Teleradiology

Richard Wright, Claire Loughrey

Advances in telecommunications and computer software have led to the development of radiology image transfer systems. Radiologists may now report radiographs at a site distant from that of the examination, in some cases almost instantaneously. Computed tomography, magnetic resonance imaging, and ultrasonography may also be supervised from afar. Developments over the past few decades are reviewed, allowing an understanding of the systems currently available. These include systems that transmit static images and real time video systems that enable interactive supervision from a radiologist at a distant site. The implications for the practice of radiology are discussed and the main areas of development over the next few years explored.

The wicked queen, staring at her glass, is presented with a picture of Snow White, a maiden more beautiful than she in a faraway place. A familiar fairy tale, but now moving closer to reality. There are many definitions of teleradiology, but a reasonable working one defines it as the use of telecommunications to deliver radiology services to patients who are located in a different place from the radiologist. Some physicians are familiar with limited transfer of computed tomograms from one centre to another, often by means of slow and fairly cumbersome systems. Anyone visiting this year's annual clinical meeting of the Radiological Society of North America would have seen clearly that teleradiology in the United States is now part of everyday practice and not the interesting novelty of a few years ago. The experience in the United States is worth reflecting on as Americans lead the world in this subject.

Initial research began using satellite as the transfer medium, but this was both expensive and technically testing. Two decades later the transfer of images along telephone lines became possible and, more importantly, much cheaper than before. Visual information could be compressed in digitised signals, transmitted over conventional telephone lines, and then reconstructed at a distant site as high quality images. In a manner similar to that experienced with personal computers, the price of both the necessary hardware and software has tumbled, bringing this new facility within reach of smaller provider units.[1]

Over the past decade considerable progress has been made in agreeing internationally accepted technical standards enabling equipment from different manufacturers to interface with each other. The major push forward has, however, come from governmental reform of health care in the United States. The Clinton-Gore administration introduced the world to the internet and the concept of the information superhighway. A presidential commission was established to investigate the possibility of making telemedicine a functional part of the United States health care scheme.

Development in the United States has, however, not been without its problems. As yet, neither private nor public sector health schemes have embraced the financial implications of paying for medicine delivered remotely. The federal based legal system is complex with stringent licensing regulations. It is becoming clear that the technology has once again raced ahead of the regulations, and this development will need to be closely examined in the near future.

Applications

The range of potential applications for teleradiology is large, stretching from simple lap top computer based systems transmitting static images to fully interactive, real time, picture interrogation. The most basic system uses equipment often already available in most radiology departments. Digitised low resolution images such as are found in computed tomography and magnetic resonance imaging are transmitted over an existing telephone line to a work station based on a personal computer; this may be at another hospital or in a doctor's home. The most recent software packages for a system such as this could be installed for less than £5000, with prices continuing to fall steadily.

Real time video systems are now commercially available. These are most suitable for applications such as ultrasonography, in which a trained radiographer may carry out an examination with interactive supervision from a radiologist. One radiologist would therefore have the potential to supervise several examinations from different places almost simultaneously.

There are two common methods of image transfer. A coder-decoder (known as a CODEC) transforms analogue images to digital information and compresses the data. At the remote site another CODEC decompresses the signal and changes it to analogue for viewing on a monitor. A camera and microphone with pan, zoom, and tilt capabilities is located at each of the remote sites and at the hub site. One camera views the patient and radiographer while the other transmits the real time ultrasound image. The cost for a state of the art system such as this remains prohibitively expensive. Currently telephone lines are being upgraded to enable such real time images to be transmitted within the United Kingdom.

Although interactive video conferencing has received most attention in the press, many advocates of teleradiology believe that simpler less expensive "store and forward" systems (figure) will become the popular choice.[2] In a store and forward system static

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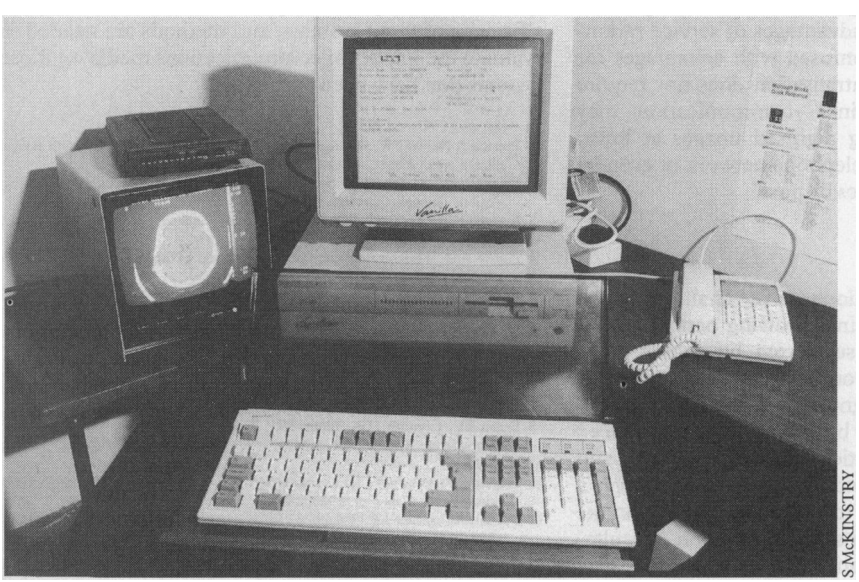

Image transfer system based on a personal computer

images are acquired and transmitted one by one to the hub site. On the basis of an assessment in Oklahoma, 85% of needs can be met in near real time using such technology. Such systems are currently available in the United Kingdom, although uptake as yet has been poor.

To allow fast transmission of images the data for digital images must first be compressed. Generally, the greater the compression the faster the transmission but unfortunately the greater the risk of losing detail. Computed tomograms and magnetic resonance images are readily compressible because the images remain of diagnostic quality even when reconstructed with relatively low resolution. Standard plain film radiographs, however, can tolerate much less compression if they are to remain of diagnostic quality. Plain radiographs are now readily transmitted in the United States, but radiologists remain divided on whether the detail of the received image is of sufficient diagnostic quality. Currently, the high resolution required for mammography makes mammograms unsuitable for transmission.

The future

Teleradiology will develop rapidly in three key areas. Firstly, subspeciality consultation will develop on an established base. This will enable general radiologists to avail themselves of skills in specialties such as neuroradiology or paediatric radiology.[3,4]

Secondly, interactive ultrasound imaging will facilitate the performance of examinations in health centres, general practice surgeries, and satellite hospitals under the distant supervision of a consultant radiologist.

Finally, the role of inexpensive personal computer based systems in providing emergency radiology cover outside normal working hours is likely to expand. The temptation to provide an on call service from home to several hospital sites will become irresistible to increasingly financially competitive hospital trusts.

Teleradiology is already impinging on everyday practice, but rapid expansion, driven by an ongoing desire for increasing cost effectiveness, will be seen in the near future. It is no longer a fairytale dream but a useful tool to be used for greater benefit of patients.

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2 Hostetler S. Lower end technology may eventually dominate. *Telemedicine (The News Magazine of Distance Healthcare)* 1994;1(Nov):17-8.
3 Cannavo MJ. Look to teleradiology's tea leaves in tracing telemedicine's future. *Telemedicine (The Monthly Newsletter of Telecommunications in Healthcare)* 1994;2(11):8.
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Smuggling and cross border shopping of tobacco in Europe

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Governments have recently become concerned about cross border shopping and smuggling because it can decrease tax revenue. The tobacco industry predicted that, with the removal of border controls in the European Union, price differences between neighbouring countries would lead to a diversion of tobacco trade, legally and illegally, to countries with cheaper cigarettes. According to them this diversion would be through increased cross border shopping for personal consumption or through increased smuggling of cheap cigarettes from countries with low tax to countries with high tax, where cigarettes are more expensive. These arguments have been used to urge governments not to increase tax on tobacco products. The evidence suggests, however, that cross border shopping is not yet a problem in Europe and that smuggling is not of cheap cigarettes to expensive countries. Instead, more expensive "international" brands are smuggled into northern Europe and sold illegally on the streets of the cheaper countries of southern Europe.

In the past few years governments in many countries have become concerned about cross border shopping and smuggling because it can lead to loss of tax revenue. Until recently, increasing tobacco tax has always resulted in an increase in real terms of tax revenue in all European countries. The tobacco industry predicted that the removal of border controls within the European Union would change this and that price differences between neighbouring countries would lead to a diversion of tobacco trade, legally and illegally, to countries with cheaper cigarettes.[1] According to the industry, this diversion would be either through increased cross border shopping for personal consumption or through increased smuggling of cheap cigarettes from countries with lower tax to countries with high tax, where cigarettes are more expensive.

At first sight such claims might seem to reflect real concern for business from honest tax paying citizens. It is clear that governments are the main losers—of tax revenue. But it is interesting to look at who might benefit from cross border shopping and smuggling. If it results in pressure to keep down tax it could result in increased sales and profits, in which case the beneficiary is the tobacco industry, especially the manufacturers. No surprise then to find the tobacco industry making vociferous claims about the dire effects of cross border shopping and smuggling and arguing strenuously that tobacco tax should be lowered. Are their claims justified?

Cross border shopping

Since the opening of the European single market in January 1993 consumers have been allowed to buy almost unlimited quantities of tobacco for their own use (with suggested "indicative" levels, below which use is assumed to be personal but above which personal use must be proved, of 800 cigarettes, 1 kg fine cut tobacco, 400 cigarillos, and 200 cigars). Belgians, French, and Germans have traditionally stocked up on cigarettes when passing through Luxembourg because of the low price of cigarettes there. It can be estimated that only 15% of tobacco bought in Luxembourg is consumed there. In 1993 cigarette sales in the European Union totalled 559 billion or 1610 per person.[2] At this average European consumption, Luxembourg (population 395 000) should have smoked 636 million cigarettes rather than the 4188 million actually sold there. The 85% difference is assumed to be due to cross border sales.

However, since the opening of its borders in January 1993 there has been a small decline in cigarette sales in Luxembourg: 4162 million cigarettes were sold in Luxembourg in 1992, 4188 million were sold in 1993, and 4106 million were sold in 1994 (Ministry of

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