Telepathology in the Diagnosis of Routine Dermatopathologic Entities

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Background: Telepathology involves the use of video technology to facilitate remote-site diagnosis. To our knowledge, no studies have compared the reproducibility of real-time telepathology between dermatopathologists with that of traditional 2-headed microscopy in the diagnoses of routine dermatopathologic entities.

Observations: The $\kappa$ statistic for both techniques was favorable: 0.76 (telepathology) vs 0.93 (conventional 2-headed microscopy); $P=.04$. The time taken per case was 42 seconds (telepathology) vs 19 seconds (conventional 2 -headed microscopy); $P=.003$.

Conclusions: Telepathology between 2 remote diagnostic centers offers a feasible means of facilitating the remote-site diagnosis of routine dermatopathologic entities. Although diagnostic accuracy and time taken per case were acceptable with video-assisted diagnosis, conventional microscopy had significantly higher accuracy and shorter time per diagnosis.

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Telepathology consists of the rendering of diagnoses remotely by evaluating electronically transmitted static or real-time images. This technique was first used by Eide in Norway in 1989, as reported by Nordrum et al2 2 years later. Since then, numerous reports have documented its utility, and it is now used to diagnose an increasing number of pathologic entities in a variety of settings.2-9 The principal forms of telepathology include static imaging and real-time (dynamic) transmission. The latter increasingly has become preferred because it allows the microscopist to analyze the entire image at multiple powers of magnification, either remotely or with the directed aid of the microscopist on the generating end. Telepathology eliminates the need to ship glass slides and/or biopsy materials to remote sites and thus provides rapid turnaround time. It also offers the option of permanent digital image storage and transmission. However, image resolution is compromised, particularly at high-power examination. The telepathological systems are expensive and not available at all sites. And, except where remote-control robotic systems are available, an experienced microscopist must be present at the generating end of the image to show the salient features of the slide.

Despite its adaptation for use with frozen sections, for diagnostic consultation, and other applications, and its recognition by an international cancer registry (UICC@www.uicc.org/programmes/detection/tpcc.shtml), telepathology-based diagnostic efficiency and accuracy have not been widely tested. Its diagnostic efficiency and accuracy may be particularly weak in the examination of entities that require the distinction of subtle architectural arrangements or cytologic features, as in dermatopathology.

Subtle-patterned arrangements of inflammatory cells characteristic of the inflammatory dermatoses and the nuances of architectural and cytologic appearance typical of the dysplastic nevus are but 2 examples of dermatopathologic entities that might create a significant degree of intraobserver and interobserver variability when diagnosed telepathologically. The ability of telepathology to allow discernment of these subtleties has not been adequately addressed. The specific aims of the present study were to compare the efficiency and interobserver variability of telepathology with those of traditional light microscopy in a series of dermatopathologic entities.
METHODS

The overall study design involved an assessment of diagnostic efficiency and interobserver variability in the diagnosis of dermatopathologic entities by telepathology. The study was validated by a comparison with traditional microscopy and statistical methods.

EQUIPMENT

The 2-headed microscopes used for both arms of this study were the Olympus model BX-40 (Tokyo, Japan). Each telepathology microscope was fitted with a Sharp XG-A1 color camera (Tokyo, Japan). The image was compressed and transmitted by a V-TELEC 3500 video codec (Rockledge, Fla), using Apps View Smari Video conferencing software (Windows 95–based v1.00.06; Microsoft Corporation, Redmond, Wash). The image was sent through a T1 line at 768 kilobytes per second using a multihand transmitter (V-TEL Enterprise Series, Model LX-2). The transmitted image was received through a reciprocal personal computer running the identical V-TEC codec and software. It was then processed and sent at a resolution of 640 x 480 active lines through an RG-59 cable to a Sony 27-inch Trinitron monitor (Model No. 2050Q; Tokyo, Japan). A separate voice-transmittal speakerphone line was present at each facility. The equipment was housed in 2 separate Veterans Affairs hospital facilities located approximately 64 km (40 miles) apart.

PATHOLOGISTS AND SUBJECT MATERIAL

The 2 pathologists were senior, board-certified dermatopathologists with extensive backgrounds in academic medicine. They evaluated 100 specimens from patients referred by local dermatologists to a community-based practice of dermatopathology. Included were approximately 25 melanocytic lesions (including 15 dysplastic nevi), 50 nonmelanoma skin cancers, 25 inflammatory dermatoses, and the remainder consisting of various benign and malignant cutaneous and adnexal-derived lesions.

PROCEDURE

Telepathology was used to diagnose the first 50 cases. The time at the start and finish of the study was recorded. The case history was read prior to each case examined. Each pathologist independently rendered an opinion without discussion. The receiving pathologist verbally instructed the generating pathologist what power of magnification to use and where the stage should be directed. When a diagnosis was rendered, the generating pathologist was informed, and the next case was examined. The other 50 cases were evaluated the next day using a traditional 2-headed microscopy procedure.

ANALYSIS

Efficiency of the procedure was measured by evaluating the average time taken per case, expressed as the total time taken to examine 50 cases divided by 50. Interobserver variability was expressed using the $\kappa$ statistic ($\kappa > 0.5$ but $\leq 0.75$, fair correlation; $\kappa > 0.75$ but $< 1.00$, good correlation; and $\kappa = 1.00$, perfect correlation). Differences between the 2 techniques for efficiency and interobserver variability were assessed using the $t$ test, with $P$ values less than .05 considered significant. To be considered similar, the diagnoses had to match perfectly (ie, dysplastic nevi with a specified degree [mild, moderate, or severe] of melanocytic atypia).

RESULTS

EFFICIENCY

With telepathology, the total time taken to examine 50 consecutive cases was 35 minutes (42 seconds per case) vs 16 minutes (19 seconds per case) with traditional 2-headed microscopy. The efficiency of the traditional method, as measured by time per case, was significantly better ($P = .003$).

INTEROBSERVER VARIABILITY

Good agreement ($\kappa = 0.76$) was found among the pathologists using telepathology: agreement was obtained in 44 of the 50 cases. Of the 6 cases of disagreement, 4 involved a minor difference of opinion, and 2 involved a major disagreement. The 4 cases of minor disagreement were as follows: (1) keratoacanthoma vs well-differentiated squamous cell carcinoma; (2) tumid lupus erythematosus vs discoid lupus erythematosus; (3) mildly dysplastic junctional nevus vs moderately dysplastic junctional nevus; and (4) actinic keratosis vs squamous cell carcinoma. The major differences involved a diagnosis of connective tissue nevus vs normal skin, and prurigo nodularis vs microinvasive well-differentiated squamous cell carcinoma.

There was excellent agreement ($\kappa = 0.93$) among the pathologists using traditional microscopy: complete agreement was obtained in 48 of the 50 cases. Both cases of disagreement involved minor differences of opinion: mildly dysplastic junctional nevus vs moderately dysplastic junctional nevus and clavus vs senescent plantar verruca. There was a significant difference in interobserver variability between the 2 techniques ($P = .04$).

Following discussion of the 6 telepathology cases that resulted in disagreement among the pathologists, a consensus was obtained in 4. The refined diagnostic opinions were attributed to improved image resolution that was not readily obtainable with telepathology in 3 of the cases and inattention to detail in the remaining case. The 2 cases of disagreement encountered in traditional microscopy were attributed to differing criteria used to discern the degree of melanocytic cytologic atypia in dysplastic junctional nevus and to separate senescent verruca from clavus.

COMMENT

The field of telepathology has existed to some degree for almost 20 years. For much of that time, it has thrived only among electronics enthusiasts and technology buffs. With the widespread acceptance of the Internet and electronic communications, however, dermatopathologists are becoming ever more dependent on technological advances. It seems likely that exchange of opinions regarding histologic sections is no longer a far-fetched dream, but rather an inevitable short-term development in our routine practice. Before patently endorsing any type of changes in the way dermatopathology is practiced, we must evaluate critically the change in procedure, comparing it with the standard methods. Not every technological advance truly represents progress.
In the present study, we have compared the efficiency and reproducibility of diagnoses rendered by 2 independent, board-certified dermatopathologists using a double-headed microscope and telepathology from 2 remote sites (approximately 64 km apart). While there was a statistically significant difference in the time required to examine a similar number of slides, in clinical practice, telepathology does not appear to present a serious time limitation, given the proper equipment and expertise of the operators. We were able to generate remote diagnoses in less than 1 minute per slide for random, unselected cases. The ability to verbally communicate in real time, allowing for the real-time movement of the slides and magnification objectives, did not present any meaningful delays in rendering diagnoses. If one were considering the routine sign-offs of hundreds of cases per day using such a format, the difference in time spent per slide would need further analysis and modification. However, in the most commonly envisioned scenario, ie, a difficult case being shared electronically with a remote consultant, the additional seconds required for the telepathologic consultation is trivial compared with the additional days or even weeks required to send the case in consultation to a remote site, have it accessioned at the second location, and await for the ensuing consultative report.

More important is the question of diagnostic reproducibility. If a technique provides inferior diagnostic service for patients, the efficiency at which it can be performed is clearly less interesting. Our data suggest that there may still be some slight limitations inherent in telepathologic consultation. While the 2 telepathologists agreed entirely on more than 85% of cases, there was still a significantly lower rate of agreement than that seen using conventional 2-headed microscopy. Diagnostic disagreement was generally encountered in 2 settings: cases that involved the assessment of subtle diagnostic criteria such as the orientation of collagen fibers in connective tissue nevus or those that required the application of contentious criteria or terms to arrive at a diagnosis such as dysplastic nevus or keratoacanthoma. It should be noted that as the number of specimens we examined was relatively small, the difference between 48 complete agreements of a possible 50 traditional comparisons and 44 of 50 telepathology comparisons hardly seems dramatic. Along the same lines, when minor disagreements are eliminated, we found virtually no difference in our ability to concur on the diagnoses in the cases we examined. Since the 2 pathologists trained in different centers and had never looked at slides together before, some disagreements are to be expected. No 2 pathologists are likely to have identical diagnostic criteria for a series of 100 unselected dermatologic conditions without prior consensus training. All of these points tend to minimize actual differences in the reproducibility between traditional 2-headed microscopy and telepathologic consultation.

We became aware of several impediments while attempting our telepathologic consultations. Given the equipment we used on the receiving end of our experiment, difficulties in resolution necessitated the constant requests for higher magnification that were not required when the 2 participants were sharing a 2-headed light microscope. While it was easy enough to see general architectural patterns, it was often difficult to make more subtle distinctions. It was difficult to determine, for example, what types of inflammatory cells were present in the dermis or whether the vacuolated cells along the dermal epidermal junction were melanocytes or keratinocytes. While attempting to examine the slides at higher magnification, we found that the issue of sampling became more of a problem. When the receiver requested a move to a higher magnification objective, it was difficult for him to describe the sections of the slide he wished to examine. Additionally, without direct control of the microscope stage, the receiving pathologist became disoriented as to which part of the slide he was viewing. While these issues were somewhat problematic, the ultimate results suggest that they were more of a feeling of unease than serious impediments to reproducible diagnoses.

The feasibility of teledermatopathology has been proven in previous studies. A total of 6 studies, each involving the transmission of static preselected images, have been reported. Weinstein et al showed nearly 100% concordance of diagnosis and margin assessment in a retrospective study that involved a surgical pathologist and frozen section analysis of mostly nonmelanoma skin cancer. Dawson et al showed similar results by frozen section in a Veterans Affairs hospital setting. Della Mea et al showed a κ statistic of 0.79 between 2 pathologists in a study of 20 melanocytic lesions. Piccolo et al showed a telepathology concordance rate of 78% that improved to 85% with conventional microscopy in a series that involved 20 various dermatologic entities. Okada et al showed 100% concordance in a study of 35 melanocytic lesions between a general pathologist and dermatopathologist. Berman et al showed a concordance rate of 80% with a variety of dermatologic entities in a retrospective analysis involving the same dermatopathologist 1 year later. The concordance rate improved to 84% with the addition of a clinical history and to 99% with the application of traditional microscopy. Interestingly, the concordance rate was statistically higher with non–squamous cell cutaneous carcinoma and melanocytic lesions than with squamous cell carcinoma and squamous cell carcinoma in situ.

As the technology continues to advance, it seems likely that each of the “problems” we encounter with telepathology will be rapidly eliminated. The electronic transmission of ever-higher-resolution images continues to occur. While at this point, the expense of this equipment may be beyond the reach of most dermatopathology practices, within a short time, very-high-resolution devices will almost certainly become accessible to most of us. In addition, the field of robotics has already provided microscopic setups that enable the recipient pathologist to control the movement of the slides and microscope objectives. This technology was not available to us. As it becomes widely available, it will serve to eliminate the disorientation derived from lack of slide control on the part of the receiving pathologist. This is a significant point because telepathology will never be widely accepted until the consultant...
pathologist feels in complete control of the slide to be examined and can therefore be confident in the diagnosis rendered.

In summary, our pilot study suggests that the use of remote expert consultation in diagnostic dermatopathology is near at hand. The technology enables rapid and reproducible diagnoses. While the comfort level of the remote pathologist may not be quite as high as in hands-on evaluation, newer advances will likely eliminate this discomfort in the near future.

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REFERENCES


News and Notes

A course on humanitarian assistance for dermatologists, intended to prepare dermatologists for participation in humanitarian assistance projects under austere circumstances, will be offered in Bethesda, Md, from June 2 through June 6, 2003. The primary audience is federal dermatologists and residents, but the course is open to civilian dermatologists and residents with interest or experience in humanitarian assistance. The course is ideal for people who might volunteer to work with organizations that provide medical or humanitarian assistance and disaster relief. The course is offered under the auspices of the Department of Dermatology, Uniformed Services University of the Health Sciences, and the Center for Disaster and Humanitarian Assistance Medicine. Up to 30 hours of AAD/AMA Level I CME will be awarded. The course has a limited enrollment. For more information, contact the course director, Scott A. Norton, MD, MPH, Dermatology Service, Walter Reed Army Medical Center, Washington, DC 20307; phone: (202) 782-9484; fax: (202) 782-9118; e-mail: scott.norton@na.amedd.army.mil.