

► Telepathology on the Solomon Islands — two years' experience with a hybrid Web- and email-based telepathology system

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Summary

The National Referral Hospital in Honiara, Solomon Islands, has used an Internet-based system in Switzerland for telepathology consultations since September 2001. Due to the limited bandwidth of Internet connections on the Solomon Islands, an email interface was developed that allows users in Honiara to submit cases and receive reports by email. At the other end, consultants can use a more sophisticated Web-based interface that allows discussion of cases among an expert panel. The result is a hybrid email- and Web-based telepathology system. Over two years, 333 consultations were performed, in which 94% of cases could be diagnosed by a remote pathologist. A computer-assisted 'virtual institute' of pathologists was established. This form of organization helped to reduce the median time from submission of the request to a report from 28 h to 8.5 h for a preliminary diagnosis and 13 h for a final report. A final report was possible in 77% of all submitted cases.

Introduction

The National Referral Hospital (NRH) in Honiara is the only major hospital in the Solomon Islands, an independent state with approximately 450,000 inhabitants, in the south-west of the Pacific Ocean. The NRH is the only referral hospital for the eight provincial hospitals. The country has about 40 doctors but not a single pathologist and consequently tissue samples for histological examination have to be sent by airmail to the nearest pathology service, which is in Brisbane, Australia. With the decline in tourism after the civil disorder in 1999, transport to the Solomon Islands has become even more limited. It is common for the doctors at the NRH to wait for three to six weeks before a histological diagnosis is available from Brisbane.

Patients from remote islands have to travel by boat for days to reach the NRH on the main island. For many patients it is difficult to return home to wait until a diagnostic result has arrived at the NRH and, as a consequence, treatment decisions often have to be made without a firm histological diagnosis. Recent advances in telecommunications and telemedicine suggest ways of overcoming such problems. There is growing evidence in the literature that telemedicine is a feasible tool, even for countries with less well developed telecommunications infrastructure¹⁻⁷. However, most of the reports deal

with teledermatology^{6,7} and teleradiology³, and there is little published experience in the field of telepathology in developing countries (only one citation in PubMed⁸).

We have therefore employed iPath, a hybrid Web- and email-based telemedicine system developed at the University of Basel⁹⁻¹¹. Basically, iPath is a collaborative platform that allows a group of specialists to discuss cases; these typically consist of a clinical description and attached images or other multimedia objects. A special feature of iPath is that it offers static as well as dynamic telepathology¹² and also several interfaces for access to data. A user can work via an email or a Web interface, but there is also the possibility of interactive remote control of a robotic microscope. iPath is available as free software¹³. In October 2001, when the project was started, the Solomon Islands telecommunications provider had a 128 kbit/s link to the Internet, which had to be shared by all Internet users in the country. Because of this limited bandwidth, only static telepathology was practicable.

Methods

A small histology laboratory was established at the NRH in Honiara in September 2001 that was able to prepare sections stained with haematoxylin and eosin. The processing of the specimens was done manually, because the repair and maintenance of any specialized automatic equipment are difficult. The gross specimens are prepared by the surgeon and the slides are usually ready two or three days later.

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From the microscopic sections prepared in this laboratory, digital photographs are taken using a digital camera (CoolPix 990, Nikon) mounted on a microscope (OptiPhot 2, Nikon). These pictures are usually scaled to approximately 600 × 400 pixels (typically 20–70 kByte) then sent via email to the telepathology server at the University of Basel.

The telepathology server in Basel is based on iPath¹³. Originally, iPath was developed as a consultation platform that offered access through a Web browser. However, the experience in the Solomon Islands led to the development of email-based access. The server can automatically import cases from email. The email text is stored as the case description and the attached images are placed in an image gallery.

These cases are then reviewed by an international group of pathologists. These pathologists are organized as a ‘virtual institute’ (VIRIN¹¹) using the ‘expert group’ facility of iPath. As in a real institute, there is always one pathologist on call. When a new case arrives, the pathologist on call is automatically notified by email. The pathologist will then use the Web interface to review the case (Fig 1).

If a diagnosis can be given easily, the expert on call will simply write the diagnosis and label it as final. The system will then close the case and send the diagnosis automatically to the NRH by email. If the case is more complicated, the expert on call may state a preliminary diagnosis and then link the case to the VIRIN. Other members of the VIRIN are informed of the case by email and can report their opinion. These

opinions are collected inside the VIRIN and are not directly accessible to the sender of the case. Finally, the expert on call will summarize the opinions of his or her colleagues and will write it down in the original case report. The referring doctors can read this diagnosis online or, in places where online Web access is difficult, the server can automatically send the final diagnosis by email.

Results

Between January 2002 and December 2003, 333 pathology consultations were submitted, by email, from the NRH to the telepathology server in Basel. These consultations comprised a short clinical description and images as attachments (an average of 8.8 images per consultation). In 50% of all consultations, a first report from a pathologist was issued in 12 h or less (Table 1).

The cases were submitted in two phases: phase I included all cases that were submitted before the introduction of the VIRIN in October 2002, while phase II included all cases submitted thereafter. During phase I, 73 cases were submitted. During this 10-month period, the pathologists were not organized in any particular way. Every pathologist would log into the system now and then and report on new cases. As Table 1 illustrates, in 50% of the cases a response from a

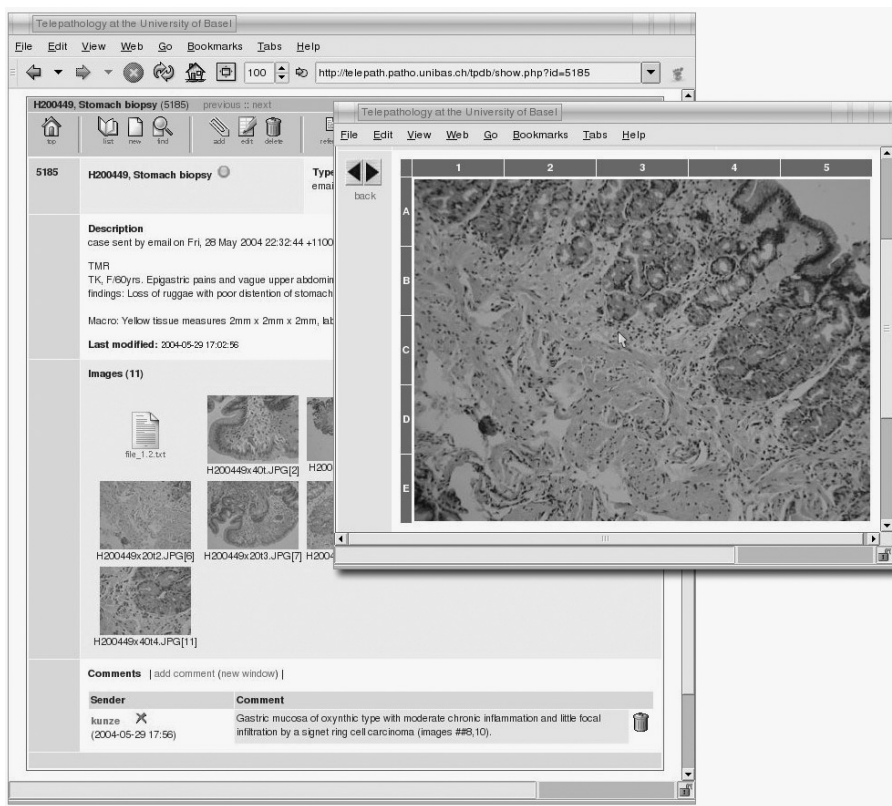


Fig 1 The iPath Web interface. Every case consists of a header with information about the sender, date and title, followed by a clinical description and an image gallery. Images can be enlarged and the experts can enter their comments and diagnosis at the bottom of the page.

Table 1 Telepathology consultations from the National Referral Hospital in Honiara

	Phase I ^a	Phase II ^a	Total
Number of consultations	73	260	333
Median time to first response (h)	28	8.5	12
Consultation possible	93%	94%	94%
Additional images requested	25%	10%	13%

^aPhase I consultations took place from January 2002 to October 2002, before the introduction of the 'virtual institute' (VIRIN). Phase II consultations took place from November 2002 to December 2003, after the establishment of the VIRIN.

pathologist was made no later than 28 h after submission of the case (on average within 32 h). In 25% of all submitted cases, the pathologists asked for additional images and requested a specific location and magnification for these images. Overall, in 93% of the cases, the submitted material was suitable for at least some degree of diagnostic interpretation.

One of the major problems with this method of collaboration was that the doctors in Honiara were left to surmise a conclusive diagnosis from the comments of the different pathologists. This led to the idea of forming a VIRIN, where second-opinion consultations were gathered in a closed discussion among the pathologists. Eventually one pathologist summarized the discussion and attached a conclusive response to the original case. This response was then automatically emailed to the doctors in Honiara.

The software to support the VIRIN was developed during October 2002 and in November the eight participating pathologists were reorganized as a VIRIN. A duty plan was prepared and each week one pathologist was on call. The iPath system automatically notified the pathologist on call about any new cases and also about new comments from other pathologists. In addition, the pathologist on call was asked to mark a diagnosis as final if, in his or her opinion, a diagnostically conclusive response was possible based on the submitted material.

In phase II, from November 2002 to December 2003, a total of 260 cases were submitted. In 50% of the cases the response time for a preliminary diagnosis was less than 8.5 h (mean 22 h) (Table 1). In 77% of all submitted cases, the pathologist on call submitted a final diagnosis (Table 2). The median response time for a final diagnosis was 13 h (mean 31 h). Eighty-three per cent of these cases were signed out directly by the pathologist on duty without further consultations, but in 17% a second opinion was requested from the VIRIN. On average, these cases received 3.7 comments from the VIRIN

Table 2 Results of the virtual institute

	Results from 260 consultations (phase II)
Median (mean) time to final diagnosis (h)	13 (31)
Consultations with final report	77%
Second-opinion consultation in the VIRIN	17%
Median (mean) time to final diagnosis after VIRIN consultation (h)	74 (89)
Mean number of second opinions in the VIRIN	3.7

and for the cases discussed in the VIRIN a final diagnosis was available after a median of 74 h (mean 89 h).

It is noteworthy that, for the 260 phase II cases, a consultation was possible in 94% and only 77% were signed out with a final diagnosis. In other words, in 6% of the submitted cases the material was not sufficient for any kind of medical interpretation. The main reasons were technical problems or communication failures. For a further 17% of all cases, a preliminary medical interpretation was possible, but the material submitted did not suffice for the experts to reach a conclusive diagnosis.

Discussion

Telepathology dramatically reduces the time from specimen collection to results. The system established in the Solomon Islands is fast, convenient and cheap. The relatively quick results are a great relief for the patients, and for the relatives who are responsible for providing food and basic services for the patients while they are in hospital. The rapid results are also very helpful for the doctors and help to overcome the professional isolation which is a problem in remote places like the Solomon Islands. In particular, the direct interaction with the remote pathologist is a great benefit for the surgeons in Honiara. Finally, any reduction in hospitalization time should reduce costs and pressure on bed space.

The two years of using the system have shown several advantages of the hybrid system:

- (1) Consultants mainly work with the Web-interface and thus they can see all the cases and comments, and can easily identify difficult cases, such as those that have been erroneously submitted twice. Probably the most important advantage is that the experts can collaborate easily and discuss difficult cases within the expert group.
- (2) The email interface has proved to be very efficient in terms of both time and resources for the submission of cases and receipt of reports. The email interface does not implement all functions, but there is always the possibility of looking up all previous consultations using the Web interface.
- (3) System administration is very simple. Most settings can be adjusted by the users themselves.

There are also some disadvantages and limitations. Some training of the consultants is necessary for their proper collaboration in a virtual institute. The time necessary to organize and train the experts should not be underestimated. There are also some limitations that are inherent in all types of store-and-forward telepathology. The main problem is that it is possible for the operator in Honiara to miss areas important to the pathologist when taking pictures from the slides. This could be a pitfall, although a comparison (unpublished) of the telepathology diagnosis with the diagnosis based on reviewing the original glass slides has shown that in our series this is not a serious problem in practice.

In addition, taking pictures, processing and sending them require some time and therefore dedication. Thus it is

important that the benefits are clearly visible in Honiara. Another specific limitation lies in the remoteness of the Solomon Islands—it is much more difficult to get broken equipment repaired than in Europe. It is therefore important to choose equipment for robustness rather than performance.

There are also some areas that need to be improved:

- (1) A major limitation is the insufficient laboratory space that is available in Honiara. However, now that the positive results of the project have become obvious, it will be much easier to convince the hospital administration of the importance of such a laboratory.
- (2) A substantial number of samples are still sent to the pathology laboratory in Brisbane and it would be helpful to improve that collaboration. For reasons of quality control and ongoing training, collaboration with a relatively nearby pathology institute remains desirable.
- (3) There is a major need for cytology as well as histology services. It would be desirable to develop sampling procedures that allow an acceptable level of telecytology quality control for cytological diagnosis without a resident specialist.
- (4) A fully automatic scheduling system needs to be developed for the telepathology software (iPath). This should include adjustable, automatically supervised time limits for each sub-process (first response, final diagnosis) so that if an expert does not respond, another expert or an administrator is automatically informed. Such supervision would prevent some cases from being overlooked.

Our experience is that it is not difficult to produce good-quality slides in a simple histology laboratory and send them by email to an expert on the other side of the world to provide a diagnosis. Once set up properly, this is cheap and reliable, and would be useful for other remote places where there is no histopathology service.

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