Does Teleradiology Improve Inter-hospital Management of Head-injury?

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ABSTRACT: ***Objective:*** In many countries, neurosurgical care is concentrated in regional centres, which often necessitates the inter-hospital transfer of patients with head injury for optimal treatment. The aim of this study was to evaluate the role of teleradiology in the management of head-injured patients when referred from a district general hospital to a tertiary neurosurgical centre. ***Methods:*** Prospective data were collected over a fifteen month period from March '95 to May '96. Head-injured patients referred without the facility of teleradiology (Group 1), were compared to similar patients referred with teleradiologic images (Group 2), with particular regard to therapeutic intervention before transfer and adverse events during transfer. ***Results:*** There were 28 patients in Group 1 and 35 in Group 2, of which 31 were transferred. Both groups were comparable with respect to age, admission Glasgow Coma Scale score, and intracranial pathology. For patients transferred with teleradiology consultation (Group 2), therapeutic interventions were more (32.1% vs. 10.7%, p = 0.06), adverse events during transfer were significantly lower (6.4% vs. 32.1%, p = 0.01), and transfer time was reduced (72 vs. 80 minutes, p = 0.38). Four patients in Group 2 were treated by a mobile neurosurgical team at the referring hospital because of rapid clinical deterioration. ***Conclusion:*** Our findings indicate that teleradiology has an important role in improving inter-hospital management of head-injured patients.

RÉSUMÉ: La téléradiologie améliore-t-elle le traitement interhospitalier des traumatisés crâniens? ***But:*** Dans plusieurs pays, les soins neurochirurgicaux sont concentrés dans des centres régionaux, ce qui nécessite souvent le transfert interhospitalier de traumatisés crâniens dans le but de leur fournir un traitement optimal. Le but de cette étude était d'évaluer le rôle de la téléradiologie dans le traitement des traumatisés crâniens quand ils sont référés d'un hôpital général régional à un centre neurochirurgical tertiaire. ***Méthodes:*** Nous avons colligé des données prospectives sur une période de 15 mois, soit de mars 95 à mai 96. Les traumatisés crâniens référés sans l'aide de la téléradiologie (groupe 1) ont été comparés à des patients semblables référés avec l'aide de la téléradiologie (groupe 2), en portant une attention particulière aux interventions thérapeutiques avant le transfert et aux incidents fâcheux pendant le transfert. ***Résultats:*** Il y avait 28 patients dans le groupe 1 et 35 dans le groupe 2, dont 31 avaient été transférés. Les deux groupes étaient comparables quant à l'âge, le score à l'échelle de coma de Glasgow au moment de l'admission et la pathologie intracrânienne. Chez les patients transférés qui avaient eu une consultation téléradiologique (groupe 2), les interventions thérapeutiques étaient plus fréquentes (32.1% vs. 10.7%, p = 0.06), les incidents fâcheux pendant le transfert étaient significativement moins fréquents (6.4% vs. 32.1%, p = 0.01) et le temps de transfert était réduit (72 vs. 80 minutes, p = 0.38). Quatre patients du groupe 2 ont été traités par une équipe neurochirurgicale mobile à l'hôpital référent à cause d'une détérioration clinique rapide. ***Conclusion:*** Nos observations indiquent que la téléradiologie joue un rôle important dans l'amélioration du traitement interhospitalier des traumatisés crâniens.

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Telemedicine, or the exchange of medical information at a distance,[1] is a technological development that has been available for approximately 30 years with the first references appearing in 1959.[2] It enables remote communities to access specialist medical care using modern computer and telecommunication facilities. Nowhere is this more evident than in the field of teleradiology, where high quality images can be transmitted with resolution almost equal to that of original radiographic films.[3]

In neurosurgery, where emergencies sometimes do not allow the luxury of time, teleradiology has the potential to improve management and outcome. The aim of this study was to assess the impact of teleradiology on the management of head injuries which occur in a peripheral hospital supported by a tertiary neurosurgical centre.

Patients and Methods

This study was conducted at our hospital, a 1400-bed university teaching hospital and the regional neurosurgical centre, serving a population base of 1.5 million with referred patients from two peripheral district general hospitals. Teleradiology

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linkage was recently established with the larger district hospital, allowing computerized tomographic (CT) scans to be transmitted via telephone lines directly to a personal computer (PC) work-station in the neurosurgical unit (Multiview Teleradiology for Windows 2.0). This was linked to a portable laptop computer which was always attended by the neurosurgeon-on-call.

The standard protocol for referring a patient to the neurosurgical unit involved a telephone consultation between the referring physician and the neurosurgeon-on-call, during which patient details were discussed. If the patient was deemed to require hospital transfer, a transfer checklist would be systematically filled out and further measures advised as necessary. Important facts would include mechanism of injury, admission Glasgow Coma Scale score (GCS), pupillary size, oxygenation, blood pressure and extracranial injuries if any. After teleradiology availability, the CT scan images were transmitted and viewed during the telephone consultation.

Over a fifteen month period from March '95 to May '96, head-injured patients referred by conventional telephone consultation prior to teleradiology availability (Group 1), were compared with patients (Group 2) referred with the aid of teleradiology. This study design was possible because there was a time lag of approximately eight months between funding approval for installation of the teleradiology system and actual delivery and set-up of the hardware. Prospective data were collected, with particular regard to accuracy of diagnosis, therapeutic intervention after consultation, secondary insults during transfer, and outcome. In both groups, the protocol of receiving the referral was the same, except for the additional use of teleradiology in Group 2.

Diagnostic accuracy was defined as agreement between the referring doctor and neurosurgeon on CT findings. Therapeutic intervention was defined as additional measures advised by the neurosurgeon prior to transfer, including endotracheal intubation for airway protection and hyperventilation, intravenous mannitol as a temporizing measure, fluid resuscitation, treatment of hypotension and surgical management of extracranial injuries. Secondary insults were defined as adverse events which could affect outcome (Table 1).[4] Some events were likely to be fatal, for example hypotension and hypoxia, while others were unlikely to be fatal on their own, but could result in poorer outcome and affect mortality, for example neurologic deterioration, hypothermia, undue delay in transfer, and loss of intravenous access.[4] Whether these occurred was determined at the time of arrival by the neurosurgeon who accepted the case. Outcome was defined according to the Glasgow Outcome Score (GOS)[5] at 6 months.

All patients were transferred by ground ambulance accompanied by personnel from the referring hospital. Transfer time, defined as time from telephone decision to arrival at the neurosurgical unit, was measured to assess the efficiency of the service.

Results

Sixty-three consecutive patients were analyzed in two groups, Group 1 consisting of 28 patients and Group 2, 35 patients (Table 2). In Group 1, there were 17 males and 11 females, with a mean age of 42.3 years (range 1 - 81) and a mean GCS of 11.2 (range 3 - 15). With regard to intracranial pathology, there were 4 extradural haematomas (EDH), 5 acute subdural haematomas (SDH), 10 intracerebral haematomas (ICH) or contusions, and 8 diffuse head injuries (DHI) (Table 2). Twelve mass lesions were evacuated surgically and intracranial pressure (ICP) monitoring performed in 5 patients with DHI. In comparison, Group 2 consisted of 22 males and 13 females with a mean age of 33.6 years (range 0.5 - 78) and mean GCS of 12.5 (range 3 -15) (Table 2). Intracranial pathology consisted of 6 EDH, 4 acute SDH, 1 chronic SDH, 7 ICH and 5 DHI. Nine haematomas were evacuated and all five patients with DHI had ICP monitoring. Four patients in this group were not transferred and were instead treated by a mobile neurosurgical team. These cases were excluded from the subsequent analysis of transferred patients.

There was generally good agreement in CT diagnosis between the referring doctor and the neurosurgical team. In only one case was the presence of traumatic subarachnoid blood missed by the referring doctor, but this did not have any impact on patient management in the acute phase. When therapeutic interventions prior to transfer were compared, these occurred three times in 28 patients (10.7%) in Group 1, and 10 times in 31 patients (32.1%) in Group 2 ($p = 0.062$, Fisher's exact test). Endotracheal intubation was requested twice and mannitol once

Table 1: Secondary Insults.

Critical
Hypoxia - Apnoea, hypoventilation, problematic endotracheal tube
Hypotension
Cardiac arrythmia - Bradycardia, tachyarrythmias
Serious
Neurological deterioration
Prolonged transfer time
Convulsions
Aspiration
Hypertension
Missed extracranial injuries
Temperature irregularity - Hypothermia, hyperthermia
Equipment failure - Loss of intravenous access, no oxygen

Table 2: Patient Characteristics in Groups 1 and 2.

	Group 1 (n = 28)	**Group 2 (n = 35)**
Age (mean ± SD) (years)	42.3 (25.1)	33.6 (26.2)
Sex	17M, 11F	22M, 13F
Glasgow Coma Score (mean ± SD)	11.2 (3.6)	12.5 (3.5)
Intracranial pathology		
- Extradural haematoma	4 (14.3%)	6 (17.1%)
- Subdural haematoma	5 (17.6%)	5 (14.3%)
- Contusion	10 (35.7%)	7 (20%)
- Diffuse head injury	8 (28.6%)	5 (14.3%)
Glasgow Outcome Scale		
- Death	4 (14.3%)	5 (14.3%)
- Vegetative	2 (7.1%)	3 (8.6%)
- Severe disability	3 (10.7%)	1 (2.9%)
- Moderate disability	4 (14.3%)	5 (14.3%)
- Good	15 (53.6%)	21 (60%)

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in Group 1, compared to Group 2 where intubation was requested in three patients and mannitol in four (Table 3). In 3 cases in Group 2, other interventional measures included suturing of scalp lacerations, increased fluid resuscitation and chest tube insertion.

The incidence of secondary insults during transfer was 32.1% (9/28) in Group 1, of which hypoxia and hypotension occurred in two instances (2/9, 22.2%) (Table 3). In comparison, the incidence of insults in Group 2 was 6.4% (2/31), hypotension occurring in one of the two cases (Table 3). Neurological deterioration occurred in five cases in Group 1 compared to none in Group 2. Interestingly, in only one of these cases was an additional therapeutic intervention requested before transfer, and that was intubation. Overall, the incidence of secondary insults in Group 2 was significantly less than Group 1 ($p = 0.017$, Fisher's exact test) (Table 3). The mean time for transfer was 80 minutes in Group 1 and 10% faster in Group 2 (72 minutes) ($p = 0.38$).

Four patients in Group 2 were not transferred but instead managed by a mobile neurosurgical team because of the nature of the head injury, coma and localizing signs (Table 4). All were operated on within one hour of the telephoned referral. Two of the patients achieved a good outcome and were discharged home within two weeks. Of the two patients who eventually died, one had a severe diffuse head injury with signs of brain stem ischaemia on admission, while the second had poor prognostic factors (age greater than 50 years, acute subdural haematoma with gross midline shift and effacement of basal cisterns on CT), for whom surgical intervention failed to prevent intractable intracranial hypertension.

The overall mortality in both groups was the same (14.3%) (Table 2). In Group 1, the proportion of patients with poor outcome (dead, vegetative or severely disabled) was higher compared to Group 2 (32.1% vs. 25.8%), although this was not statistically significant. Similarly although the proportion of patients with favourable outcome (good or moderate disability) was greater (74.3%) in Group 2 than in Group 1 (67.9%), this was also not statistically significant.

Patients who sustained secondary insults during transfer generally had poor outcome at six months. In Group 1, 44.4% (4/9) were vegetative or dead, 22.2% (2/9) were severely disabled, and 33.3% (3/9) were moderately disabled. In Group 2, of the two patients with secondary insults, one died and the other was vegetative at six months.

Table 3: Therapeutic Interventions and Secondary Insults.

Intervention	No. of patients (Group 1) (n=28) (%)	No. of patients (Group 2) (n=31) (%)
Endotracheal tube	2 (7.1)	3 (9.6)
Mannitol	1 (3.6)	4 (12.9)
Others (chest tube/spine immobilization, etc.)		3 (9.6)
Total	3 (10.7)	10 (32.1)
Secondary insult		
Critical		
Hypoxia	1 (3.6)	
Hypotension	1 (3.6)	1 (3.2)
Serious		
Neurologic deterioration	5 (17.7)	
Convulsions	1 (3.6)	
Hypertension		
Missed injuries	1 (3.6)	1 (3.2)
Undue delay		
Total	9 (32.1)	2 (6.4)

Discussion

The phase of inter-hospital transfer is a dangerous period in the management of severely injured and comatose patients. Extracranial injuries may not have been completely identified, resuscitation may be inadequate, and the ambulance environment is unsuitable for the provision of critical care. Kanter in 1989 showed that the incidence of physiologic deterioration during transport was significantly greater with greater pretransport severity of illness or injury.[6] When these adverse events did occur, most seriously hypoxia and hypotension, the clinical outcome was inevitably poor.[7]

Sadly, despite efforts to improve such transfers, including faster and better equipped transport vehicles, trained paramedical staff and even specialized retrieval teams,[8] morbidity from hazardous transfers over a thirteen year period has remained virtually the same. Gentleman reported in 1981 that 45% of cases had at least one untoward incident[7] while Hicks in 1994 reported a similar incidence when auditing the transfer of head-injured patients to a stand-alone neurosurgical unit.[9]

Does teleradiology, with the advantage of adding a visual image to the telephoned referral, enable the arrangement of a less hazardous transfer? Several points of interest emerged from this study.

Firstly, to ensure safe transfers, time should be taken before transfer to adequately stabilize patients. For patients transferred with teleradiologic images (Group 2), we found that the neurosurgeon asked for more pre-transfer procedures compared to the group without teleradiology, this increase almost reaching statistical significance ($p = 0.062$). Endotracheal intubation was frequently requested as a means of airway protection in patients with altered consciousness, primarily to prevent aspiration and hypoxia, and secondarily to permit hyperventilation when necessary. It was interesting to note that mannitol was requested in four patients in Group 2 compared to once in Group 1. The basis for this was a combination of clinical discussion, in which the GCS was noted to have decreased in two cases and was poor (4/15) in one, and the teleradiologic images, which showed a mass lesion with some mid-line shift in all four cases. In the one case where mannitol was given in Group 1, the decision was based solely on clinical discussion.

Similarly for other interventions in Group 2 patients, the degree to which teleradiology improved the clinical discussion and impacted upon the subsequent requests for intervention is difficult to quantify. In one case for example, when CT findings alone could not account for the occurrence of hypotension, additional clinical discussion revealed a large scalp wound with profuse haemorrhage requiring immediate suturing before transfer. It would be reasonable to say therefore that teleradiology improves information acquisition, thus resulting in a clearer clinical impression of the patient as a whole. Armed with this,

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Table 4: Clinical Profile of Patients Treated by Mobile Team.

	Sex/Age	GCS	Pupils (mm)	Diagnosis	Treatment	Outcome
1.	M / 15	9	5 / 3	Extradural haematoma	Craniotomy + evacuation	Good
2.	M / 52	4	6 / 3	Acute subdural haematoma + tSAH	Decompressive craniectomy + ICP monitor	Death
3.	M / 58	15 -> 6	2 / 5	Chronic subdural haematoma	Burr-hole drainage	Good
4.	F / 27	3	4 / 3	Diffuse head injury + tSAH + splenic / lung injury	Burr-hole for ICP monitor	Death

the neurosurgeon is able to anticipate problems and can advise more boldly on preventive measures before transfer. We suggest that this probably subsequently resulted in the significant reduction of secondary insults occurring during transfer in this series. However unless larger patient numbers are available and the issue subjected to a randomized trial, this point will remain speculative.

Secondly, despite initial "normal" CT scans, 26 patients were still transferred for neurosurgical management, of whom 13 (50%, 13/26) were subsequently diagnosed to have diffuse head injuries and 10 (38.4%, 10/26) required ICP management. Although no patient in our study developed a delayed mass lesion, unit policy dictated the transfer of all head-injured patients for a period of observation, simply because CT scans were performed very early after injury and delayed or evolving lesions could still occur.[10, 11]

Thirdly, the concept of a mobile neurosurgical team or "flying squad" service which has been suggested[12] as a strategy for managing injuries in remote locations, remains an attractive option in circumstances where slow transfer time results in poor outcome.[13] In this study, the transfer time of both groups of patients was over 1 hour (80 and 72 minutes), despite normal driving time between both hospitals averaging 30 minutes. This was probably the result of logistic and organizational difficulties within the ambulance and emergency service, which in Hong Kong had to manage 300,000 calls in 1995.

Time however, is of the essence. A recent study in Britain estimated that an ambulance response time of eight minutes (current standard 14 minutes) can save 3,000 lives per year.[14] In neurosurgery particularly, investigators have shown that patients with extradural haematomas and fixed dilated pupils have a survival rate of 82% if operated on within three hours, yet 27% still die or remain severely disabled.[15] As we move towards the ideal of "zero mortality" in neurotrauma, these potentially reversible factors and problems must be tackled and solved. Thus, the clinical circumstances and rapid neurological deterioration of four patients prompted emergency surgical treatment by our mobile neurosurgical team so as to eliminate delays from slow transfers. This decision was only made possible because teleradiology, in conjunction with the telephone consultation, provided sufficient information for the surgical team to act decisively.

Does teleradiology then make any difference to outcome? From the available data, there was a higher percentage of favourable outcome and lower percentage of poor outcome in Group 2. However, a statistical difference could not be demonstrated and mortality rates in both groups were the same. Whether these improved figures could be attributed to teleradiology alone or whether a tighter triage system and a more cautious attitude prevailed later in the study, it would be difficult to conclude from our data. To properly address such an issue, a randomized controlled trial should be conducted, but this would raise ethical questions because the best available technology for these difficult transfers would not be used for some patients.

The main advantage of teleradiology is that it seems to confer some degree of confidence to neurosurgical management decisions. By improving the overall clinical picture, our team asked for more things to be done before transfer and was prepared to bypass transfer in certain cases so as to treat on-site. The underlying truth however is that telephoned referrals alone have historically been frought with problems, and additional information, acquired by teleradiology or whatever other means, will undoubtedly improve patient management.

Teleradiology, an example of simple modern technology which has been available for some years and which will inevitably see cost reductions in future, has the potential to reduce morbidity and mortality in head-injured patients who require hospital transfer. We recommend that this facility be considered when planning health care and allocating resources in countries where remote populations exist.

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