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Digitally Diagnosed

Pathology labs are revolutionized by the use of digital images and telepathology.

By Susan Hopkins

The advent of digital imaging and telepathology has created new opportunities for pathologists. They can now incorporate images into pathological reports and share them with patients and colleagues. Telepathology is another revolutionary application of digital imaging. It allows consultations between pathologists and other physicians via the Internet and includes the study of images from gross surgical pathology specimens as well as histopathology and cytology specimens.

Digital Image and Telepathology Applications

Digital images (DIs) are the new format for photography and are replacing classic film photography, explains Francisco G. La Rosa, MD**,** pathologist, director of TelePathology Consultants, PC (www.telepathology.com), and assistant professor from the Department of Pathology, University of Colorado Health Sciences Center.

"Interestingly, film images have been used as the gold standard for comparing the quality of DIs; however, current charge-coupled device (CCD) technology is ready to provide image quality that is above that of conventional film. In addition to the high-resolution images achieved by new camera CCDs, DIs have the advantage of being able to be copied in unlimited amounts and transferred throughout the world, with exactly the same quality as when they were acquired," Dr. La Rosa says.

Furthermore, DIs can be improved in sharpness and color by easy-to-use computer software, and they can be subjected to quantitative analysis of structures and colors. In contrast to film-captured images, DIs are far faster to produce, more efficient and do not need the long and tedious process of developing and printing. They are ready for study as soon as they are generated.

The use of DIs has provided a great advantage to the field of pathology, since pictures can be easily taken from a microscope and transmitted directly through the Internet in a matter of seconds for diagnostic purposes. This technique is called telepathology. This revolutionary approach saves a great amount of time, and pathology images with additional patient information can be delivered to and from colleagues located in remote areas around the world. Access to subspecialists in different areas of pathology is now easily achieved, providing a more accurate diagnosis and, by consequence, better patient care.

Digital imaging gives you the ability to refer the slide to someone else but keep the slide and perform QA/QC on it without having to ship it, explains Mark Newburger, president, CEO and founder, Apollo Telemedicine, Falls Church, VA.

"With telepathology, if implemented with the appropriate functionality, you have the ability to perform remote primary diagnosis, where the pathologist does not need the microscope—they can be in another location," Newburger says. "Instead of having two pathologists in the same room with a multi-headed microscope, they can be separated by a distance. You also can do continuing medical education, archiving, QA/QC on your anatomic pathology cases, and perform remote frozen section diagnosis."

Telepathology often is used for conferences and examinations to test people. DIs frequently are incorporated into surgical pathology reports.

"The use of DIs in the pathology reports has been definitively a major achievement. However, the addition of this important information in the reports has not been adopted by most pathology practices because of the lack of adequate compensation by the corresponding reimbursement systems and the lack of LISs that can effectively integrate these images with the rest of the patient's information," says Dr. La Rosa. These are some of the reasons that have deterred most pathologists from investing extra time, money and energy on wider use of images in their reports.

Nevertheless, DIs have been very successful in the areas of pathology teaching and research. Now medical students can access large databases of pathology images through CDs and Web pages. Researchers can readily acquire images, select and share them in an easier and faster way than with conventional film.

"In the past, we had to wait for the long process of film developing and printing to realize whether our experiment was well documented. Lectures can now be put together in a matter of minutes and slides can be updated or corrected just seconds before the presentation. Furthermore, these same electronic slide presentations can be used in teleconferences with no limitations of distance or frontiers," explains Dr. La Rosa.

The technology is really helpful in gross pathology. "We have a digital camera mounted in our gross pathology room, and we can take pictures of the whole bowel or breast with the tumor in it or an unusual vascular malformation," says David Novis, MD, chairman of Pathology, Wentworth-Douglass Hospital, Dover, NH, and vice chair of the CAP quality practices committee.

Customers can understand the images better and get a better feeling for what's going on. "For example, we'll take a picture of a bowel cancer and put it in the report and with the software be able to show the measurements of it and how close the tumor is to the margin of section. We take the images to the cancer conference, and when you show the gross images, everyone has an immediate understanding of what's going on," Dr. Novis says.

"My group first looked at telepathology in 1981 as a way to put a microscope in a hospital 20 miles away and be able to perform frozen sections at a distance of 20 miles, so we wouldn't have to put a pathologist on site," he says. "The problems then were that you couldn't get the resolution that you can now. The resolution issue is somewhat solved; however, it's still not as good as looking down a microscope. Very few people have the temerity to actually make diagnoses on frozen sections using that technique."

Imaging Requirements

Digital imaging requires a high-quality microscope that can be mounted on a video camera or a still digital camera and, of course, a computer and digital camera software. "I've been using DIs for about 15 years. The equipment was relatively inexpensive and easy to hook up, but I think it scared a lot of pathologists. We were using DIs very early," Dr. Novis says. "Our next phase is to put a monitor in the operating room so that when we look at frozen sections we can show our surgeons what we're looking at. Whether telepathology will help doctors with their surgery remains to be seen." Dr. La Rosa adds that the most important requirement is the microscope. "We do not gain much by having a refined image capturing device if we do not have a good microscope. Next is to have a high-resolution digital camera, then high-speed Internet connectivity."

Telepathology can be of two types, static (store and forward) and dynamic. In the former, the diagnosis is based on the study of a set of individual images chosen by the pathologist requesting consultation. The latter is based on real time, dynamic study of a whole pathology specimen in which the telepathologist has full control of a remote microscope by using complicated and expensive telerobotic systems. These systems require that a technical person, not necessarily a pathologist, positions a proper slide in the remote microscope.

"One of the main problems I have seen in the practice of static telepathology is trying to make a diagnosis using poor quality images, especially with those taken with TV cameras, which have a very limited resolution. High-resolution digital cameras, however, are more appropriate for telepathology," he says. "In the past, the use of these cameras was very limited by their high cost. However, in recent years we have seen the fast introduction of new camera chips of five megapixels and more, even in domestic cameras, which make telepathology very affordable. The situation becomes more complicated when we talk about dynamic telepathology and telerobotic systems in which the telepathologist needs hardware and software to control the microscope, review the slide, acquire images and deliver the diagnosis. In addition, digital cameras are not suitable for dynamic telepathology because you have to have a live broadcast of the images, which is only possible with TV cameras."

For the beginner telepathologist, it is not necessary to invest in expensive equipment. A simple practice of static telepathology can be started with the same basic set up for taking conventional photographs and by acquiring a simple slide scanner and personal computer with Internet access.[2] In addition, it is possible to take very good pictures using some conventional digital cameras of 3.5 megapixels and above, and manually attaching them to the eyepiece of the microscope, Dr. La Rosa notes. The advent of digital single lens reflex (SLR) cameras has opened a new way to the pathologist since they can now replace their old film SLR cameras mounted in their microscopes with new digital cameras and without the need to change their old mounting devices.

The market is now filled with numerous alternatives, both in equipment specifications and prices, on digital cameras for histological studies, which can be used in static telepathology.

Newburger adds that digital imaging follows the requirements of regular pathology. Pathologists want the images to have good color depth, resolution and fidelity, so they can get an accurate representation both in color, contrast and resolution. "Pathologists accept a 1k x 1k pixel resolution quality to represent the field of view in the slide. They are looking for true color, which is 24-bit color depth," he explains.

Proven Benefits

The benefits of telepathology are many and provide new ways for pathologists to communicate and educate each other. Telepathology is great for conferences, as is digital imaging. It has made conferencing and education efficient. "Some of the conferences will just send you a CD and you can look at the pictures, and the pictures of tissue will already be at different levels and powers, of different areas and with special stains," Dr. Novis says.

"We can place the report on the Internet so our customers can access their reports online, which is a lot quicker for them, and they can also see the pathology. DIs are helpful so that the doctors can show their patients to help them understand their disease," he says. "You can monkey with a DIput labels on it, and do it in seconds; we use it a lot for autopsy pathology.

"Customers love to see the pictures and it saves you from having to write a long description of what you're looking at. It's also used to make images to put in journal articles and reports," Dr. Novis adds.

Dr. La Rosa considers the practice of telepathology to be exactly the same as the practice of pathology. "The only difference is that with telepathology, we are using some special tools, which allow pathologists to share images from their microscope and other patient information with an unlimited number of pathologists or other physicians, almost instantly. This has a great impact on our diagnostic turnaround time and accuracy by having prompt accessibility to second opinions from the best specialists around the world."

A rapid diagnosis can be translated into less time in a hospital bed and a faster delivery of specific treatment, all in benefit of patient care, with resulting reduced expenses.

A New Language

Standards have been implemented for the transmission of medical images. DICOM (Digital Imaging and Communications in Medicine) is an application layer network protocol for the transmission of medical images, waveforms and ancillary information, explains Dr. La Rosa. It was originally developed by the National Electrical Manufacturers Association (NEMA) and the American College of Radiology for CAT and MRI scan images. It is now controlled by the DICOM Standards Committee and supports a wide range of medical images across the fields of radiology, cardiology, pathology and dentistry.

The Unified Medical Language System (UMLS) is a project developed by the National Library of Medicine (NLM) with the purpose of facilitating the development of computer systems that behave as if they "understand" the meaning of the language of biomedicine and health. For this, the NLM develops and distributes multi-purpose, electronic "Knowledge Sources" and associated lexical programs for system developers. This is used to build or enhance electronic information systems that create, process, retrieve, integrate and/or aggregate biomedical and health data and information, as well as in informatics research.

Apollo Telemedicine utilized the DICOM standard to implement the VA ViSTA interface.

Recent Advances

There is no doubt that the most important advance in digital imaging has been the improvement of image resolution in the digital cameras, says Dr. La Rosa. "The next improvement is still coming with the advent of widespread use of fiber optics Internet communications (Internet 2), which allows transmissions with speeds of Gigabites per second."

This fast speed will make feasible the transmission of the "electronic pathology slide," also called the "virtual slide" or the "digital slide," and not only of a set of biased selected images. Conventional histopathology slides can be completely scanned at high-power magnification, and the acquired files contain all the image information from the original specimen slide. "I envision that this electronic slide will be the way most pathologists will interact in the future, being able to review the whole histopathology specimen with full detail of cellular features. This technology is almost at hand but needs the integration of a faster Internet speed," Dr. La Rosa explains.

This new technology, not widely implemented yet, enables the pathologist to digitize the entire slide and store that very large image on a server, explains Newburger. It can then be viewed through an Internet browser. "The ultimate goal is to be able to digitize the slide in under a minute, but that's not available yet," he says. With the advent of broadband communications available to most health care institutions, it is now very cost effective to implement telepathology. With digital imaging there are constant improvements in imaging acquisitions technology like various cameras.

"Probably the most important thing in both digital imaging and telepathology is the notion of interoperability between digital imaging, telepathology systems and LISs, and that's all done through standards based implementations of the various systems," Newburger says. "That is probably the most important area that most of the telepathology/digital imaging/ LIS vendors are all working on together—implementing standards to make systems interoperable."

Room for Improvement

Despite the many benefits digital imaging and telepathology bring to pathology, there is still room for improvement. Digital imaging systems do not yet integrate well with LISs. In addition, more progress is needed before telepathology will be used to perform primary diagnoses in real time.[1]

The other problem with telepathology in real time has to do with robotics. "When you look at the slide, you have to look at the whole slide at several different powers, so you're constantly moving things around. You can't process that image and send it as quickly as you can when you're sitting right over the scope," says Dr. Novis.

Maurizio Vecchione, CEO, Trestle Holdings Inc., Irvine, CA, says that their core focus has always been to allow pathologists to collaborate remotely on a sample that is manipulated robotically via the Internet over a workflow application.

"The key transformation that will allow both clinical laboratory and pharmaceutical businesses to scale this business is in looking at workflow applications tied to the devices, and allow various devices that are optimized for applications to integrate data in a platform that can support various cases that all need to come together for good laboratory practice," he says.

Trestle is focused on not just the device but the building of these workflow applications that sit on top of the devices as well as looking at specific use cases. "The key challenge for the industry is not just to produce a device and leave the doctor to figure out how it impacts his workflow but to really look at entire workflow solutions that the lab can bring onboard and integrate into LISs and other type of laboratory automation," Vecchione says. The three areas he focuses on are:

1. Human review: How does the doctor interact with the database that's been created? Creating the right level of documentation so that the practice of viewing images in a digital manner are not only compliant but fall into best practices.

2. Interfacing these applications to various computer-assisted diagnostic tools. Analysis, computer aided analysis or rare cell events.

3. Documentation, publication and distribution of resulting data in a manner that is standards compliant, FDA friendly and HIPAA compliant.

There is no doubt that the era of medical informatics has revolutionized the practice of medicine. "Now it is difficult to imagine a medical system without the presence of computers, data processing and networks," Dr. La Rosa says. "The specialties of radiology and pathology have greatly benefited from the advances on digital imaging and information systems. Other medical specialties that also benefit from DIs, due to their strong visual and objective components, are dermatology and surgery."

"I consider that the technique and methodology for the acquisition and transmission of DIs has reached a desirable level of optimization for a good practice of telepathology," Dr. La Rosa says.

Susan Hopkins is an assistant editor.

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