The First Telemedicine Link For The British Forces

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SUMMARY: In January 1998 a telemedicine link was established between the Hospital Squadron (from 22 Field Hospital) in Sipovo, Bosnia and the Royal Hospital Haslar, United Kingdom (UK). This link uses a high resolution digital camera, laptop computer, satellite telephone and a landline to obtain specialist opinions in radiology, dermatology, plastic surgery, orthopaedics, urology, ophthalmology, pathology and maxillo-facial surgery. This is the Defence Medical Services' first such link from an operational scenario. As such, this pilot study provides a useful testbed to enable clinicians in the three services to gain experience in this developing field, and to help determine the military applications of telemedicine.

Introduction
Telemedicine is the term used to describe the process whereby expert medical advice can be provided through the use of communications technology. This can range from a simple phone call to links through the entire communications spectrum, including the use of electronic mail (e-mail), the internet, and the transmission of digitised still or video images, through to full on-line, real-time videoteleconferencing. The preferred method is to store and forward high quality still images, which occupy much less digital space and so are easier and cheaper to transmit, as well as being more convenient as neither party is constrained by the need to synchronise activities.

Military telemedicine in the 1990s.
The concept of isolated, non-specialist doctors in front line medical units transmitting images for consultation to specialist colleagues in base hospitals has attracted the attention of the American military medical services in particular, especially since the Gulf War of 1990-1991 (1). With the aim of providing access to specialist consultation for personnel on operational deployment, of a standard comparable with that available in the United States, the American military have invested millions of dollars in teleradiology and videoteleconferencing systems. The most ambitious of these systems is Primetime III. This provides round the clock telemedicine support to American units in Bosnia via links to Germany, Hungary, mainland USA and Hawaii (2,3). There have been distinct benefits, including the prevention of some unnecessary aeromedical evacuations, and the widespread use of clinical e-mail. There have also been problems, such as lack of technical support, low user acceptability, the need to train clinicians to use complex technology, and difficulty in justifying the expense involved.

Following the problems faced by the isolated Dutch medical services during their siege in Srebrenica three years ago, the Dutch authorities decided in 1996 to install advanced teleradiology equipment in their field hospital in Novi Travnik, Bosnia. However, the minimal workload has not provided sufficient clinical material to adequately test the system, nor is it adaptable for other aspects of telemedicine.

The British Defence Medical Services (DMS) have traditionally preferred to invest capital in training personnel (as in BATLS and BARTS training) to enable

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them to provide the best standard of care possible at the point of injury. The DMS have been content initially to learn at second hand from the research and development experience with teledicine of other nations, until its military applications have been more clearly defined. The DMS had also been waiting for advances in technology to enable better integration of teledicine into the Surgeon General’s Information Strategy (SGIS).

**Surgeon General’s Information Strategy**

The SGIS aims to meet the entire information requirements of the DMS in both peace and war while maintaining a strong operational focus. It is currently defining how these requirements can best be met and researching the most appropriate technology to achieve these goals.

An integral part of this Strategy is the Medical Operational Support System (MOSS), still in its early stages at present. Its aim is to provide electronic means to collate information from the operational environment, encompassing patient and resource recording. Thus, patient records will be interlinked from primary health care records maintained in the peacetime location through to frontline operational medical assets. Clinical interventions (including teledicine) at all levels of care (Roles 1 to 4) and in all three services will be recorded accurately and robustly in an easy to retrieve format. It is intended that the system will facilitate accurate and timely patient tracking and casualty reporting. It will link dynamically with in-theatre personnel and logistics systems to provide commanders with relevant strategic medical information.

An important aspect of MOSS will be the provision of a medical records repository which will make records more accessible and facilitate epidemiological studies.

**Concept of Sipovo-Haslar teledicine link.**

In September 1997 it was decided to trial a teledicine system to link the British Hospital Squadron in Sipovo, Bosnia to the Royal Hospital Haslar, with the pilot study commencing in January 1998. The aims of this pilot study were to provide a testbed to enable clinicians in the three services to evaluate benefits for operational medical care, to gain experience in this developing field, to see if available technology should become more widely available, and perhaps, be incorporated as part of the SGIS.

The focus was different to the American and Dutch systems. It had the same aim of providing specialist advice to isolated clinicians for the care of operationally deployed troops, but it had to be more versatile, cheaper, more user friendly, easier to maintain, robust, portable, and potentially usable in high intensity operations by mobile medical units. It also had to be capable of accessing the medical databases on the internet for up to date clinical information. The use of satellite based telecommunications technology would make it independent of vulnerable landlines.

To concentrate on essential requirements and keep costs down, it was decided to transmit only still images with accompanying clinical information as e-mail. The equipment required for Sipovo consisted of a high resolution digital camera, a laptop computer and a satellite telephone. At Haslar an ordinary telephone line and modem, a high resolution teleradiology monitor and a desktop computer were required. An ISDN line was also requested. Communication software and e-mail facilities would be installed at each end.

Approval was obtained from the Surgeon General’s Department, funding was provided from the MOSS project and the pilot study was taken under the aegis of the Director of Medical Operations & Plans at the Ministry of Defence, Northwood, Middlesex.

**Concurrent activity at Medical Library, Haslar**

In late 1997, the librarian at the Royal Hospital Haslar developed a Haslar Library Web page, with links to medical and military medical topics on the internet (4). A multiuser subscription was taken out with Core Biomedical, allowing members of the Defence Medical Services direct access to the medical (Medline), nursing (Cinahl) and psychiatric databases on the internet. It also gives full text access to a wide variety of clinical journals. This Web page was designed specifically for the benefit of operationally deployed medical units and personnel, so long as they can get access to the internet, as through the Sipovo - Haslar teledicine link.

**Materials and Methods**

1. **The Digital Camera**

Digital cameras range from low resolution models to professional photographers’ very high resolution models costing over £20,000. The authors chose the Olympus C1400L after trawling the internet. This camera became
available on the UK market on 1 Nov 97. It has a resolution of 1280 by 1024 pixels (a total per image of 1,410,000 pixels), and provides the highest resolution available below the £6000 bracket. Its UK cost in November 1997 was £1300 including VAT (the price had fallen by July 1998 to below £900). For comparison, the American system uses a Kodak DCS 420 (1524 by 1012 pixels) costing over £6000. The choice of the Olympus C1400L was confirmed after tests on radiographs in November showed it provided high enough resolution for a radiologist to give a confident opinion. A 6 volt ac transformer was obtained to power the camera. Two close-up filters (+3, +4 dioptres) used singly or in combination, were obtained for use on eye or skin lesions (Figs 1 & 2).

Flattened scanners were assessed but discarded. They were more expensive, not robust or portable, and could only be used with radiographs. Scanned images also had much larger file sizes even after compression, so took too long to transmit.

Fig. 2. Teleradiography with Olympus C1400L.

2. The Laptop Computer
A Rock Mentor 620 was procured. It has a large (13.3 inch) TFT screen, Intel Pentium 200MMX chip, 48 Mb RAM (for image manipulation), 2.1 Gb hard drive, and Windows 95 software.

3. The Satellite Telephone
This is a Saturn Bt transportable Inmarsat-B terminal (Nera Ltd, Croydon), weighing 35 kg. It was chosen in preference to the lighter Saturn Bp for its detachable antenna. The Saturn Bt offers both Asynchronous Data Service (ASD) for data transmission at 9.6 kbps via the built-in modem, and High Speed Data Service (HSD) allowing a 56/64 kbps full duplex or simplex link with an ISDN network.

4. Communication & Image Manipulation Software
I. America on Line (AOL) (Internet Service Provider). A subscription allowing unlimited use was taken out for the Sipovo hospital. The Telemedicine Unit at Haslar was already using Compuserve. This allowed images to be sent as store-and-forward e-mail attachments whenever convenient directly to the e-mail address of the Telemedicine Unit and then shown to individual specialists.

II. Photophone for Windows (Imagebase Technology). This communication software is used by the Ministry of Defence throughout the UK and Germany, primarily by engineering units. It can transmit static and video images, and allows both store-and-forward transmission and live interactive communication. It was procured for both ends of the Sipovo-Haslar telemedicine link to assess its suitability for telemedicine purposes. It was thought that the increasing availability of Photophone in the MOD could enable medical officers with a digital camera both on ship and ashore to gain access to transmit images to Haslar. Drawbacks of Photophone are its expense (£2000 per computer) and the fact that it does not interact with other communication packages.

III. Adobe Photoshop 4.0 (Adobe). This gold standard image manipulation software is used to import, display, compress, and store images. This software is also used by G3 Media Ops at HQ Land, whose advice was obtained to standardise the storing and transferring of images.

5. Field trial
A field trial was carried out at Longmoor Training Area, Hampshire, with 33 Field Hospital on Exercise Top Cat on 11 Nov 97. A satellite link was set up at Haslar, and digital images of radiographs and casualty simulation patients were transmitted.

6. Procurement
Procurement was co-ordinated through a MOSS deputy project officer, staffed through MOD at Northwood and actioned by MOD Contracts at Bath. The final authority for procurement was received on 19 Dec 97, three months after the initial plan. The equipment was delivered to the Royal Defence Medical College on 20 Jan 98 for configuration and testing at Haslar on 21 Jan 98, and delivered to Hospital Squadron Sipovo on 25 Jan 98.

7. Preparatory work at Sipovo
The first author deployed to Sipovo on 30 Dec 97. He was authorised to set up an e-mail facility for the Hospital Squadron using civilian PTT landline as an adjunct to the satellite telemedicine link. This was established through the internet service provider AOL on 5 Jan 98.

8. Photograph transmission
For radiographs, the Olympus C1400L camera is used on a tripod, in self-timer mode, without flash, in a darkened room. The radiograph is transilluminated on a viewing box, at a distance of 20-40cms from the camera (Figs 1 & 2). The images are downloaded onto the laptop using a serial adapter cable and software that is included with the camera. The images are compressed using the
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Joint Photographic Experts Group (JPEG) algorithm, and manipulated as necessary, resulting in file sizes of 50-250 kilobytes, depending on whether they are 256-gray scale (for radiographs) or 24-bit color. The images are either attached to e-mails or imported into Photophone for modem to modem transfer. Typical file transfer times are fifteen seconds to three minutes by either landline or satellite telephone. Routine telemedicine referrals are sent in the evening, and picked up by the Telemedicine Unit at Haslar the next morning, with reports sent back the same day. Urgent referrals are preceded by a telephone call to alert the Telemedicine Unit to the situation, and are then dealt with accordingly.

Patient confidentiality is preserved by use of code numbers for each patient.

**Progress**

1. **The Sipovo Experience**

Radiographic images taken with the Olympus C1400L prior to deployment were transmitted to Haslar via the landline connection to test the system. A computerised database (Microsoft Access) was used to record telemedicine consultations. E-mail connections with various military organisations in the UK (Royal Hospital Haslar, MOD at Northwood, and the Royal Defence Medical College) and in Bosnia (HQ SFOR in Sarajevo, the American 396th Combat Support Hospital in Tuzla, and the Canadian Advanced Surgical Centre at Corunica) were established, and proved reliable in an area where communication by military telephone lines is notoriously poor.

A lower resolution digital camera (Olympus C800L, 1024 by 768 pixels per image) was used to transmit images of radiographs and patients to Haslar following a mass casualty incident due to a Czech Hip helicopter crash in Bosnia on 8 Jan 98 (5). The e-mail facility was also used to report on the role played by the Defence Medical Services in this incident.

The Olympus C1400L, laptop computer and Saturn Bt telephone arrived on 25 Jan. The two radiographers at Hospital Squadron quickly familiarised themselves with the C1400L, working out the method to give the desired results prior to transfer of images. The camera was also used to record skin and eye lesions and electrocardiograms, and a novel technique was developed by pathology laboratory staff to photograph microscopical specimens on blood films, allowing positive identification of abnormal red cells, malaria parasites, streptococci, and other organisms (Figs 3 & 4).

2. **The Haslar Experience**

The development of a telemedicine capability at The Royal Hospital Haslar generated considerable interest both within the hospital and with outside organisations. A formal assessment of image quality is being undertaken but initial impressions have been very favourable. The various means of image transfer have been assessed. There have been few technical problems in developing the service. Some delays occurred initially in locating other

**Fig. 3.** Field telepathology - photographing blood films with Olympus C1400L in Path Lab, Hosp Sqn Sipovo.

**Fig. 4.** Post-splenectomy blood film (x400) photographed with Olympus C1400L.
specialists to deal with non-radiological images. It is hoped that as the Wide Area Network extends through the Defence Secondary Care Agency and specialists are allocated their own e-mail addresses, such delays will be avoided. Routine reports are generally supplied within 24 hours.

Initially all telemedicine activity was centred on a single desktop computer in a radiologist's office, which occasionally caused difficulties. A different area, designated the "Telemedicine Suite", is now in use and additional communications including an ISDN line have been installed.

Discussion

The main aim of this low cost military telemedicine link (total £33,500 - the major part being the cost of the satellite telephone) was to evaluate the benefits of providing specialist advice to isolated clinicians on operational deployment, and to see if currently available technology met clinical requirements. American experience has shown that radiology, dermatology and ophthalmology are the specialities where telemedicine can most impact on clinical practice.

Hospital Squadron Sipovo was chosen for the pilot study as it is currently the main operational medical unit outside the UK. If the use of this system can prevent unnecessary aeromedical evacuations, then it will have justified itself. The use of satellite communication technology is crucial in an operational scenario [and for mobile medical units], where recourse to landlines cannot be guaranteed, but it is not essential for static units in peacetime.

Civilian use of internet to send X-ray and clinical images as e-mail attachments over landlines has been reported (6). The transmission of images over landlines from Sipovo illustrates the potential for military use of landlines for telemedicine in peacetime, without recourse to more expensive satellite telephones (Fig 5). This would limit costs to the camera, computer, modem, software, ISP subscription and telephone bills.

Another aim was to provide the means to enable operational medical units to become more proactive in relaying urgent news and digital images of their activities up the command chain and to G3 Media Ops at HQ Land. The need for this was highlighted by the minimal British press coverage of the Czech Hip helicopter crash, with a fleeting reference to the minor injuries sustained by a British P3 casualty (7). No reference was made to the Defence Medical Services, despite the Hospital Squadron, 24 Armoured Field Ambulance and the aeromedical Squadron having to deal with the largest mass casualty incident involving international peacekeepers in Bosnia since war broke out there in 1992 (5).

The internet service provider AOL was chosen because it has a large number of contact telephone numbers throughout Europe, including Croatia and Germany. It proved much easier in Sipovo to connect via landline to AOL in Germany than to UK ISPs. In Jan 98 there were no internet service providers in Bosnia.

In the first five months of its existence, there have been telemedicine consultations on 56 patients. The management of 17 patients (one third) has been significantly affected, and additional reassurance has been provided on 8 other patients. The following specialities in Haslar have been consulted: Radiology (32 cases), Dermatology (10 cases), Plastic Surgery & Burns (7 cases), Maxillofacial Surgery (2 cases), Pathology (2 cases), Urology (2 cases), Orthopaedic Surgery (2 cases), Ophthalmology (1 case).

Thus, valuable plastic surgical opinions have been provided (8), the treatment in one dermatological case was significantly improved (9), receipt of images at Haslar prior to arrival of Aeromed patients helped clinicians there plan their treatment in advance, and advice on the images of the blood films of a patient with suspected lymphoma helped in his management (10). No aeromedical evacuations were prevented though two were downgraded to routine flights. It must also be borne in mind that Hospital Squadron Sipovo has five experienced consultant staff, who are generally capable of coping in isolation. The situation would be different in an isolated medical practice manned by an inexperienced junior doctor.
This project has provided very useful practical experience in telemedicine. The equipment has more than lived up to expectation, producing images of excellent quality in a range of situations. It is the opinion of the authors that e-mail with image attachments offers the easiest system of working. In addition, it is relatively cheap and easy to extend this method to other medical units, especially if a satellite telephone is not required. The Telemedicine Unit staff at Haslar are now confident that they can advise other medical units on the most cost effective methods of telemedicine provision. By October 1998, it is planned that similar telemedicine links will be in place in the Falklands, South Georgia and Gibraltar, with plans actively being considered for other isolated medical units.

The internet and use of e-mail are here to stay, and are increasingly being used by medical professionals worldwide (11). The rational use of telemedicine has tremendous potential to improve clinical practice. It is up to us to fully utilise this potential for the benefit of the military medical services.

Conclusion
The first telemedicine link between an operationally deployed British field medical unit and the main tri-service hospital in UK has been successfully established (12). Initial experience with this cost-effective system, using simple hardware and software, is very promising and is proving useful in defining the military applications of telemedicine. It relies primarily on an inexpensive yet high resolution digital camera, and on transmission of static images as e-mail attachments. Its ease of use and its versatility mean that it could readily be used by individual practitioners, or indeed by most Defence medical units, operational or otherwise, for relatively little cost. As such, it merits serious consideration for inclusion in the SGIS. The use of satellite technology allows timely access to critical medical information for British forces worldwide. This telemedicine link heralds the readiness of the DMS to utilise modern communications technology for the benefit of our patients.

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