PERSPECTIVE

Telemedicine

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Telemedicine in its broadest definition is the assessment and review of patient information (history, examination, or investigations) by a health professional who is separated temporally and/or spatially from the patient. In a sense this has always occurred with colleagues discussing difficult cases when they meet or over the telephone. Carrying *x* ray films to meetings would constitute a form of telemedicine under this broad umbrella. As such, telemedicine did not particularly constitute a subject for research or special interest. With the advance of technology, however, it has become possible to capture and store or transmit an ever increasing amount of information in the form of clinical records, sound, static images, and moving images. As the opportunities for information transfer are opening, so uses are emerging. We are still in an enormous state of flux with respect to telemedicine. The literature contains a large number of pilot ideas or projects from vastly disparate specialties exploring disparate uses. Another use that does not fully fit within the above framework is medical education. This major additional use will also be included for the purposes of this review.

Ophthalmology is a specialty that relies heavily on images for the diagnosis and management of the majority of ailments. It is not surprising that a considerable number of ophthalmologists have therefore been exploring telemedicine with enthusiasm, particularly as technology increasingly offers us the quality of information transfer we require to make safe and reliable clinical decisions. This article seeks to present an overview of telemedicine for ophthalmologists, and to present some important facets of the subject that need consideration as we adapt our medical practice to encompass the present technological revolution.

Technology

A prolonged discussion on technology would mostly be out of date by the time it went to press. There are, however, some underlying principles that are helpful in understanding data transfer. The transfer of non-image data is not a problem. We do it regularly down telephone lines and in many other ways. Generally the bigger the line the faster it travels. ISDN (integrated services digital network), kilostream, and cable are examples of currently available lines with broader band widths for the rapid transmission of data.

Static images are merely large data files—the higher quality the image the bigger the data file. Such files can be transferred down any line without degradation of quality, it is only the speed at which they are transferred that may vary. Moving images are a different matter. These consist of many frames that need to be transferred quickly. Thus, the transfer of digital video images is highly dependent on the capacity and quality of communication link you have between two stations. World standards for video and audio conferencing have been created to ensure compatibility between systems.[1] ISDN 6 is proving to be a popular compromise for transmission band width.

The quality of images ultimately ends up being a compromise between the resolution of the capture mechanism and display, power of the workstation, transmission capabilities, and affordability. Compression algorithms may be applied to images to reduce the size of the file and maximise equipment capabilities. JPEG (joint photograph experts group) compression is now the accepted standard.

Telemedicine projects

Einthoven attempted to send electrocardiogram readings down telephone lines as early as 1906. In 1959 microwave video links were reported from the University of Nebraska in use for medical consultations and continuing education.[2] All projects initiated before the 1980s in America ultimately failed; largely because large amounts of federal funding were required for these time limited projects, and because the early components were unbelievably cumbersome and impractical.[3] Other countries with large distances between small communities have also had telemedicine projects in operation for many years including Norway, remote Pacific islands, Canada, and Scotland.

Radiology was one of the vanguard specialties; however, uses have now been reported in most specialties. Particular efforts have been made in the use of telemedicine for emergencies in remote situations, especially in the battlefield[3] and on ships, aeroplanes, and expeditions.

Reported uses of telemedicine cover virtually every level of health care. Many groups are now investigating improved patient management and care through home monitoring systems using both passive monitoring and active measurement. Systems are described watching the movements of the elderly or sick living alone, delivering drugs in automated doses to improve compliance and safety, and monitoring patients' clinical wellbeing.[4] The use of telemedicine for screening programmes or detection of early disease is being widely explored as, for example, with a "mobile hospital" in Japan looking for lung cancer.[5] Primary healthcare workers in developed and developing countries are using telemedicine systems to gain expert opinions on difficult cases.[6 7] Finally, many diverse links are being established within and between hospitals both for clinical review of cases and for teaching.

It is difficult to guess how each of these uses will develop. Norway is one of the most advanced countries with respect to telemedicine. A recent report of a survey of telemedicine projects in Norway showed a majority of projects to be centred on distance learning. There was a trend towards asynchronous telemedicine as opposed to video conferencing and few telemedicine programmes were directed towards primary or home based care.[8]

In ophthalmology, screening programmes, particularly for diabetic retinopathy, have been widely initiated. Projects involving the support of primary healthcare provi-

sion and accident and emergency departments, have generally reported ophthalmology among other specialties rather than support specific to the specialty. At the hospital level, many reports of teleteaching include ophthalmology among the specialties covered in the programmes. Scattered reports exist of other uses such as the transmission of electrodiagnostic results[9] and follow up of postoperative patients.[10]

Telemedicine and the NHS

The government has pledged to introduce telemedicine as a means of delivering health care where it has been shown to be effective and efficient. Professor Wootton writes "in broad terms, telemedicine can be expected to improve the efficiency of a national health service by enhancing communication up and down the health care pyramid. Widespread adoption of telemedicine would permit decentralisation".[11] The main problems at present seem to be defining the role of telemedicine and "diffusion of innovation".[12]

Telemedicine and cost effectiveness

For home care the frequency and nature of contacts via telecare have to be defined before costs can be calculated. Studies then have to investigate any health gain and/or saving in hospital visits. Earlier discharge of patients, the desire to provide equality of care, management of the chronically ill, and reduced home visits are all potential areas for study.[13]

In general, the cost effectiveness of telemedicine projects between healthcare professionals are a balance between the costs of equipment, communication, and two healthcare professionals per consultation on one side and convenience of time, travel savings, and educative benefits on the other side. Detailed structures for investigating the economics of telemedicine have been given by Lobley[14] and McIntosh and Cairns.[15]

Telemedicine and risk

Clinical confidentiality is a major issue that requires careful attention in any telemedicine project. Since uniform systems of data protection do not exist, particularly between countries, there is a very real danger that confidential information may be accessed by unauthorised individuals during telemedicine consultations. At present most projects involve some form of consent to disclosure which facilitates the development of the systems and uses. In the longer term, however, confidentiality must be an inherent part of any system. Some encryption systems do exist and any practice needs fair comparison with present systems which include telephone and fax.

Another aspect of telemedicine that deserves consideration is medical liability. Decisions and recommendations may be made across geographic and political boundaries raising issues of clinical responsibility and equipment capabilities. There is wisdom in considering these issues and developing clear guidelines from the outset in telemedicine projects.

In a search of current litigation with reference to telemedicine in Australia, Mairinger *et al* concluded that none of the legal issues raised to date was beyond resolution by use of present legislature.[16] Stanberry offers a rational approach to the practice of telemedicine to minimise risk and the chance of legal action. He details the current legal situation in the United Kingdom.[17]

From the point of view of clinical risk, telemedicine should be recorded as part of the routine clinical and investigative data sets for that patient. These should be subject to audit and health service costing in the same manner as other such data. If telemedicine should become a "treatment of choice" it may become unethical not to provide that facility. As in the use of all systems, adequate reliability should be ensured together with backup provisions in the event of system failure.[18]

Research in telemedicine

Taylor outlines an approach to research in telemedicine that is helpful. He distinguishes between research into telemedicine systems and research into telemedicine services. Research into telemedicine systems he divides into three phases. The first involves identifying the technical specification required for the application under consideration; the second involves testing that this is appropriate in practical use; and the third involves establishing a set of standards and guidelines to ensure that the system is used to best advantage.[19] For research into telemedicine services he again divides research into three areas. The first is research into models of telemedicine comprising treatment services (remote robotic surgery, for example), diagnostic or management services, and information or educational services. The second is research into the implementation and installation of telemedicine services. The third is research into the effects of telemedicine services including user satisfaction, medical outcomes, and financial measures.[20] It is of great importance that pilot projects are subject to careful research to ensure their usefulness and safety before wider implementation. The design of research protocols to answer important questions in telemedicine systems and services can be quite challenging.

Implementation of telemedicine

As the subject grows, courses are now available in telemedicine[21] and an ever widening group of health professionals have practical experience. Implementation has proponents in favour of a "top down" approach such as Great Ormond Street where a hospital telemedicine strategy document has been developed; and proponents of a "bottom up" approach with the initial development of individual projects by interested parties within healthcare units.

At Moorfields Eye Hospital we have developed a telemedicine link between our community clinic at Ealing General Hospital and the main hospital in central London. Three inputs are available, video slit lamp images, high resolution video camera images (for lids and orbits), and standard video conferencing images. Very high resolution examination is achieved by the capture of static images. The link is regularly used for examination of postoperative patients. A trained ophthalmic nurse reviews the patient at Ealing while the surgeon views images in central London during live teleconsultations (Fig 1). A second use is in the

Figure 1 The surgeon views an image in his office during live teleconsultations with another hospital.

provision of oculoplastic and other subspecialist opinions not available at Ealing. In the development of this project we have discovered some practical points which may seem obvious but I hope may be of help.

(1) The technology is important. We initially had poorer technology while waiting for our more advanced equipment to arrive. Patients and healthcare professionals alike could not tolerate the poor image and sound quality, which only led to frustration.
(2) The quality of image capture is of vital importance—rubbish in one end = rubbish out the other end! A good deal of care must be taken in ensuring the image acquisition is of sufficient quality. The most useful tip for slit lamp use in particular is for the person acquiring the image to look at the monitor not down the slit lamp.
(3) A new technique has to be learnt for patient-doctor consultations. It is difficult to pinpoint exact techniques but I have observed that my own satisfaction from consultations has been progressively improving as I gain more confidence in the use of the equipment. Different physicians adopt different techniques. Personally I find the use of several different picture frames helpful. Thus, for a consultation involving me in central London and the ophthalmic nurse, patient, and one relative at Ealing I may have three preset pictures—one showing only the relative, one only the patient, and one all three individuals. As the conversation flows I can flip between these images and the consultation feels more interactive.
(4) Interest in the use of this technology is stimulated by the physical presence of the technology. Ideas are generated and can be tried—some work, some do not.

Conclusion

Telemedicine is already becoming an integral part of our teaching and clinical practice. Its exact role and the extent of its role have yet to be defined. Much "experimentation" is required to determine what roles it may play. Once a use has been suggested, pilot studies should investigate its practicality. If practical, systematic research programmes should then be designed to determine its usefulness in terms of appropriate outcomes. These outcomes may be in terms of patient wellbeing, service provision, cost/benefit, or a combination of these. All work should be mindful of issues of clinical risk management.

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