Automated specimen transport (AST) is becoming more practical and essential in today's laboratory environment for diagnosis, collaboration, and education. Telepathology, a form of AST, is the process of transforming slide specimens into electronic images and then transmitting the slide images via electronic means, such as the Intranet or e-mail. Telepathology is quickly emerging and being adopted by medical laboratories and institutions around the world to help achieve cost savings by eliminating slide courier fees and reducing the risk of slide breakage.

Additional benefits of telepathology include:
- elimination of travel between multiple sites;
- reduction of down time waiting for slides to be transported;
- real-time collaboration for second opinions and consults;
- access to high-resolution slides from home 24/7;
- service area expansion without additional facilities or staff;
- electronic storage of knowledge bases for future reference; and
- facilitation of distance learning and education.

While there are two methods of viewing digitized images, this discussion will focus on live digital imaging: the process whereby digital images are captured and viewed in real time while the slide is on the microscope.

**How live digital imaging works**

AST can be achieved by utilizing a live digital-imaging device. This device enables multiple physicians and scientists to remotely view, navigate, and share high-fidelity microscope images at submicron resolution over standard Internet connections in real time. Either intraoperative frozen or paraffin sections are prepared for viewing and diagnosis by simply loading the slide on the microscope.

The hardware configuration for a live digital-imaging device consists of a robotic microscope attached to a standard PC using application software designed for most Windows platforms. Once connected to the Internet, multiple users can log on and view the slide, while the microscope is controlled from virtually anywhere. The system allows full navigation of the slide, including control of objective, focus, magnification, and illumination. The system also enables field-of-view capture with a variety of image-quality and -editing tools, including annotation, precise measurement, and image archiving.

The slide resides on the microscope stage while the electronic image is transmitted, allowing up to 64 users to simultaneously review the electronic slide remotely — from anywhere in the world. This results from the use of a collaboration server, built into the application, that automatically synchronizes all users logging onto the same microscope site, eliminating the need for a multipoint control unit or conferencing server, which could impact image transfer speed and reliability.

**AST and telepathology apps in the medical profession**

Medical professionals are currently utilizing live digital-imaging devices for AST and telepathology as part of their everyday workflow. The Armed Forces Institute of Pathology (AFIP) located at the Walter Reed Army Medical Center (WRAMC) in Washington, DC, practices telepathology on three continents, primarily for consultations conducted from a distance, saving a significant amount of time and expense. In the case of institutional learning, the Pathology Department at the University of Southern California Keck School of Medicine (USC-Keck) based in Los Angeles employs telepathology in its research labs for both frozen- and paraffin-section evaluation.

Live digital-imaging devices are used at the AFIP facility for pathologist consultation for difficult, challenging cases that require a second-opinion expert or subspecialty consultation. “We largely rely on the systems to connect pathologist to pathologist on those types of cases; and when we have used it, AST helped us decrease turnaround time on those cases or consultations. It also provides us with the ability to deliver specialty or subspecialty care in places where they don’t have ac-

Live digital imaging improved the response time for consults and provided access to experts located outside of the USC-Keck’s perimeter.

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cess to such expertise,” says Keith J. Kaplan, MD, medical director, Cytopathology and Army Telepathology Program, WRAMC.

The AFIP utilizes live digital imaging on three continents — North America, Europe, and Asia. Kaplan offers an example of how consultations are processed at the AFIP. “In the case of a hematopathology consultation, not every hospital in the Army has a board-certified hematopathologist. Sometimes, it is necessary to obtain a hematopathology consultation on a difficult bone-marrow case. These live digital-imaging devices provide our pathologists at Fort Sill, Oklahoma, or at the Landstuhl Army Medical Center in Germany, access to subspecialty experts based at the AFIP. Turnaround time is usually four hours. The technology is very enabling for cases that mimic traditional consultation methods. That has largely been the consultation matrix we have been using successfully at the AFIP,” Kaplan comments.

When compared to static telepathology, live digital-imaging removes limitations, such as slide image transfer and single focal-plane viewing. With live digital imaging, everyone involved in the consult can review the slide at the same time and collaborate with other pathologists, technologists, and related medical staff.

Another value-added benefit is that the pathologist can review the materials even before the patient arrives at the hospital or is transferred from another facility. As Kaplan explains, prior to live digital imaging, patients often waited at their new facility for days or weeks until their slides arrived via mail. “In some cases now, we know the answer before the patient arrives. There is enhanced timeliness and enhanced quality of care because speciﬁms are able to precede the patient. Discussions about management of care can be taken at that point. And in some cases, this technology may decrease hospitalization time,” Kaplan says.

AST Evaluation and Installation at the AFIP

During the initial system-evaluation stage, the AFIP developed criteria to ensure an implementation of the best live digital-imaging device available. “First and foremost, we wanted a system with high-quality, high-resolution digital imaging. Second, it had to run over our existing networks without any special networking requirements. And ﬁnally, it had to work with the existing personnel that we have in place,” Kaplan comments.

The system selected met all requirements, and the installation and training process was fairly straightforward. Now, having completed 21 installations around the world since 2001, Kaplan’s team has garnered ﬁrst-hand experience with existing personnel and continues to update its training matrix, via lessons learned, following each installation. The 22nd installation is planned at the combat support hospital in Iraq.

When a new installation is initiated, Kaplan describes, it begins at the top with the hospital CEO (or hospital commander, the title used in the Army). The technician explains what the system consists of and how it will be used, and requests support for installation. The next step is providing the pathologists with space requirements and the IT personnel with network requirements. All site training and troubleshooting are performed by WRAMC/AFIP, although the team also has access to 24/7 vendor customer support.

The U.S. Department of Defense is the largest employer of solo pathologists — 105 are on staff around the world. Systems are being used in and are most applicable to sites with one to two pathologists. The systems installed at larger facilities, like at WRAMC, however, have 10 pathologists and have some subspecialty expertise in every area of surgical pathology and histology. At WRAMC, the live digital-imaging device is also used for residency-program training in surgical pathology and autopsies. With this training, residents gain experience and understand how to use the application when they arrive at a remote location, such as in Alaska, Kentucky, or Oklahoma, which is typically staffed by one or two pathologists.

AST in an Institution

The Pathology Department at the USC-Keck services seven hospitals, ﬁve are within 15 to 20 minutes’ walking distance, and the other two are approximately six miles away. Live digital imaging improved the response time for consults and provided access to experts located outside of the facility’s perimeter.

“In anatomic pathology, it has always been tradition that the pathologist goes to a central place to review the tissue slides or specimens. This meant that you moved expensive people around; and there is much time, effort, and inconvenience in that process. What telepathology allows is the movement of that specimen, that is the tissue slide, to wherever he may be, including — or theoretically — on an island in the Caribbean,” says Clive Taylor, MA, MD, DPhil, senior associate dean for academic affairs professor and chair, Pathology Department, USC-Keck.

“This technology has a real cost beneﬁt. It allows one to get access to experts that might otherwise be diﬃcult to reach because they are distant. And it reduces the time required for expert access or expert opinion because it is almost instantaneous. By shortening the turnaround time, the whole of the inpatient-care protocol, including hospital stay, is impacted. Not only are pathology expenses reduced, but also the whole hospitalization therapeutic process is improved,” Taylor explains.

The Pathology Department at the USC-Keck acquired its ﬁrst live digital-imaging devices in 2000, and they have been used extensively to produce digital banks of tissue-slide...
data. This data was then made available for access and transmission to people to evaluate at remote PCs, or alternatively transmitted to image-analysis systems.

Taylor explains why it was important to acquire live digital-imaging technology due to the distance between the various facilities the USC Department of Pathology serves. “If there is a specimen here that happens to be a pediatric tumor, our pediatric experts are six miles away. But now, we can access them with telepathology instantaneously. We actually set up a prototype system on this campus to share telepathology specimens between the cancer center and the university hospital, which are about a quarter of a mile apart.”

There are currently two live digital-imaging devices at the facility, with a third used for educational purposes. Additional installations are planned following the completion of another permanent facility. Once the new installations take place and become the standard for conducting frozen-section evaluations, broader training will be performed. Furthermore, Taylor notes that the digitized images produced by the device can be easily archived, and those archived specimens are then used for teaching.

“The use of live digital-imaging technology is still a bit ahead of its time,” Taylor says. “As electronic medical records come online with the actual digital tissue slide, it can become directly part of the record that is accessible by anyone in any place whenever the patient arrives, instead of trying to figure out how to transmit a slide across the country. The acceptance of this whole process will move along with the growth of electronic medical records. Pathologists need to recognize that they need to become digital pathologists, not limited to glass slides, because technology will pass them by.”

The use of AST and telepathology has become widely accepted for use in routine surgical pathology for frozen section, paraffin section, primary diagnosis, consultation, and distant learning. Live digital-imaging devices fulfill the requirement of viewing a high-quality, high-resolution image in real time on existing networks. Medical laboratories and institutions have experienced enhanced timeliness, improved patient care, and overall cost reductions. Pathologists employing this technology are now obtaining real-time answers with the ability to access specialty or subspecialty experts anywhere in the world.

“Pathologists need to recognize that they need to become digital pathologists, not limited to glass slides, because technology will pass them by.”

Jack Zeineh, MD, is the chief science officer at Trestle Corp., based in Newport Beach, CA. The company’s MedMicro performs AST by allowing multiple physicians to remotely view, navigate, and share high resolutions slide images over standard Internet connections.

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