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ARTICLE

Intra-hospital Use of a Telepathology System

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Utilization of telepathology systems to cover distant geographical areas has increased recently. However, the potential usefulness of similar systems for closer distances does not seem to be widely appreciated. In this study, we present data on the use of a simple telepathology system connecting the pathology department and the intra-operative consultation room within the operating theaters of the hospital. Ninety-eight frozen section cases from a past period have been re-evaluated using a real-time setup. Forty-eight of the cases have been re-evaluated in the customary fashion; allowing both ends to communicate and cooperate freely. Fifty of the cases, however, were evaluated by the consultant while the operating room end behaved like a "robot"; moving the stage of the microscope, changing and focusing the objectives. The deferral rate was lower than the original frozen section evaluations. Overall, the sensitivity was 100%, specificity 98%, negative predictive value 96,5% and positive predictive value 100%. No significant difference was found for the diagnostic performances between the cooperative and robotic simulation methods.Our results strengthen the belief that telepathology is a valuable tool in offering pathology services to remote areas. The far side of a hospital building can also be a remote area and a low cost system can be helpful for intraoperative consultations. Educational value of such a system is also commendable. (Pathology Oncology Research Vol 6, No 3, 197–201, 2000)

Keywords: telepathology, frozen section

Introduction

Telemedicine involves providing health care services between two or more locations through the use of telecommunication technology. A number of medical services including radiology, pathology as well as consultations in specialised disciplines like neurology, dermatology and cardiology can readily be delivered or accessed remotely using information technology.[3]

Telepathology is a part of telemedicine and has been defined as the practice of pathology over a distance by viewing images transmitted from a remote site, with specimens viewed indirectly on video monitor rather than directly through a light microscope.[1] It involves the visualization of gross and microscopic images as well as radiographs or electron micrographs on a video monitor.[4]

The concept of using video microscopy to provide diagnostic pathology services to remote locations was first formally tested as part of the Massachussets General Hospital – Logan airport telemedicine project, initiated in April 1968.[10] In 1986, the first dynamic robotic telepathology system was engineered and constructed in Chicago. A test-of-concept demonstration in that year between El Paso, and Washington DC, was successful using a satellite to transmit live video images of breast biopsy frozen sections.[3]

There are currently two main forms of telepathology; static and dynamic. In the static mode, a small number of digitized images are captured and transmitted to a telepathologist who views them sequentially on a video monitor. In the dynamic mode, live video images of the microscopic slides are transmitted and visualized in real time.[3] Some of the dynamic systems allow the robotic remote control of the microscope.[4] Hybrid telepathology systems combine features of both static-image and dynamic-robotic telepathology systems.[3] The subject has been extensively reviewed recently.[5]

The transmitted images may be used for primary diagnosis, consultation, quality assurance, proficiency testing, and distance learning.[5,11] By allowing real time, interac-

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tive, long distance pathology consultations, telepathology has the potential to increase access to general or subspecialty pathology services in remote areas, decrease costs by reducing turnaround time for consultations, and reduce professional isolation of the rural pathologist. However, these benefits will not materialize if diagnoses made using a telepathology system are less accurate than those made using a conventional light microscope.[1]

In this retrospective study, we have evaluated frozen section (FS) slides of 98 cases using an intra-hospital telepathology system. We have assessed the specificity and sensitivity of this telepathology system. Furthermore, dynamic-robotic telepathology systems have been simulated to compare the performance of these costly systems with that of the conventional ones.

Material and Methods

One-hundred cases that had been sent for intraoperative consultation and evaluated with frozen section examination in the pathology department within the first three months of 1995 and 1996 have been studied. Two cases have been excluded due to the lack of sufficient data (no records of the original FS diagnoses) decreasing the number of cases to 98.

An intra-hospital live telepathology system between the intraoperative consultation room and the pathology department has been used for this study. The intraoperative consultation room is in the premedication section of the operating theaters. A three-chip CCD color video camera (Sony) attached to a light microscope (Nikon E 400) and an 11 inch video monitor (Sony) were used. Another three-chip CCD color video (Sony) camera with zoom feature was available for macroscopic imaging. A switcher allowed sequential capture and transmission of images from these two sources. The sections were prepared using a cryostat (Leica CM-800).

A 200 meter co-axial cable was used to connect the intraoperative consultation unit with the department which was on the fifth floor of the hospital. A 21-inch video monitor (Sony) displayed the macroscopic and microscopic images sent from the intraoperative consultation room. The system also included microphones and speakers to allow vocal communication between the two ends.

Study design

Pathologist A at the intraoperative consultation room end of the system transmitted live images to pathologist B who evaluated these on the video monitor in the pathology department. For simulation purposes, the cases were randomly divided into two and 50 of them were evaluated without cooperation between the pathologist A and B (blind method). The remaining 48 cases were evaluated cooperatively as if both pathologists were sitting next to each other and using a microscope with teaching heads. In the blind method, robotic dynamic telepathology systems were simulated by limiting the content of communication between the pathologists. Pathologist A presented the slides according to directions of pathologist B; the age and sex of the patient, the site of the biopsy and the clinical request (if specified) were also transmitted. However, no comments about histological findings were allowed. Specifically, pathologist A was not allowed to bring pathologist B's attention to features he thought might be important. In the cooperative method, all verbal interactions were allowed and pathologist A was free to assist pathologist B in selecting the microscopic fields.

The time spent for the diagnosis of each case was noted. A break of 15 minutes was given every hour. Original frozen section diagnoses were not told to pathologist B at the time of study.

Routine histopathologic examination diagnoses were accepted as "gold standard" final diagnoses for this study.

Data were evaluated statistically with Student's t test, Mann-Whitney U and Mc Nemar tests. The sensitivity and the specificity of the methods were calculated. Negative and positive predictive values were also determined.

Results

Most of the samples in this series werefrom the thyroid, breast, lymph node and the ovary. (*Table 1*) The results were classified as positive for malignancy (POS), negative for malignancy (NEG) and deferred diagnosis (DEF) (*Table 2*).

The diagnoses of 84 cases were compatible with the original FS diagnoses (85.7% concordance). Eight cases

Table 1. **Summary of cases used in the study**

Organ/System	*Number*
Thyroid	20
Breast	11
Ovary	11
Lymph Node	11
Soft tissue	8
Brain	7
Bone	5
Liver	4
Stomach	3
Small and large intestines	2
Lung	2
Others*	14

* Ureter 1, oral cavity 1, lip 2, pancreas 1, larynx 1, upper mediastinum 1, uterus 1, Douglas pouch 1, upper eye lid 1, lacrimal gland 1, testis 1, paratesticular 1, scrotum 1.

Table 2. **Comparison of diagnoses of cases evaluated with two different methods blind (BM) and cooperative method (CM)**

Frozen section diagnosis	Study diagnosis						
	NEG		POS		DEF		
	BM	CM	BM	CM	BM	CM	Total
NEG	26	27	–	1	3	1	58
POS	–	–	16	12	–	1	29
DEF	3	5	–	–	2	1	11
Total	29	32	16	13	5	3	98

(NEG: negative for malignancy, POS: positive for malignancy, DEF: defered, BM: blind method, CM: cooperative method)

deferred in the study were from thyroid (2), breast (1), ovary (1), soft tissue (1), bone (1), oral cavity (1) and Douglas pouch (1). One case diagnosed as POS in the study, was NEG in the FS evaluation (false positivity). The re-evaluation of paraffin sections of this case confirmed the original FS diagnosis and no proof for malignancy could be demonstrated.

When compared with the paraffin section diagnoses, the gold standard of this study, the diagnoses of 89 cases have been correct (90.8%). The diagnoses of 8 cases were deferred (8.25). The deferral rate for the original frozen section evaluation was 11.2% (11 cases). A potentially risky diagnostic error (false positivity) was made in one case (1%).

Blind telepathology

The diagnoses of 45 cases from a total of 50 were compatible with the paraffin section diagnoses (90%). The diagnoses of 5 cases (10%) were deferred.

Cooperative telepathology

The diagnoses of 44 cases from a total of 48 cases were compatible with the paraffin section diagnoses (91.6%). The diagnoses of 3 cases were deferred (6.2%). A case was misdiagnosed as POS in this group. This case constitutes the only false positivity in our series. The time spent for the evaluation of each case is shown in *Table 3*. The average time spent in the evaluation of cases was calculated as 286 seconds (4.7 minutes) .

Discussion

The first commercial prototype of a color video/robotic telepathology system was constructed in the United States.[10] The first telepathology network was established in France.[11] Today, more than 200 references are retrievable from the Medline database using "telepathology" as a search word. Weinstein et. al. reported in 1997 that telepathology workstations had been installed in more than a dozen countries.[11] A summary of European efforts has been provided recently.[5]

The use of telepathology as an intra-hospital activity has not been reported before. The system described in this article is now being used for selected cases as a quick way of intradepartmental consultation. The system used in this study utilizes a coaxial cable for the seamless transmission of live video images. Instead of a electromechanical remote control, vocal communication is used to move the stage.

Diagnostic accuracy is an important topic for the routine use of telepathology. Studies on diagnostic performance fall into three broad categories: feasibility studies, validation studies, and clinical studies. Our study is an example of a validation study.

The diagnostic accuracy of the evaluation of static images have been reported to be range from 68.8% to 95.0% for frozen tissue sections and from 86.0% to 96.4% for permanent sections.[1] The difference in diagnostic accuracy results stems from the interpretation, video image quality, video monitor experience, field selection and the type of the surgical specimen.[1,6,9,11]

The concordance rate with respect to diagnosis of the lesions as malignant or benign, an important task in frozen section services, varies from 85% to 95%. This is probably below the general diagnostic agreement rate in the traditional intra-hospital frozen section services. The differences between remote and intra-hospital frozen section diagnoses have been ascribed to the higher rates of deferred diagnoses in the remote situation.[7] The pathologists inexperienced in the use of telepathology have a greater tendency to defer their diagnoses. However, it is still not certain whether the increased deferral rates are due to the increased complexity of telepathological evaluations or to the lack of experience with this method. Familiarity with electronic images has been shown to positively effect the performance.[6]

Glass slide diagnosis was the "gold standard" for this study. The original frozen section diagnoses of all cases

Table 3. **Time spent in the evaluation of cases (seconds)**

	BM	(n)	CM	(n)	P value
NEG	226.0 ± 135	(29)	309.7 ± 207	(32)	0.07
POS	279.5 ± 207	(16)	251.7 ± 135	(13)	0.682
DEF	439.4 ± 48	(5)	569.7 ± 60	(3)	0.071
NEG+DEF	257.4 ± 147.1	(34)	331.9 ± 211.8	(35)	0.095
Total	264.5 ± 166.9	(50)	310.3 ± 196.0	(48)	0.216

(BM: blind method, CM: cooperative method, NEG: negative for malignancy, POS: positive for malignancy, DEF: deferred, n: number of cases) (except 11 deferrals) were compatible with their permanent slide diagnoses. All the telepathology diagnoses excluding 8 deferrals and 1 false positive case, were compatible with gold standard diagnoses. The sensitivity, specificity, negative and positive predictive values for the original frozen section diagnoses were 100%. For the telepathology cases as a single group, these values were calculated as follows: Sensitivity 100%, specificity 98%, negative predictive value 96.5% and positive predictive value 100% (*Table 4 and Table 5*).

Nordrum has evaluated the results of 17 telepathology studies based on real-time systems. He found that the diagnostic accuracy of those remote frozen section services were probably adequate.[7] The very low number of reported false positive diagnoses regarding malignancy is also reassuring. According to Nordrum, efforts must be concentrated on decreasing the number of deferrals in the future.[7] In general, deferrals in frozen section evaluation should be less than 10%. Higher rates of deferrals may make the use of frozen section evaluations questionable. In our study, the number of deferrals in the telepathologic evaluation were less than that for the original frozen section evaluations (11 vs 8). This is in contrast to the previous reports in the literature. This seemingly anomalous condition can be due to the lower level of experience of pathologists who have evaluated the original frozen sections. No formal study has been done, however, to investigate this hypothesis. There have been only 3 cases for which the diagnoses were deferred in both the original frozen section and the telepathological studies. For this reason, we assume that the factors causing deferrals can be different for these methods. Other studies may be needed to address this issue.

Table 4. **Diagnostic accuracy of frozen section and telepathology**

	Diagnosis			
	Telepathology		*Frozen section*	
Original paraffin diagnosis (gold standard)	POS	NEG	POS	NEG
POS	28	–	29	–
NEG	1	61	–	58

(NEG: negative for malignancy, POS: positive for malignancy)

Table 5. **Sensitivity, specificity, positive and negative predictive value for frozen section and telepathology diagnoses**

	Frozen section	*Telepathology*
Sensitivity	100%	100%
Specificity	100%	98%
Positive predictive value	100%	100%
Negative predictive value	100%	96.5%

The false positive telepathology diagnosis in one case in this series makes the interpretation of diagnostic accuracy difficult. This case had been evaluated cooperatively with the transfer of a clinical information as "papillary formation in the lower part of ureter". In the permanent sections the sample consisted of bladder mucosa with a significant degree of cautery artefacts. This slide has also been evaluated by the other pathologists in the department. Most have stated that deferring the diagnosis in this case would have been more suitable. No follow up information is available for this case. It is not clear whether telepathology did contribute to this false positivity or not. This single error can be a personal misinterpretation and could conceivably have happened during a conventional frozen section evaluation. Since "frozen section evaluation" is not a final diagnostic test, a certain amount of error (in general <3%) is acceptable. In a previous study made in our department on 1316 frozen section evaluations, the false negativity rate was 1.1% and the false positivity rate was 0.3%.[2]

It seems safe to say that the real time telepathology system as described in this study does not cause any insufficiency in ruling out a malignancy (negative predictive value 100%). The receiver operating characteristic (ROC) area have been calculated as 0.98 with the permanent section diagnoses as gold standard. This also supports our view that the efficiency of the telepathology method did not differ significantly from that of the frozen section evaluation (ROC area: 1.0).

During the telepathology study, the lack of urgency for a diagnosis was a factor which could have affected the diagnostic performance positively.On the other hand, the loss of concentration due to the necessity of evaluating many cases in one session, and the lack of contribution from the gross examination were noticeable disadvantages. The contribution, if any, of these factors to the results of telepathology validation studies like ours have not been evaluated.

The average evaluation time for diagnosis was calculated as 286 seconds (4.7 minutes). This suggests that telepathology method would not delay the diagnosis significantly.

Our findings support the view that dynamic telepathology can be used for intraoperative consultation by an experienced pathologist familiar with this method. This method can be used within the established limits of intraoperative consultation examinations.

Establishing a system like ours can also be thought as a cost-effective way of providing training to potential users of telepathology systems.

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