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## Recommendations

### Level I

There is insufficient data to support a Level I recommendation for this topic.

### Level II

There is insufficient data to support a Level II recommendation for this topic.

### Level III

The Glasgow Coma Scale (GCS) is the most frequently used scoring system for assessment and classification of traumatic brain injury.

Immediate triage and assessment of the severity and probable survival of the traumatized patient should be made whenever possible already at the scene of injury. Of useful help are the various trauma scores that have been developed to triage the patients for proper care and evaluate the severity of injury. The scores are based on physiological and/or anatomical features, as well as patient responses. Physiological scores are exemplified by Glasgow Coma scale (GCS) (Teasdale and Jennett 1974), the Revised Trauma Score (RTS) (Champion et al. 1989), and the Pediatric Trauma Score (PTS) (Tepas et al. 1987). The Injury Severity Score (ISS) is an anatomical score based on the Abbreviated Injury Scale (AIS) that provides an overall score of the patient (Baker et al. 1974).

The GCS has been the most valuable and frequently used scoring system for assessing the severity of a head trauma.

To estimate severity of brain injury after head trauma, various classification systems of head injury have been proposed and modified throughout the years. Most of them are based on the patients' level of consciousness according to the GCS, as e.g. the Head Injury Severity Scale (HISS) (Stein and Spettell 1995). The Swedish Reaction Level Scale 85 (RLS) is a somewhat

## 2.1 Overview

Head injuries can be categorized in several ways: by mechanism of injury (closed or penetrating injury), morphology (fractures, focal intracranial injury, diffuse intracranial injury), or severity of injury (mild to severe).

### Tips, Tricks, and Pitfalls

- Severe head injury is defined as a patient with conscious level of GCS 3–8 (RLS 4–8) after head injury.

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- Traumatic brain injury is defined as primary or secondary injury to the brain after trauma.
- The definition of a paediatric patient varies in Scandinavian hospitals, with an upper age limit either below 16 or 18 years.
- Neurologic assessment, including GCS and pupil response, should be assessed as soon as possible either prehospital or at admission, preferably before sedation and intubation, for a more correct classification of the severity.
- Intoxicated patients are challenging to classify and should be treated with higher awareness. The GCS score may be decreased by 2–3 points due to heavy alcohol intoxication or drug use; a problematic confounding factor when assessing the level of consciousness in a head-injured patient.

simpler scale than the GCS, though less frequently used outside of Sweden (Starmark et al. 1988a).

## 2.2 Background

In the 1960s, there was a common belief amongst neurosurgeons that, aside from evacuating occasional hematomas or elevating depressed fractures, little could be done to influence outcome after head injury. However, with improvement of intensive care and resuscitation, the challenge for neurosurgeons was to assist in reducing mortality and morbidity for these severely head-injured patients. Pathological studies in Glasgow showed that by avoiding potentially preventable secondary brain damage, one could limit the degree of disabilities in survivors (Reilly et al. 1975).

Complications, such as the development of intracranial haematomas or increased intracranial pressure, were difficult to recognize; hence treatment was delayed. These concerns lead to the development of the Glasgow Coma Scale by Jennett

and Teasdale in 1974 (Teasdale and Jennett 1974). The scale was initially designed as a research tool for assessment of the comatose patient, but is now one of the most frequently used scales in triage of head injuries and in daily assessment of severe head injury. The drawback of using the GCS is the confounding effect of alcohol or other drugs, especially during the first few hours after injury. Heavy alcohol intoxication has been associated with a reduction of 2–3 points in GCS in assaulted patients (Brickley and Shepherd 1995).

### 2.2.1 Classification Systems

In 1981, Rimel and colleagues defined minor head injury as a head trauma with patient's GCS score of 13–15 at admission, loss of consciousness (LOC) less than 20 min, and a duration of hospital admission less than 48 h (Rimel et al. 1981). About a decade later, Stein and Spettell introduced a modified classification system, the Head Injury Severity Scale (HISS), a five-interval severity scale (minimal through critical) based primarily on initial GCS score. The HISS scale also includes the aspects of retrograde amnesia, loss of consciousness, and focal neurological deficits for each severity intervals (Stein and Spettell 1995).

In 2000, the Scandinavian Neurotrauma Committee (SNC) presented guidelines of management of adult head injury (Ingebrigtsen et al. 2000), using a modified version of the HISS classification, by classifying head injuries into minimal, mild, moderate, and severe (Table 2.1):

- Minimal head injury is presented by a patient with GCS 15 at admission and with no LOC or focal neurological deficits.
- Mild head injury is defined as initial GCS of 14–15, brief LOC (<5 min) and no focal neurological deficits.
- Moderate head injury defines a patient with initial GCS of 9–13 and/or focal neurological deficits or LOC ≥5 min after head trauma.
- Severe head injury includes all patients with an initial GCS score of 8 or below, hence, unconscious patients.

The definitions of mild and moderate head injury vary in the literature, especially with regard

**Table 2.1** Classification of head injuries according to SNC in 2000 (Ingebrigtsen et al. 2000)

HISS category	Clinical characteristics
Minimal	GCS=15, no loss of consciousness
Mild	GCS=14 or 15, brief (<5 min) loss of consciousness or amnesia, or impaired alertness or memory
Moderate	GCS=9–13, or loss of consciousness ≥5 min, or focal neurologic deficit
Severe	GCS=3–8

to the importance of a GCS score of 13 and the duration of loss of consciousness.

Comotio cerebri is a clinical definition of an awake patient with posttraumatic amnesia possibly due to brief LOC after head trauma, but without any apparent brain injury. Amnesia is most often retrograde, but in some cases even antegrade amnesia is present, i.e. the inability to recall new memories after the head injury event.

### 2.2.2 Primary and Secondary Brain Injury

Primary brain injury refers to the immediate brain damage caused upon impact. This includes cerebral contusions, shearing lesions (diffuse axonal injuries – DAI), lacerations from a foreign body, and acute subdural or epidural hematomas. Secondary brain injury refers to progressive cerebral oedema, which is more commonly seen in children, ischemia, and the expansion of cerebral contusions and the surrounding focal oedema, which causes an increase in intracranial pressure (ICP) within the confined skull and can eventually lead to cerebral herniation and death.

### 2.2.3 Assessment Scales

The GCS has been the most valuable and frequently used scoring system for assessing severity of neurologic injury after head trauma. The scale is divided in three parts: eye response, verbal response, and motor response, adding to a total score of 3–15 points. The GCS scale has, however, been considered difficult to apply on especially preverbal children (Yager et al. 1990)

since their ability to express themselves verbally or nonverbally in a consistent manner is limited. The response from an infant is also clearly different from an adult. Reilly et al. were the first to design the paediatric version of the GCS, where verbal responses were reported as appropriate words, social smiles, cries, irritability, and agitation (Reilly et al. 1988; Simpson and Reilly 1982). Some modifications of the scale have later also been made to suite even the youngest children and infants (Table 2.2). The paediatric GCS scale has proved to be accurate in evaluating preverbal children with head trauma with regard to the need for acute intervention (Holmes et al. 2005).

In Sweden, the most practiced scale for assessment of the level of consciousness is the Swedish Reaction Level Scale 85 (RLS) (Johnstone et al. 1993; Starmark et al. 1988a, b). This scale evaluates the consciousness in an inverted manner to the GCS, with a scoring range from 1 (best) to 8 (worst), and without specific focus on the verbal response (Table 2.3). This has made the score more practical to use, particularly on neurologically traumatized patients (who also may suffer from aphasia) and children, as well as more easily remembered in acute situations.

The Revised Trauma Score (RTS) is a numeric grading system for estimating the severity of injury. It is composed of the GCS, systolic blood pressure, and respiratory rate, each giving rise to a score between 0 and 4. The severity of injury is estimated by the total sum of the three parameters, where the highest score is 12, hence, the least severe injury (Table 2.4).

The Injury Severity Score (ISS) is an anatomical score that provides an overall score of the patient with multiple injuries after severe trauma (Table 2.5). It is based on the AIS score, which

**Table 2.2** The Glasgow Coma Scale

Glasgow Coma Scale			
<i>Standard</i>		<i>Paediatric version</i>	
		1–4 years	<1 year
<i>Eye opening</i>			
4	Spontaneous	Open	
3	To speech	To voice	
2	To pain	To pain	
1	None	No response	
<i>Verbal response</i>			
5	Orientated	Oriented, speaks, interacts	Coos, babbles
4	Confused conversation	Confused speech, consolable	Irritable cry, consolable
3	Words (inappropriate)	Inappropriate words, inconsolable	Persistent cry, inconsolable
2	Sounds (incomprehensible)	Incomprehensible, agitated	Moans to pain
1	None	No response	No response
<i>Best motor response</i>			
6	Obey commands	Normal spontaneous movement	
5	Localizes pain	Localizes pain	
4	Flexion, withdraws to pain	Withdraws to pain	
3	Flexion, abnormal to pain	Decorticate flexion	
2	Extension (to pain)	Decerebrate extension	
1	No response	No response	
3–15	<i>Total score</i>		

**Table 2.3** The Swedish Reaction Level Scale

Reaction Level Scale (RLS 85)	Score
Fully awake. Oriented	1
Lethargic. Confused. Contact after mild stimuli	2
Stupor. Confused. Contact after rough stimuli or pain	3
Unconscious. Localizes to pain	4
Unconscious. Withdraws to pain	5
Unconscious. Abnormal flexion to pain	6
Unconscious. Abnormal extension to pain	7
No response to painful central stimuli	8

determines six body regions (head, face, chest, abdomen, extremities and pelvis, and external). The three most severely injured regions are squared and added to produce the ISS. The ISS correlates to mortality, morbidity, hospital stay, and other measures of severity, but is not considered a good tool for triage (Baker and O'Neill 1976; Baker et al. 1974).

## 2.3 Specific Paediatric Concerns

The head injury classification systems mainly apply to adults, although in clinical practice the SNC classification is also used on children and adolescents. This is mainly due to the lack of specific head injury classification systems for children. In some hospitals, the level of consciousness is more properly evaluated with use of the paediatric GCS score (Reilly et al. 1988). The Pediatric Trauma Score (PTS) has been developed as an assessment score for trauma severity in children (Table 2.6), but its use in Scandinavia has so far been limited.

Definitions of mild to moderate head injury in children vary even more extensively in the literature than for adults, especially with regards to the duration of LOC (AAP 1999; Schutzman et al. 2001). Other clinical factors, such as scalp haematoma, low age (<2 years), history of excessive vomiting, and suspected skull fracture and post-traumatic seizures, have in former studies and proposed guidelines been considered as risk factors for developing an intracranial complication (Dunning et al. 2006; Holmes et al. 2004;

**Table 2.4** The Revised Trauma Score scale

Revised Trauma Score (RTS)			
GCS score	Systolic blood pressure (mmHg)	Respiratory rate (breaths/min)	Coded value*
13–15	>89	10–29	<b>4</b>
9–12	76–89	>29	<b>3</b>
6–8	50–75	6–9	<b>2</b>
4–5	1–49	1–5	<b>1</b>
3	0	0	<b>0</b>

RTS score <11 indicates a more severe trauma and need for immediate treatment

\*Total RTS score = the sum of the coded values for every category (GCS, systolic blood pressure and respiratory rate)

**Table 2.5** The Injury Severity Scale

Injury Severity Scale (ISS)			
Region	Injury description (examples)	AIS	Square top three
Head and neck	No injury	0	
Face	Minor injury	1	
Thorax	Moderate injury	2	
Abdomen and viscera	Serious injury	3	*
Bony pelvis and extremities	Severe injury	4	*
External structures	Critical injury	5	*
<i>Injury Severity Score = sum:</i>			<i>0–75</i>

Lethal injury (incompatible with life)= Abbreviated injury scale (AIS) 6=ISS 75

\*The three most severe injuries are squared and added, to produce the final ISS score

**Table 2.6** The Pediatric Trauma Score scale

Pediatric Trauma Score (PTS)			
Component	Category		
	+2	+1	–1
Size (kg)	≥20	10–20	<10
Airway	Normal	Maintainable	Unmaintainable
Systolic BP (mmHg)	≤90	90–50	<50
CNS	Awake	Obtunded/LOC	Coma/decerebrate
Open wound	None	Minor	Major/penetrating
Skeletal	None	Closed fracture	Open/multiple fractures

Sum total points: –6 to +12. Score < 9=potentially significant trauma

Schutzman et al. 2001), requiring hospitalisation or further radiological investigation (Schutzman and Greenes 2001).

The definition of severe head injury in children still include all with GCS 3–8 (Adelson et al. 2003).

## References

- Adelson PD, Bratton SL, Carney NA, Chesnut RM, du Coudray HE, Goldstein B, Kochanek PM, Miller HC, Partington MD, Selden NR, Warden CR, Wright DW (2003) Guidelines for the acute medical management of severe traumatic brain injury in infants, children, and adolescents. Chapter 1: Introduction. *Pediatr Crit Care Med* 4:S2–S4
- Baker SP, O'Neill B (1976) The injury severity score: an update. *J Trauma* 16:882–885
- Baker SP, O'Neill B, Haddon W Jr, Long WB (1974) The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma* 14:187–196
- Brickley MR, Shepherd JP (1995) The relationship between alcohol intoxication, injury severity and Glasgow Coma Score in assault patients. *Injury* 26:311–314
- Champion HR, Sacco WJ, Copes WS, Gann DS, Gennarelli TA, Flanagan ME (1989) A revision of the Trauma Score. *J Trauma* 29:623–629

- Committee on Quality Improvement, American Academy of Pediatrics and Commission on Clinical Policies and Research, American Academy of Family Physicians (1999) The management of minor closed head injury in children. *Pediatrics* 104:1407–1415
- Dunning J, Daly JP, Lomas JP, Lecky F, Batchelor J, Mackway-Jones K (2006) Derivation of the children's head injury algorithm for the prediction of important clinical events decision rule for head injury in children. *Arch Dis Child* 91:885–891
- Holmes JF, Palchak MJ, Conklin MJ, Kuppermann N (2004) Do children require hospitalization after immediate posttraumatic seizures? *Ann Emerg Med* 43:706–710
- Holmes JF, Palchak MJ, MacFarlane T, Kuppermann N (2005) Performance of the pediatric glasgow coma scale in children with blunt head trauma. *Acad Emerg Med* 12:814–819
- Ingebrigtsen T, Romner B, Kock-Jensen C (2000) Scandinavian guidelines for initial management of minimal, mild, and moderate head injuries. The Scandinavian Neurotrauma Committee. *J Trauma* 48:760–766
- Johnstone AJ, Lohln JC, Miller JD, McIntosh CA, Gregori A, Brown R, Jones PA, Anderson SI, Tocher JL (1993) A comparison of the Glasgow Coma Scale and the Swedish Reaction Level Scale. *Brain Inj* 7:501–506
- Reilly PL, Graham DI, Adams JH, Jennett B (1975) Patients with head injury who talk and die. *Lancet* 2:375–377
- Reilly PL, Simpson DA, Sprod R, Thomas L (1988) Assessing the conscious level in infants and young children: a paediatric version of the Glasgow Coma Scale. *Childs Nerv Syst* 4:30–33
- Rimel RW, Giordani B, Barth JT, Boll TJ, Jane JA (1981) Disability caused by minor head injury. *Neurosurgery* 9:221–228
- Schutzman SA, Barnes P, Duhaime AC, Greenes D, Homer C, Jaffe D, Lewis RJ, Luerssen TG, Schunk J (2001) Evaluation and management of children younger than two years old with apparently minor head trauma: proposed guidelines. *Pediatrics* 107:983–993
- Schutzman SA, Greenes DS (2001) Pediatric minor head trauma. *Ann Emerg Med* 37:65–74
- Simpson D, Reilly P (1982) Pediatric coma scale. *Lancet* 2:450
- Starmark JE, Stalhammar D, Holmgren E (1988a) The Reaction Level Scale (RLS85). Manual and guidelines. *Acta Neurochir (Wien)* 91:12–20
- Starmark JE, Stalhammar D, Holmgren E, Rosander B (1988b) A comparison of the Glasgow Coma Scale and the Reaction Level Scale (RLS85). *J Neurosurg* 69:699–706
- Stein SC, Spettell C (1995) The Head Injury Severity Scale (HISS): a practical classification of closed-head injury. *Brain Inj* 9:437–444
- Teasdale G, Jennett B (1974) Assessment of coma and impaired consciousness. A practical scale. *Lancet* 2:81–84
- Tepas JJ 3rd, Mollitt DL, Talbert JL, Bryant M (1987) The pediatric trauma score as a predictor of injury severity in the injured child. *J Pediatr Surg* 22:14–18
- Yager JY, Johnston B, Seshia SS (1990) Coma scales in pediatric practice. *Am J Dis Child* 144:1088–1091

Management of Severe Traumatic Brain Injury

Evidence, Tricks, and Pitfalls

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