Traumatic brain injury: assessment and management

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Suspected traumatic brain injury is a common presenting problem for emergency department staff. Sorting out who needs to have a computed tomography scan, who should be admitted and who should be followed up can be difficult. A framework for making these decisions is provided in this article.

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Suspected traumatic brain injury (TBI) is a common presentation to hospital emergency departments. Exact figures are unknown, but it is estimated that around 250 admissions for TBI per 100 000 population are made each year, 80% of which are classified as mild or minimal TBI (Thornhill et al, 2000). There is increasing pressure on hospitals to reduce bed days and limit admissions. The previously common practice of applying a low threshold for admission for suspected TBI is being replaced by more careful assessment in the emergency departments and clinics and in GP surgeries – investigations are carried out as appropriate, followed by a period of observation and discharge home without hospital admission. This requires a good system for risk assessment of acute complications of TBI, good information for discharged patients and adequate follow-up for unresolved problems.

There are no randomized controlled trials of different acute assessment and management strategies for people with suspected TBI. However, some high-quality prospective cohort studies have added to our understanding of who should receive a computed tomography (CT) head scan in the emergency department (Arienta et al, 1997; Haydel et al, 2000; Stiell et al, 2001). Draft recommendations on who should receive a CT scan were compiled, based on published data, reviewed by a range of health providers in New Zealand (including GPs, neurosurgeons, rehabilitation specialists, emergency department physicians and psychologists) and then revised based on feedback from the review process. A summary booklet *Clinical Guidelines: Acute Management Traumatic Brain Injury* and accompanying information sheets for adults and children were published early in 2001 by the New Zealand Accident Compensation Corporation (Harwood and McNaughton, 2001). With the publication of an important study in May 2001 (Stiell et al, 2001), these recommendations have been revised further for this article, although they aim to maintain focus not just on acute complications but also on identifying people at risk of long-term consequences.

TABLE 1.
Diagnosis of traumatic brain injury (TBI)

Definite TBI	Episode of external force to the head and brain (including deceleration force such as car crash) and
	Neurological symptoms and/or signs (including loss of consciousness and amnesia) and
	These symptoms/signs can be attributed to the TBI
Possible TBI	Neurological symptoms and/or signs (including loss of consciousness and amnesia) and
	Uncertainty about whether external force has occurred or whether symptoms/signs relate to TBI
Head injury without TBI	Episode of external force to head but no neurological symptoms/signs

DEFINITIONS

The term 'traumatic brain injury' or TBI is used here in preference to 'head injury' because the important consequences relate to the brain rather than the head alone (Whyte et al, 1998).

A diagnosis of 'definite TBI' can only be made, in the authors' view, where there is evidence of an episode of external force to the head (including a deceleration force such as in a car crash) and there are neurological symptoms and/or signs (including loss of consciousness or amnesia) which can reasonably be attributed to trauma to the brain. Situations which do not meet these criteria can be defined as 'possible TBI' or simply 'external force to the head without TBI' (*Table 1*).

TBI SEVERITY

Assessment of severity of TBI depends on a combination of the Glasgow Coma Score (GCS)

(*Table 2*) (Teasdale and Jennett, 1974) and length of post-traumatic amnesia (PTA) (Bishara et al, 1992). There is disagreement about which GCS should be used for estimating severity – the best score in the first 24 hours, the worst in the first 24 hours, the GCS following resuscitation, the GCS on admission or the GCS 1 hour after admission. Practically, the most important thing is that the GCS is measured in the first place. The authors' experience of retrospective audit is that the only measurement that occurs often enough to be useful in medical records is on admission to the emergency department (Stiell et al, 2001).

PTA is the period of loss of continuous memory after the injury, including any period of unconsciousness. Resolution of PTA can be estimated retrospectively by asking the person to report the first post-injury memory and subsequent events (to ensure that memory is continuous) (King et al, 1997). *Table 3* describes severity levels of TBI for different GCS and PTA values. Where the GCS and PTA values do not match, the GCS is usually accepted as defining the severity level, although there is evidence that PTA is a better predictor than GCS of long-term outcome following TBI.

TABLE 2.
Glasgow Coma Score in adults

Response			Score
Eye opening response	Spontaneously		4
	To speech		3
	To pain		2
	None		1
Best motor response (in arms)	Obeys commands		6
	Localization to painful stimuli		5
	Normal flexion to painful stimuli		4
	Spastic flexion to painful stimuli		3
	Extension to painful stimuli		2
	None		1
Best verbal response	Orientated		5
	Confused		4
	Inappropriate words		3
	Incomprehensible sounds		2
	None		1
Modification of normal response in children under 5	Age	Best motor response	Best verbal response
	< 6 months	Flexion	Smiles and cries
	6–12 months	Localization	Smiles and cries
	1–2 years	Localization	Sounds and words
	2–5 years	Obeys commands	Words and phrases

PRINCIPLES OF MANAGEMENT

Resuscitation and initial assessment

Attention to the airway, breathing and circulation is of course the first priority. Assessment for other injuries is the next priority, particularly of the neck but also long bone fractures, chest and intra-abdominal injuries. Conscious level should be assessed using the GCS, every 10 minutes in the first hour and then according to progress. Any focal neurological deficits should be noted. The differential diagnosis of impaired conscious level should be considered, including metabolic and toxic causes that may require specific treatment.

Identify patients at risk of immediate complications of TBI

The primary concern is intracranial haematoma. In order to safely discharge people home, the threshold for performing a CT head scan to rule out intracranial haematoma must be low. CT is the preferred investigation, with skull X-rays usually only considered where CT is not available. In this article, recommendations for different situations are made (*Table 4*) based on a combination of the work of Arienta et al (1997) from a retrospective cohort study of 10 000 people with suspected TBI and the 'Canadian CT head rule' developed by Stiell et al (2001) based on 3121 patients with a GCS of 13–15. The aim is to minimize the risk of missing important brain injury but still limit the need to admit patients to hospital 'just in case'.

The recommendations from Haydel et al (2000) set a lower threshold for CT than that adopted here. Their recommendations would mean a CT head scan for everyone with TBI and GCS <15. For patients with TBI, GCS of 15 and none of seven clinical features (short-term memory deficits, i.e. PTA >0, intoxication, physical evidence of trauma above the clavicles, age >60 years, seizure, headache or vomiting), they consider a CT scan unnecessary. This would have reduced the CT scan rate by 22% from a 'CT scan for everyone' rule. In the authors' view, this errs too much on the side of caution. Recommendations in this paper assume regular monitoring of conscious level and neurological deficit during any observation period. Particular caution, and a lower threshold for admission, is advised for children under 5 years (Simon et al, 2001); the elderly (>60 years); patients difficult

TABLE 3.
Severity of traumatic brain injury

Severity	GCS	PTA
Mild	13–15	<60 minutes
Moderate	9–12	60 minutes–24 hours
Severe	3–8	>24 hours

GCS = Glasgow Coma Score; PTA = post-traumatic amnesia

to assess or who are uncooperative, e.g. those with psychiatric disorder, under the influence of alcohol, other intoxication or epilepsy; and people with no telephone or social support.

Alcohol and TBI

The proportion of people presenting with suspected TBI who are affected by alcohol varies from around 40–70% in hospital-based studies (McNaughton and Wadsworth, 2000; Thornhill et al, 2000). The signs of alcohol intoxication and TBI have considerable similarity, making the GCS unreliable in alcohol-intoxicated patients, particularly where levels exceed 43.4 mmol/litre (Jagger et al, 1984). Conversely, if the blood alcohol concentration is below 43.4 mmol/litre, alteration in the conscious level should not be attributed to alcohol alone. This suggests that the presence of alcohol should signal caution in the assessment of people with possible TBI with a lower threshold for CT scan and admission. Routine blood alcohol concentration testing in suspected TBI might allow more accurate risk stratification and eventual diagnosis. However, the Canadian CT head rule avoids this by using a decision point 2 hours after admission – if the GCS has not returned to 15 by then, a CT scan is indicated whether or not alcohol is involved (Stiell et al, 2001).

Identify patients at risk of long-term complications

Much of the initial assessment and management is reasonably directed at possible acute complications of TBI. Nevertheless, the long-term sequelae of TBI can be considerable even after apparently mild TBI (Thornhill et al, 2000). At initial assessment some consideration should be given to identifying patients at higher risk of long-term, particularly cognitive, sequelae. Evidence for the effectiveness of routine follow-up of all people presenting with mild TBI is not convincing (Wade et al, 1997, 1998). However, the evidence that provision of information about common symptoms and good prognosis to patients and caregivers limits long-term disability and handicap for people with mild TBI is more persuasive (Paniak et al, 1998, 2000; Ferguson et al, 1999). This suggests that simple information sheets emphasizing

TABLE 4.
Assessment, investigations, management and follow-up for suspected TBI

INCREASING SEVERITY AND RISK ↓

Diagnosis and assessment	Immediate management	Expected complications	Follow-up
Head injury without TBI. All of: No recorded loss of consciousness GCS = 15 PTA = 0 Normal neurology No vomiting Minimal soft tissue swelling	Home with supervision Provide instruction sheet	Nil	GP as necessary
Mild TBI, no added risks. All of: GCS = 13–15 GCS = 15 within 2 hours PTA up to 60 mins Normal neurology No more than 1 episode of vomiting Minimal soft tissue swelling No sign of basal skull fracture Age >5 years and <60 years	Observe and monitor minimum of 4 hours If no deterioration, home with supervision Provide instruction sheet	Close to nil if no change after 4 hours	GP as necessary Consider indications for referral to specialist clinic
Mild TBI with risks. Both: GCS = 13–15 PTA up to 60 minutes Plus any 1 or more of: GCS <15 at 2 hours Pre-injury amnesia >30 mins Signs of basal skull fracture Age <5 years or >60 years Abnormal neurology More than one episode of vomiting Significant soft tissue swelling	CT head (preferred) or skull X-ray: If normal, observe at least 4 hours. If GCS 15 and neurology normal after 4 hours, discharge home with supervision and instruction sheet If CT/X-ray abnormal or GCS <15 or persisting neurological signs or other risk factors for safe discharge after 4 hours, treat as moderate TBI	Up to 6% with significant intracranial lesions (particularly if >65 years or skull fracture)	See GP within 2 days of discharge from ED/ward/clinic Consider indications for referral to specialist clinic
Moderate TBI. Either: GCS 9–12 and/or PTA >60 mins and/or Skull fracture	Immediate CT head: If normal, admit to hospital for observation. Repeat scan if deterioration in status If abnormal, admit to hospital and discuss with neurosurgeon	Up to 41% with significant intracranial lesion	Refer all to specialist clinic (to be seen within 3 months of injury)
Severe TBI: GCS < 9	Resuscitation Immediate CT head Admit to hospital, neurosurgical ward or intensive care unit Discuss with neurosurgeon		

CT = computed tomography scan; ED = emergency department; GCS = Glasgow Coma Score; PTA = post-traumatic amnesia; TBI = traumatic brain injury

a good outcome but listing both common symptoms and those requiring urgent attention should be provided to all patients discharged after a period of observation following TBI.

Routine follow-up in a 'TBI clinic' at 2–3 months may be reasonable for people with moderate or severe TBI to determine any persisting cognitive deficits that might justify intervention; this is currently happening in many places in New Zealand. In particular students returning to study, operators of heavy machinery, people in occupations requiring a high level of cognitive functioning and people with previous TBI within 6 months should be considered for follow-up cognitive assessment by a neuropsychologist. Advice for sports people following TBI is usually to avoid returning to active sports unless the player is free of unusual symptoms, able to manage team training without problems and able to score well on a psychometric test that assesses the person's perception and decision-making ability.

Diagnostic coding

Unfortunately, discharge coding of TBI in hospitals is inaccurate (McNaughton and Wadsworth, 2000). The International Classification of Diseases (ICD) has multiple, potentially overlapping codes for TBI and allows for such vague descriptions as 'intracranial injury, unspecified nature' (S06.9 in ICD-10-AM). To bring some order to the this problem, the authors have made recommendations on the use of particular ICD-10AM codes (*Table 5*) for each situation described in *Table 4*, specifically avoiding the use of S06.9 described above.

CONCLUSION

Careful attention to initial assessment and diagnosis along with a targeted plan of investigations and management should allow the best compromise between minimizing short-term complications of TBI and judicious use of health resources. Attention to longer term sequelae of TBI needs to be emphasized to try and minimize these effects. In the first instance, information sheets provided to all patients and caregivers can improve health outcomes following mild TBI. HM

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TABLE 5.
Discharge codes

Diagnosis	Description	ICD-10-AM
Head injury without TBI	'Observation suspected concussion (cerebral)'	Z04.5
Possible TBI	'Observation suspected concussion (cerebral)'	Z04.5
Definite TBI/ intracranial injury	'Concussion'	S06.0
	'Concussion with loss of consciousness of unspecified duration'	S06.02
	'Concussion with loss of consciousness less than 30 minutes'	S06.01
Skull fracture	'Fracture of skull or facial bones'	S02
	'Fracture of skull base'	S02.1
Open head wound	'Open wound of head'	S01

ICD-10-AM = International Classification of Diseases, 10th revision (Australian modification)

KEY POINTS

Comprehensive management of the patient with suspected traumatic brain injury requires:

- Consistent application of diagnostic criteria
- Appropriate assessment of acute risk
- Computed tomography head scan and admission to hospital where necessary
- Good information for patients and carers
- Provision for follow-up, especially for people with moderate and severe injuries.