ORIGINAL ARTICLE

Effect of teleradiology upon pattern of transfer of head injured patients from a rural general hospital to a neurosurgical referral centre

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Emerg Med J 2007;**24**:550–552. doi: 10.1136/emj.2006.044461

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Accepted 6 May 2007

Objective: To assess the effect of teleradiology upon the need for transfer of head injured victims requiring hospitalisation but referred initially to a rural level 2 trauma centre without neurosurgical capacity.

Methods: Head injured patients requiring hospitalisation, admitted to a rural level 2 trauma centre between August 2003 and August 2005, were identified. A digitalised copy of the computed tomographic (CT) scan was transferred to the neurosurgical referral centre via teleradiology and was available for review by the neurosurgeon on-call, who then, together with the trauma surgeon in the rural level 2 trauma centre, decided whether to transfer the patient to the neurosurgical referral centre.

Results: Of 209 trauma victims with neurosurgical pathology in need of hospitalisation, 126 (60.2%) were immediately transferred while 83 (39.7%) of the patients were hospitalised in the rural level 2 trauma centre for observation. Two (2.4%) failed the intent to treat locally. One patient, suffering from multi-trauma, was stabilised after damage control laparotomy only to succumb to an enlarging epidural haematoma. Another patient was transferred 2 days after admission because of difficulty in clinical evaluation due to a previously existing neurological disorder, but no active treatment was necessary. All other 81 patients recovered uneventfully.

Conclusions: Selective head injured patients with pathological CT scan may be safely managed in level 2 trauma centres. A committed trauma team in the rural trauma centre, neurosurgical consultation and availability of a teleradiology system are requisites. Currently existing transfer criteria should be carefully re-evaluated.

Head injuries are common and approximately 50% of all trauma deaths are associated with head injury.[1] The Advance Trauma Life Support (ATLS) guidelines have set a principal that trauma victims should no longer be transferred to the closest hospital, but rather to the closest appropriate hospital, preferably a designated trauma centre.[2] Transfer criteria of head injured patients endorsed by the ATLS and the Israeli Ministry of Health are summarised in table 1.

Nevertheless, in rural areas, trauma centres with neurosurgical expertise are not always within reach of the local prehospital system. In these areas, a non-designated, or a level 2, trauma centre serves as the only available medical treatment facility where diagnosis, primary treatment and the decision to reallocate the trauma victim to a neurosurgical referral centre are undertaken. Only in exceptional circumstances will a rapidly expanding epidural haematoma not allow insufficient time for transfer to a designated trauma centre with a neurosurgical service.

Hillel Yaffe Medical Center (HYMC) is a 410 bed general hospital designated as a level 2 trauma centre. It is located in a rural area and is the only trauma centre available for immediate transfer of injured patients within a 90 km diameter. Overall, as many as 24 000 trauma patients are taken care of in the emergency department yearly and about 2800 trauma victims are hospitalised. Yet, HYMC lacks a neurosurgical service. Currently in Israel, there are six neurosurgical departments, one

Abbreviations: ATLS, Advanced Trauma Life Support; CT, computed tomography; GCS, Glasgow Coma Scale; HYMC, Hillel Yaffe Medical Center; ISS, Injury Severity Score

Table 1 Inter-hospital transfer criteria of head injured patients

ATLS guidelines	Israeli Ministry of Health guidelines (edited and translated by J Haspel)
Head injury Penetrating injury or depressed skull fracture Open injury with or without CSF leak GCS score <14 or GCS deterioration Lateralising signs	Recommended neurosurgical or neurological consultation in the presence of at least one of the following: Patient not fully conscious Deteriorating state of consciousness Neurological deficit per history and/or abnormal clinical examination Abnormal imaging finding
Spinal cord injury or major vertebral injury	Transfer of patient to a neurosurgical facility is mandatory if: GCS <15 and a CT is not available Recognised need for neurosurgical care in the presence of normal CT scan Any patient who is not considered as having mild head injury (fully alert and with no neurological deficit)

ATLS, Advanced Trauma Life Support; CSF, cerebrospinal fluid; CT, computed tomography; GCS, Glasgow Coma Score.

in each of the six level 1 trauma centres. Direct transfer of patients from the site of injury to the nearest level 1 trauma centre may add between 30–60 min to the primary evacuation time, depending on traffic congestion or air-transport availability.

Up to 2003, almost all patients with neurosurgical diagnoses were transferred from our hospital to a level 1 trauma centre. The only patients not transferred were those with minor head trauma (fully conscious and with no neurological deficit) and with no abnormal computed tomographic (CT) findings other than linear fractures. The transfer of some patients was temporarily delayed because of concomitant life threatening injuries and the patients' unstable condition prohibiting transfer. Retrospective evaluation of neurosurgical patients admitted to HYMC's emergency department during 2002, who were eventually transferred to a level 1 trauma centre, demonstrated that just 17 (15%) of 116 victims transferred ended up needing specialised neurosurgical treatment—14 patients underwent surgery and three underwent insertion of an intracranial pressure monitor. All the other patients were actively observed with repeat CT scan. In this latter group, average hospitalisation time was only 2.6 days; 57 (49%) were admitted to either the general surgery department or the paediatric department.

Inter-hospital transfer of trauma patients may influence the decision making process regarding priorities and procedures in the care of the individual patient and is costly. Furthermore, half of the patients transferred during 2002 did not receive care and monitoring beyond what they would have received in HYMC, if not transferred. In view of these considerations, we were looking for a way to reduce the number of transferred head trauma patients without compromising the quality of care and avoiding any additional risk.

METHODS

A cooperation agreement was established between HYMC and a level 1 trauma centre (Sheba Medical Center, Tel-Hashomer). A rapid and reliable 24 h teleradiology route was opened between the two institutions and an online consultation process was developed. Head injury patients are evaluated clinically by the HYMC trauma team and, according to history and physical findings, a head and neck CT scan is performed. All CT scans are interpreted by a local radiologist. Whenever pathological or equivocal findings are identified, an online consultation is set, in which all the clinical information and the scan itself are discussed between the HYMC senior trauma surgeon and the neurosurgeon. A joint decision is taken whether to transfer the patient to the level 1 trauma centre or to admit him or her to HYMC for observation.

We analysed retrospectively the trauma registry records of head injury patients who were admitted to the HYMC emergency department from 1 August 2003 to 31 August 2005. Patients with mild head trauma (fully conscious, with no neurological deficit and/or normal CT scan), who were discharged directly from the emergency department, were excluded. Information retrieved included age, gender, Injury Severity Score (ISS), Glasgow Coma Scale (GCS), medical diagnosis, neurosurgical interventions, and in-hospital mortality.

A comparison between two groups was conducted:

- Group A—patients transferred to the level 1 trauma centre
- Group B—patients hospitalised in HYMC.

Patient characteristics, treatment variables and outcomes of the two groups were compared using χ^2. Failure to treat was considered in group B whenever a patient failed observation in the HYMC and needed prompt transfer to the level 1 trauma centre or died from his/her neurosurgical injury.

RESULTS

During the 24 month study period, a total of 4750 trauma victims were hospitalised in HYMC. In 671 (14.1%) patients, head CT was obtained as part of their evaluation. Of these, 209 (4.4%) were found to be pathological. This latter group of patients comprised the study population; 126 (60.3%) patients were immediately transferred to a level 1 trauma centre and 83 (39.7%) patients were admitted to HYMC. The mechanisms of injury in each case are summarised in table 2. Patient characteristics are presented in table 3. Gender distribution was similar between the two groups. Patients in group B were younger and had overall better ISS. However, no difference in admission GCS was found between those transferred and those who were not.

In group B patients hospitalised in HYMC, there were two (2.8%) whom we defined as failures of treatment. One was a 25-year-old woman who had multiple injuries after being involved in a motor vehicle accident. She suffered massive haemorrhaging from an injured liver and spleen and an emergency laparotomy was performed. The bleeding was stopped by damage control surgery that included a splenectomy and liver packing. Her haemodynamic indices stabilised after surgery. A head CT was obtained postoperatively which revealed a large epidural haematoma. While preparing for transfer to the level 1 trauma centre she developed signs of brain herniation and died. The second patient was a 78-year-old man who had fallen at his nursing home and was diagnosed with subarachnoid and small intracerebral haemorrhage. During his observation at the HYMC, the patient developed hallucinations which made it difficult to assess his neurological status. He was transferred to the level 1 trauma centre for further observation. He had an uneventful course and after a few days was discharged back to the nursing home.

DISCUSSION

Due to the limited availability of neurosurgical services in Israel, many head injured victims are initially evaluated and treated in general hospitals or non-designated trauma centres. Concern about delay in the neurosurgical treatment usually results in early transfer of all significant head injuries to a level 1 trauma centre, in accordance with ATLS transfer criteria and the Israeli Ministry of Health guidelines (table 1).

It is beyond any discussion that all patients who clearly need a neurosurgical intervention should be transferred as early and quickly as possible. However, inter-hospital transfer of trauma victims is a complex procedure. The decision to transfer a patient to another hospital might influence substantially other treatment decisions regarding priorities and even mode of treatment. As an example, patients with splenic or hepatic injuries, that would have been treated non-operatively if the need for transfer had not arisen, will undergo laparotomy for haemorrhage control to enable safe transfer to the neurosurgical facility. Considering that most of those transferred did not receive any care different from what they would have received in the HYMC, we believe that criteria for patient transfer should be harsher.

Defensive medicine might be a real concern in head trauma victims who remain in hospitals without neurosurgical capabilities. One can always rely upon the existing guidelines to support an assumed claim that inadvertent results of a head trauma victim care are because transfer to a neurosurgical facility was delayed. Therefore, we find it increasingly important to show that this is not always true. Finally, but

Table 2 Mechanisms of injury in 209 head trauma patients with pathological head computed tomographic scans

Mechanism of injury	Number of patients (%)
Falling down	70 (33.5)
Motor vehicle accident	92 (44)
Pedestrians hit by car	16 (7.7)
Assault	14 (6.7)
Terrorist attack	1 (0.5)
Other mechanism	16 (7.7)
Total	209 (100)

no less important, unnecessary transfers impose a great burden on an already strained medical system. They consume specialised manpower and equipment and increase costs of treatment.

The whole thesis presented in this paper would not be possible without the development and widespread distribution of teleradiology systems. For several years, health care systems have explored different ways to reduce the number of unnecessary transfers and to improve radiological services to remote areas.[3 4] Teleradiology is a promising technology which, if incorporated into the system of inter-hospital consultations, allows more rational use of resources and significantly reduces costs by reducing the amount of unnecessary transfers.[5 6] In trauma, teleradiology has been in use since the early 1990s, especially in patients with head injury. In 1990, Lee *et al* described a 43% reduction in neurosurgical referrals.[7] Similarly, Goh *et al* demonstrated that as many as 21% of the transfers of head injured patients could be avoided by a system incorporating online neurosurgical consultation and teleradiology.[8] In this study, there was a trend towards more therapeutic interventions and significantly less adverse events during transport in patients in whom teleradiology consultation was obtained before transfer. Even in patients in whom the need for transfer is obvious, teleradiology allows changes in treatment to be done in the referring hospital upon the advice of the neurosurgeon being consulted.[9]

Today, teleradiology is used by many medical facilities around the world. These systems are reliable and the quality of transferred images is good, which allows prompt and accurate interpretation by the consulting neurosurgeon or the neuroradiologist.[10] Use of this system allows neurosurgeons to evaluate and consult online an unprecedented number of patients.[11] Reliability of image transfer to mobile phones has been reported, demonstrating possible future applications of this system.[12 13] Another recent advance is the availability of real time audio-visual teleconferencing, which like teleradiology, has been shown to have a favourable impact on emergency neurosurgical referrals.[14 15]

CONCLUSION

Carefully selected head trauma patients can be safely managed in a level 2 trauma centre, provided a reliable teleradiology system is available around the clock for neurosurgical consultation, there are strict criteria for patient selection, and the trauma team in the level 2 trauma centre is highly committed.

Table 3 Characteristics of patients transferred (group A) and not transferred (group B) to a level 1 trauma centre

	Group A	Group B	
	126 patients (%)	83 patients (%)	χ^2 Analysis
Gender:			
Male	92 (73)	65 (78.3)	$\chi^2=0.5$,
Female	34 (27)	18 (21.7)	p=0.48
Age (years):			
<1	15 (11.9)	6 (7.2)	$\chi^2=9.6$,
1–4	17 (13.5)	24 (28.9)	p=0.047
5-14	15 (11.9)	13 (15.7)	
15–64	55 (43.7)	29 (34.9)	
⩾65	24 (19)	11(13.3)	
GCS:			
Unknown	3 (2.4)	1(1.2)	$\chi^2=0.38$,
GCS 13–15	98 (77.8)	65 (78.3)	p=0.83
GCS 9–12	8 (6.3)	7 (8.4)	
GCS ⩽8	17 (13.5)	10 (12)	
ISS:			
1–8	12 (9.5)	27 (32.5)	$\chi^2=33$,
9–15	14 (11.1)	22 (26.5)	p⩽0.0001
16–24	60 (47.6)	18 (21.7)	
25–75	40 (31.7)	16 (19.3)	

GCS, Glasgow Coma Score; ISS, Injury Severity Score.

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Competing interests: None declared

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