstation within the UHN across a virtual local area network (VLAN) at a transfer rate of 100 Megabits per second. eFilm also enables the communication of digital images over great distances between the UHN and locations outside of the VLAN (such as the workstations of community physicians in Toronto and beyond). eFilm operates on the DICOM-3 (Digital Imaging and Communications in Medicine version 3) standard, the international standard for teleradiology,<sup>4</sup> which ensures compatibility between different centres that may employ different forms of technology in their respective radiology departments.

#### Advantages and Disadvantages

As with all new technologies, there are advantages and disadvantages of filmless radiology. Traditional film requires a large storage space, is expensive, is not always readily accessible, and is often of poor viewing quality.<sup>2</sup> Computed radiography provides a number of improvements over film, albeit with its own unique drawbacks. Digital radiographic images require less physical storage space than traditional films. The images can be kept with patients' computer records for future reference. As well, storage on disk decreases the chance of losing images, which often occurs with films.<sup>5</sup>

Several advantages exist for the independent radiologist. Digital images are immediately accessible and can be viewed after-hours and at remote locations. Several physicians can also view the images simultaneously. Expert analysis of images can thus be provided for all regions. In addition, when radiographs are combined with electronic patient charts, the differential diagnosis can be narrowed, thus increasing the speed of clinical decision making.<sup>1</sup>

However, there are also risks associated with instant accessibility. Physicians may make inappropriate or hasty clinical management decisions based on quickly available images instead of waiting for a complete report from a radiologist. Similarly, radiologists and other physicians may have fewer discus-

sions about images, discussions that are often necessary for accurate diagnosis.

Digital radiographs have improved viewing quality. Computers allow for easier sorting and viewing of multiple images. Image manipulation improves standardisation between sequential radiographs and reduces the need for repeat radiographs due to underexposure.<sup>2</sup> Manipulation of digital pictures by edge enhancement, filtering techniques, magnification and reduction, and temporal subtraction improve the radiologist's ability to detect abnormalities.<sup>5</sup> Altering the window width and level to highlight different tissues also provides more diagnostic information (see Figure 2). In the future, computer algorithms may be able to combine radiographic results and then aid the clinician by providing diagnoses or treatment options.<sup>1</sup>

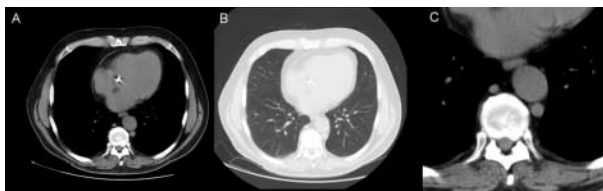


Figure 2. Contrast and brightness are manipulated to create "windows" which best accentuate specific structures. A. CT with "abdomen" window; B. CT with "lung" window; C. Magnification of vertebral body, with "abdomen" window.

The World Wide Web and CD-ROMs are useful as image libraries for teaching and clinical research. Unfortunately, the transmission of images over the Internet decreases picture resolution, and more importantly brings forth confidentiality concerns. Security measures such as algorithms and passwords are needed to protect patient confidentiality.<sup>1</sup> Also, future implementation of voice recognition software will decrease the need for typists and reduce the time for dictating reports.<sup>2</sup> However, such systems are currently not available because of expense.

The implementation of a filmless radiology department is very costly. Short-term costs for initial installation and running of workstations, networks, and software are very high while long-term costs are still uncertain. The costs for film, chemical developers, and offsite film storage are lessened. Fewer people are needed as film clerks, typists, and dark room technicians; however, well-trained technicians are still required. Therefore, overall, the long-term benefits of digital imaging are expected to justify the initial high costs.<sup>2</sup>

#### Legal Implications

The digitalisation of radiological films has created a vast array of opportunities. With these, however, have arisen a variety of legal issues. The most important issue is that of privacy in Internet transmission of information. Computer files may be easily stolen by capable hackers, thus endangering patient confidentiality. While the American College of Radiologists (ACR) has guidelines dealing with the issue of confidentiality, there is no assurance that these standards are being achieved with telemedicine.<sup>6</sup> An image compression process that encrypts radiographic data is commonly used in teleradiology. This process appears to prevent casual theft, although more work is required to ensure that patient confidentiality is assured.<sup>6</sup>

Another issue is licensure. An increasing conflict exists between the ability of teleradiology to transcend barriers technologically and the legal responsibilities of medical licensing boards.<sup>6</sup> The ACR policy declares that “states and their Medical Board should require a full and unrestricted medical license in the state in which the examination originates, with no differentiation by speciality, for physicians who wish to regularly practice telemedicine.”<sup>7</sup> This implies that physicians must be licensed both in the state where they practice medicine and in the state where the image originated. Many states in the USA have either passed legislation or implemented rulings that follow the ACR policy. Such legislation may prove to be a great impediment to the delivery of telemedicine services.<sup>6</sup>

Another very interesting issue that recently came to light was that of authentication of material. Since the images are obtained digitally, the possibility of interfering with or manipulating the images exists.<sup>8</sup>

#### Implications for Medical Education

The recent development of a “virtual” radiology department at the UHN has many potential implications for medical education. These implications can affect both trainees and educators who must learn how to use the new system. The use of digital imaging is relatively uncommon in Toronto and even less frequently utilised in other parts of the province. Therefore, radiology residents must continue to be taught to read traditional radiological films in addition to digital radiology. The question then remains as to what the *actual* effects of virtual radiology are on medical education.

There are several stages in the Radiology training program, not all of which are affected by the advent of a virtual radiology department. The basic principles of anatomy and pathology that are applied by radiologists are not affected by the new “filmless” format. The many advantages of digital imaging, however, have the potential to aid trainees in the learning process.<sup>1</sup> If one assumes that the clarity and definition of computer-generated images are equal to those of previous films, then the only difference that exists is in the means by which these images are accessed. The digital imaging programs are also designed to aid the radiology trainee gaining an orientation to radiographic presentation of human anatomy (Figure 3).

Residents in training today have considerable knowledge about the use of computers. The effort required to learn the use of a digital imaging program is thus minimal.<sup>9</sup> In addition, the programs are designed to be very user-friendly thus enabling quick retraining of physicians familiar with the old system. The ability to place digital images on the World Wide Web thus serves as an excellent source for continuing medical education.<sup>10</sup> Although some physicians may find it very difficult to adapt to the new *eFilm* system, practising radiologists learn quickly because of experience with digital-type images such as CT and MRI.<sup>9</sup>

The ability to manipulate and enhance digital images is an advantage to the radiology trainee. Previously, radiologists were not able to manipulate the images after they were permanently recorded on film. The ability of the radiologist to vary the image at his/her computer console allows him/her to extract the most

information from an image during its initial examination. In addition, the same computer may provide the radiologist with the entire clinical record or even with investigational programs that can be used to find reports of similar cases that may be used to aid in diagnosis.<sup>1</sup>

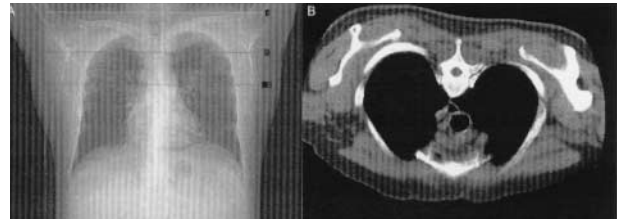


Figure 3. Plain radiograph is used to demonstrate the level of a cross-sectional image. A. Chest radiograph demonstrating highest and lowest levels of CT images taken and the level of CT image currently being examined; B. Cross-sectional CT image.

Finally, the use of computer-aided instruction can benefit all levels of medical education. Picture archives of radiological images have been developed and placed on the World Wide Web where they can be accessed by people around the world.<sup>11</sup> Similarly, the possibility exists to form educational programs that include radiological images and associated case histories that can be used by students to learn radiology.<sup>1,12</sup> Instead of having many students crowd around a single viewing box, the potential exists to teach several students at individual computer consoles, each displaying the same image.<sup>9</sup>

Although tremendous potential exists for integrating digital radiological imaging into medical education, most of these tools are not currently available. For this reason, Dr. Weisser, an educator in Radiology at St. Michael's Hospital reported that there has been “no substantial impact [of digital images] at the moment in terms of radiology or undergraduate teaching” at the University of Toronto. However, radiologists training with *eFilm* at the UHN are at no disadvantage with respect to their education or future abilities to work outside of the UHN. The many immediate and long-term advantages of virtual radiology make this new system an asset to the UHN and to medical education.

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