Telepathology and Pathology at Distance: an Overview
Dražen M. Jukiæ, Carlo B. Bifulco
Department of Pathology, Memorial Sloan Kettering Cancer Center, New York, NY; and 1Department of Dermato-pathology and Department of Pathology Informatics, University of Pittsburgh Medical Center, Pittsburgh, Pa, USA

Telepathology is probably the latest addition to the world of pathology. The costs of pathologic tests have increased, the requirements for shortened turnaround time are omnipresent and we are all aware of the current litigious environment. Telepathology is one of the answers to at least some of these requests. Here we review the current status of telepathology in the world of telemedicine; compare differences, similarities and applications of static and dynamic telepathology; and give a short introduction to the basic setup of a telepathology laboratory.

Key words: computer communication networks; Croatia, pathology; diagnostic imaging; image processing, computer assisted; pathology; software tools; telepathology; telemedicine

What is telepathology? To answer this question, one can employ the definition proposed by the leaders in this field: “Telepathology is the practice of diagnostic pathology performed at a distance, with images viewed on a video monitor rather than directly through the (light) microscope” (1).

The history of telemedicine and telepathology is a relatively short one; one can say that the first telemedicine session took place in space, as NASA remotely monitored the EKG of astronauts orbiting around the earth. The first real ground session was organized between Logan airport and Massachusetts General Hospital (Boston, MA, USA) in 1960s. Since then, there has been an amazing progress in the field.

In 1986, Ronald S. Weinstein proposed, in an editorial written for the Human Pathology (2), the integration of robotic microscope, imaging, and broad-band telecommunication connections in wide-area pathology networks. Ten years later a whole issue of the Human Pathology was devoted to telepathology (1,3-8), and it remained a journal which followed the progress in the entire field (9,10). The purpose of this article is to elucidate the current applications and “brands” of telepathology, to give an overview of the field, and a perspective on its current place in the telemedical world. We will also give an outline and some general ideas for those who would like to set up a telepathology laboratory.

Before going any further, one thing must be realized: telemedicine, and consequentially telepathology, is not a science of the future but of the present (3,11-16) and is here to stay, to the point that today’s physicians are more and more required to have at least some knowledge of telemedicine. Not surprisingly, in 1998, Canada has produced its first physician specialized in telemedicine (17).

Principles of Telepathology
To better understand today’s telepathology applications, one should distinguish between static image and dynamic image telepathology and consider the pros and cons of each. Static image telepathology (SIT) is practiced by capturing microscopic images with a still photo camera, converting them to a digital format and sending them via either wide-area network or local-area network to a recipient (10). A classical static-image system is composed of a microscope, camera (either digital camera, analog-computer camera, or conventional photo camera coupled with a slide scanner), and some kind of either Internet or direct network connection. The images that are captured in this way are usually of high quality (over 1 megapixel in size) and require extensive storage space and bandwidth. Usually the images are limited in number and represent only a fraction of the entire histologic specimen. Proprietary software is not necessary, as the adherence to standard digital image formats (jpeg, bmp, tiff, or gif) will suffice. In this system the recipient has no input on the capturing of the image and has to render the diagnosis on the images received. The recipient also does not need any special software to open the pictures, as any high-end internet browser will suffice. These SIT systems are relatively cheap, easy to set up and maintain, and are more than sufficient if the primary purpose of the telepathology system is to run a consultation service. However, if the originating pathologist (sender) misses an area on the glass slide of potential diagnostic importance, so will the receiving/consulting pathologist. Hence, the diagnosis rendered on a telepathology consult specimen

March 1999 (Volume 40, Number 3)
should always include a statute of limitations and the images should be stored and retained in the digital data banks of both the sender and the recipient. Dynamic-image telepathology (DIT) captures images from the glass slides and transmits them to recipient continuously and in real time, allowing him/her in most cases an unlimited control of the input (5). For instance, the recipient is the one who decides which magnification and which slide field should be used. A DIT system should include a digital or charge coupled device (CCD) video camera, proprietary software, stable, broad-bandwidth connection between originator (sender) and recipient, high-resolution monitors, qualified personnel on both ends and dedicated hardware (computers) capable of handling all the above described requirements. The DIT captured images are usually of lower resolution than those utilized in SIT, but are continuous and allow the receiving pathologist to browse throughout the whole slide. As an addition, a robotic microscope used at the originating location will allow the receiving pathologist to actively scan the glass slide and to choose the slide fields, eliminating the need for a trained pathologist in the originating location. However, these systems are much more expensive than the static ones, more complex to set-up and maintain, and are ideal for running a high-volume service that deals primarily with routine cases (18,19). They are also the most appropriate systems for understaffed areas (20) and for frozen-section telepathology (13,21-23).

Reliability of Telepathology
As stated in the study performed at Iron Mountain, dynamic telepathology achieves concordance between telepathology and "real" pathology diagnosis of 97.5% (5,16), which is definitely superior to static telepathology concordance of 88% (10,16,24). One study revealed a diagnostic accuracy of 100% for SIT, but since the consulting pathologist was one of the authors, the findings may be overestimated (3). These studies are relatively old (1996-1997), at least in cyber age terms, and new ones with higher-end hardware should be performed. Accuracy, at least in the case of static telepathology, will always depend on the pathology background of the person capturing images and choosing the image fields (6); this is ideally overcome in dynamic telepathology applications, especially with regards to small biopsy specimens (i.e., skin or prostate) that can be captured whole with low-magnification objectives on a digital microscope. Despite all this, one must remember the flourishing consultation service ran by the Armed Forces Institute of Pathology, which thrives mostly on static telepathology, with images in most of the cases received as an e-mail (25,26). For less detailed images, other approaches may be warranted: for instance, a group from Spain has used a low-cost videophone system to perform immunohistochemical and DNA analysis consultations (27).

Legal Issues and Standards
As some legal issues are being raised for various types of "healing at distance" (28), it becomes apparent that, as every new specialty, telepathology also needs legal support. Several complex legal and regulatory issues, such as quality, patient confidentiality, licensing, evaluation, practice standards, reimbursement, patient and provider acceptance, costs, equipment standards and compatibility, and malpractice will have to be addressed before a widespread use of telepathology can occur. In addition, the technological infrastructure required for broad scale application of telemedicine is still in its infancy, and the regulatory framework needed to address such issues as fair pricing and equal access to telecommunications services has yet to be developed.

So far there is no single telepathology standard that would allow flawless and endless communication between different dynamic telepathology system and, as it looks at the moment, it will not be reached in the near future either. One attempt in the direction of unification of standards are the Digital Imaging and Communications in Medicine (DICOM) protocols. DICOM standards are to be set by the Image Exchange Committee of the College of American Pathologists. Even then, this would be just the beginning.

Legal issues are still up in the air and often incompletely addressed. One can say that there is more concern than decisive action in this field (29-32). If standards will indeed be set up in a near future, this will facilitate not only image exchange, but by setting up a database standard, also information warehousing. This will also have implications on future and current telepathology software and hardware, which will have to adhere to certain criteria. This process has been already successfully applied in teleradiology (33).

Telepathology in Small Countries
Croatia is one of the middle-European countries that is heavily involved in the general trend of telepathology in Europe. A group in Zagreb (18,19) developed its own software and is collaborating with groups in Germany and Austria. But does Croatia need a unified internal telepathology system? Croatian pathology would certainly benefit from the possibility of instantaneous inter-institutional consultation. However, considering today's economic situation, it would be impossible for most hospitals in Croatia to obtain and maintain high-end dynamic telepathology systems. Turnaround time
is still not a pressing issue in Croatian medicine. The present situation calls more for a not very expensive system that would allow occasional consultation with experts in Europe and beyond. A static system seems therefore to be appropriate for most Croatian pathologists.

Setting a Telepathology Laboratory

At this point, what would one need to implement a telepathology system in his/hers home institution? The answer relies in choosing the system wisely after having defined the needs and the possibilities offered by the existing (or nonexistent) computer hardware. In cybernetically most advanced pathology departments, static telepathology means only to send to a recipient/consultant images that had already been routinely captured (34). For day-to-day routine pathology work, e.g., daily frozen section diagnosis, dynamic system would be needed. However for occasional consultation service, one might revert to the static system, as cost would be minor and easier to defend in the constant daily battle for funds.

Any high-end Pentium or Macintosh should suffice for a telepathology computer; proprietary software is also needed, especially in the case of dynamic systems, and the same kind of proprietary software will be needed at both ends of the connection (originator/recipient). The display of images is also important; however, any high resolution large computer monitor will be more than appropriate, despite the current prestige of high definition television. High number of images per unit of time (DIT systems) need appropriate bandwidth. The connection between the sender and recipient are also important (Table 1).

Table 1. Comparison of currently commercially available connections between senders and recipients of computer messages

Another important decision to take is between low-end CCD cameras and fully digital devices; again system needs and available bandwidth (digital devices, as a rule, generate bigger images) will determine the choice.

Education of the existing medical personnel (pathology staff) is also an important task; in general the younger the pathologist, more familiar he/she will be with a case diagnosis on the digital screen. In a recent overview of telepathology (35), the top reasons for the system failure were: lack of interest, lack of support personnel, too ambitious or too complicated systems and, finally, the most terrifying one – loss of funding.

Future of Telepathology

Despite all these potential pitfalls, it looks like the path for telepathology is cleared: telemedicine, and consequently, telepathology are here to stay. Today, numerous health systems and hospitals in Europe (36-39), North America (40-42), and other continents (43,44) have already embraced and adopted tele-health principles and practices. In addition to diagnostic pathology, proposals were also made to use telepathology sessions for graduate and postgraduate education, which would contribute towards the knowledge needed to take exams for the European Diploma of Pathology (45).

References
36 Taylor P. Guide to medical informatics, the Internet and telemedicine; Cybermedicine. BMJ 1998;316:158.

Received: March 23, 1999
Accepted: April 15, 1999

Correspondence to:
Dražen M. Jukiæ
Departments of Dermatopathology and Pathology Informatics
University of Pittsburgh Medical Center
200 Lothrop Street
Pittsburgh, PA 15213, USA
hr0925@pol.net

Copyright © 1999 by the Croatian Medical Journal. All rights reserved. Created 22/7/99 - Last Modified 22/7/99
Created and maintained by: Tinman