The impact of teleradiology on the inter-hospital transfer of neurosurgical patients and their outcome

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The impact of teleradiology technology used in the management of neurosurgical emergencies between district general hospitals and tertiary neurosurgical centres is reviewed. Its effect on clinical management such as diagnostic accuracy and the prevention of secondary insults has been shown to be favourable. Problems and possible future developments are also discussed.

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Introduction

Running a tertiary neurosurgical service is expensive. Not only does it require 24-hour two-tier neurosurgical staff coverage, but other services such as emergency operating facilities, diagnostic radiology equipment (for computed tomography [CT], magnetic resonance imaging [MRI], and cerebral and spinal angiography), anaesthesia facilities, and an intensive care unit are needed. Traditionally, patients with a head injury or probable brain haemorrhage have been transferred from district general hospitals to their regional neurosurgical centre for definitive management following a telephone consultation. Transfer of this group of patients who are often critically ill, is fraught with problems. Firstly, the clinical information given to the neurological centre may be inadequate.[1] Secondly, a delay in diagnosis and treatment has been shown to be inevitable and to result in an unfavourable outcome.[2,3] Thirdly, the occurrence of secondary insults during the transfer of these critically ill patients was shown to be common in the 1970s,[4] and this had not changed by the 1990s.[5]

The dissemination of high-technology imaging equipment to large district general hospitals in the 1980s (CT scanners) and the 1990s (MRI scanners) has reduced the number of unnecessary transfers of patients for the imaging of their central nervous system. Teleradiology—a computer-based radiographic image transfer system—supplements and enhances telephone consultation prior to the transfer of a neurosurgical emergency. Standard commercial telephone networks can be used inexpensively and the quality of the transmitted images is comparable in resolution and diagnostic accuracy to original films.[6] In this seminar paper, we describe an affordable teleradiology system in the setting of a large district general hospital with a catchment population of 0.5 million and an academic neurosurgical unit. A clinical audit has been carried out using this technology to illustrate its cost-effectiveness in the management of neurosurgical emergencies,[7,8] although randomised controlled studies have not been done.

Description of the teleradiology system

The application of teleradiology technology in the management of acute neurosurgical referrals has been described in the early 1990s in both Europe[9-11] and the United States.[12] Teleradiology programmes implemented in Hong Kong in the early 1990s varied between powerful workstations using dedicated data lines as part of an academic information technology project and commercially available systems using standard personal computers (PCs) and telephone lines.[13] The system that has been shown to make a favourable impact is the inexpensive, commercially available PC program.[7,8,12,13]

This PC-based teleradiology system was installed in 1995 in the academic neurosurgical unit at the Prince of Wales of Hospital, Shatin—a 1400-bed teaching hospital with a tertiary referral population of 1.5 million. The system was linked to the United Christian Hospital, Kowloon—a large district general hospital with a catchment population of 0.5 million. The linkage enabled CT scans to be transmitted via telephone lines directly to a PC in the neurosurgical unit (using

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Multiview Teleradiology for Windows 2.0).[14] There was also a linkage to a portable notebook computer, which was attended by the on-call neurosurgeon.

Images are captured from a CT or MRI scanner, either directly in a digital format from the scanner console or transferred from film to digital data by a film scanner. The images may be viewed individually or side by side in a flicker-free display. A standard, non-dedicated analog telephone line is used for transmission between hospitals and the duty neurosurgeon's home. The transmission time for 12 slices of a CT examination is usually 3 minutes at a transmission speed of 28.8 bits per second via the internal modem. The 500 MB hard drive can store more than 10 000 images, and 80 images can be stored on a 1.44 MB diskette. The cost of equipment acquisition ranges from US$20 000 to US$40 000 per hospital (1995 figures).

The impact of teleradiology on the transfer of neurosurgical patients

Early reports on the subject focused on the system's feasibility and the accuracy of the radiological diagnosis obtained.[6,11,12] A 21% reduction of unnecessary transfer of ill patients was documented when teleradiology was included in the telephone consultation.[7,11] To date, there has not been a prospective randomised trial on the impact of teleradiology on the inter-hospital transfer of neurosurgical patients.

The strongest evidence comes from prospective observational studies that compare differences in clinical parameters and outcome immediately before and after the acquisition of the technology.[7,8] Two studies have demonstrated that unnecessary transfer can be reduced by 21% (14/66); diagnostic accuracy is 96% (63/66); appropriate therapy is recommended more frequently for head-injured patients—32% (10/31) versus 11% (3/28) [P=0.06]; and adverse events during the transfer are significantly reduced—8% (4/52) versus 32% (16/50) [P=0.002]. The proportion of patients with favourable outcome is higher in the teleradiology group, being 74% (26/35) versus 68% (19/28), although this difference was not statistically significant (P=0.6).

In neurosurgical emergencies, safe inter-hospital transfer is crucial to achieving a good outcome. In 1981, Gentleman and Jennett first described the hazards of transferring severely head-injured patients and noted that 45% of patients had at least one adverse event, with hypoxia occurring in 23% and hypotension in 11%.[4] Thirteen years later, Hicks et al reported improved transfer, with the incidence of hypoxia at 10%, hypotension 7%, and hypovolaemia 11%.[15] The demonstration that teleradiology significantly reduced the incidence of adverse events during transfer was important. The improved communication between referring physician and neurosurgeon, as a result of the teleradiology input, with improved understanding of the diagnosis, severity of disease, and urgency of the transfer, most likely contributed to the safer transfer.

With the visual benefit of a teleradiographic image, a more confident decision regarding the value of transferring an ill patient can be made, particularly in unsalvageable cases or where surgical intervention, is inappropriate. This has important implications for optimising overloaded hospital and ambulance services, which in 1995 in Hong Kong, had to respond to 300 000 emergency calls. The majority of head-injured patients, despite having an initial normal CT scan, had either skull fracture or impaired consciousness and were transferred: one third (10/26) of these patients required intracranial pressure monitoring and its management.[8]

Problems and future developments

Head-injured patients with risk factors[16] such as skull fracture and impaired consciousness are transferred to the neurosurgical unit in a stable condition. When our teleradiology system was first installed in 1995, these patients were given a CT scan prior to the telephone consultation, with the result that three patients deteriorated with an evolving mass lesion while waiting 4 to 6 hours for a CT scan. In a neurosurgical centre, these patients are assessed and given a CT scan within 1 hour, whereas in the district general hospital, timing is more variable, depending on the experience of the emergency surgeon and availability of the 24-hour CT service. This problem was well illustrated in a recent telemedicine case report.[17] With the present concept of managing head injury with a zero mortality rate, the system should avoid the development of a mass lesion. Those with a high-risk mild head injury[16] should be transferred to a neurosurgical unit as soon as possible, and CT scanning should only be performed if it can be arranged within 1 hour. Any delay in the district general hospital in conducting CT scanning and teleradiology should be avoided (Table).

The importance of delayed or evolving[18,19] mass lesions in causing mortality and morbidity should be emphasised to all concerned. In other words, patients with skull fracture or impaired consciousness, or both should be observed very closely in a neurosurgical unit, even when the first CT scan is normal.

Table. Guidelines for the transfer of head-injured patients from a district general hospital to a neurosurgical unit

Patient category	Recommended action
Minor head injury with no risk factors	Observe in district general hospital
Stable head injury with risk factors	Urgent transfer to neurosurgical unit
Unstable head injury patient with hypotension, hypoxia, or deteriorating consciousness level	Resuscitation with or without immediate computed tomography and teleradiology Inform the neurosurgical unit of the need for the mobile neurosurgical team

The concept and strategy of a mobile neurosurgical team is an essential component of teleradiology.[2] There are two scenarios where a patient can be pronounced "not fit for transfer"—one is when the patient is hypoxic or hypotensive, the other is when they have a mass lesion causing rapid deterioration of the level of consciousness. Basic neurosurgical equipment should be made available so that burr holes for intracranial pressure monitoring and decompressive craniotomy can be made. These patients can be transferred back to the neurosurgical unit after they have become stable.

Telemedicine—the practice of medicine at a distance—is an alien concept to both physicians and patients. During the year 1995 to 1996, there were five occasions when the neurosurgeon was asked to counsel the families of patients who were in too poor a condition to be transferred. The most common concern was that a specialist who has not seen a patient cannot possibly make a firm diagnosis and recommend surgery or not. We therefore recommend that these patients be seen daily until they are fit to be transferred to the neurosurgical unit or can be classified as brain-dead.

Conclusions

Telephone referrals have always been fraught with problems,[1] but coupled with a standard check-list and teleradiology, safe transfers can be achieved and unnecessary transfer avoided. With improving technology and falling computer costs, such telecommunication linkage between district general hospitals and neurosurgical centres is feasible, cost-effective, and may improve outcomes. Essential elements for optimising the use of teleradiology in the management of neurosurgical emergencies include an efficient 24-hour CT service in both hospitals and a dedicated neurosurgical team committed to treating patients at both sites.

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