

Early Indicators of Prognosis in Traumatic Brain Injury and their Association with Outcome

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Abstract

Introduction: The uncertainty that exists about the likely outcome after traumatic brain injury (TBI) is encapsulated in the Hippocratic aphorism: "No head injury is so serious that it should be despaired of nor so trivial that it can be ignored." [1]. Today, physicians' estimates of prognosis are still often unduly optimistic, unnecessarily pessimistic, or inappropriately ambiguous. It still remains impossible to say with certainty what will be the future course of events in an individual patient, but intensive research in the last three decades has made it possible to be much more confident about what is likely to happen, and to consider prognosis in terms of probabilities rather than prophecies. Traumatic brain injuries (TBI) are a real social problem, with an upward trend worldwide. Assessing prognosis after traumatic brain injury is very important in order to help clinicians to make a decision about the implementation of specific methods of treatment, and to make communication with the patient and the patient's family easier.

Objective: The objective of this review was to present prognostic factors, to assess outcomes within a short time after a moderate to severe traumatic brain injury, as well as to predict functional outcome. The most important independent variables were: age, Glasgow Coma Scale (GCS) motor score, pupil response, Marshall CT classification and traumatic subarachnoid haemorrhage. Other important prognostic factors included hypotension, hypoxia, glucose, coagulopathy, haemoglobin and category of CT characteristic, such as midline shift, mass lesion, basal cistern.

Conclusions: Gender and intraventricular haemorrhage did not have predictive value. This subject needs much more research in the area of new prognostic factors which would be better associated with outcome after traumatic brain injury.

Keywords: traumatic brain injury, prognostic factors, outcome, prognosis

I. Introduction

It has been observed that a growing number of injuries are associated with industrialization and the rapid growth of motorization. Traumatic brain injuries (TBI) are a real social problem, with an upward trend worldwide [2]. TBI is the leading cause of death and disability, especially among young men. It is estimated that nearly 1.5 to 2 million persons are injured and 1 million succumb to death every year in India. Road traffic injuries are the leading cause (60%) of TBIs followed by fall (20%-25%) and violence (10%). Alcohol involvement is known to be present among 15%-20% of TBIs at the time of injury. The advances in prognostication reflect the establishment of methods for categorizing outcome and early injury severity. These became widely accepted and led to multinational, multicenter studies that identified the features about the patient, the injury, and the early clinical course with a distinctive, consistent relationship to outcome.

TBI is a complex injury caused by a sudden blunt trauma to the brain or by an object piercing the brain tissue in which a broad spectrum of symptoms and disabilities can be observed [5]. It is a major cause of death and disability. Establishing a reliable prognosis after injury is difficult. On the other hand, clinicians treating patients often make therapeutic decisions based on their assessment of prognosis. 80% of doctors believe that an accurate assessment of prognosis was important when making decisions about the use of specific methods of treatment, such as hyperventilation, barbiturates, or mannitol. Assessment of prognosis could help communication with a patient and the family [6].

II. Objective

The aim of this study was to present current knowledge about prognostic value of determinant in TBI and the association between determinant and outcomes. The Glasgow Outcome Scale (GOS) was used in most studies at 6 months post-injury in order to assess the outcome. The scale was divided into: favourable (level 4 or 5) or unfavourable (level 1, 2 or 3) (Tab. 1). Severe traumatic brain injuries were categorised according to the Glasgow Coma Scale (GCS) on mild TBI (13–15 GCS), moderate TBI (9–12 GCS) and severe TBI (3–8 GCS). Most studies consider patients of moderate and/or severe TBI (3–12 GCS).

Table 1. Glasgow Outcome Scale

Level	Term
1	Dead
2	Persistent vegetative state
3	Severe disability
4	Moderate disability
5	Good recovery

III. Discussion

Prognostic factors are divided conventionally into 7 categories, out of which Gender and intraventricular haemorrhage do not seem to have predictive value as per recent studies [7]. All of the others are associated with outcomes but Glasgow Coma Scale (GCS) admission, motor score, mid-line shift on computer tomography scan, subdural haematoma have strong evidence for predicting outcomes at 6 months.

Gender. Trauma and TBI are more common in males than females. There was no evidence of relationship between gender and outcomes [7, 8, 9, 10, 11]. There are a few studies which indicate that gender was associated with different outcomes, but those studies included a smaller number of patients after TBI. It has been shown in a few studies that the better outcomes in females might be due to the neuroprotective effect of progesterone [12]. On the other hand, several other studies indicate that females have poorer prognosis than males [13, 14].

Age. The prognosis for recovery from trauma as one ages is a function not only of the aged brain, but the type of injury that occurs frequently in each age group. In addition, a decline in health as one ages may predispose the aged to systemic complications after head injury. Increasing age was associated with worse outcomes [7, 8, 9, 15]. Other authors state that the association was apparent only after the age of 40 [6, 16], and especially above 60 [17]. On the other hand, there is no association between TBI outcome and age lower than 40 years [6, 17]. Plausible explanations for this include extracranial comorbidities, change in brain plasticity, or differences in clinical management associated with increasing age [6]. Some studies found no relationship between age and outcomes [10, 18], or inverse relationship, an older age was associated with a better outcome [11].

Glasgow Coma Scale (GCS). According to the literature, there is strong evidence for the prognostic value of the GCS on admission to hospital and the GCS motor score [7, 8, 15, 17, 19]. Lower admission GCS and lower GCS motor scores were associated with worse outcomes [7, 15, 19, 20]. The GCS showed a clear linear relation with mortality [6]. When considering the use of the initial GCS score for prognosis, the two most important problems are the reliability of the initial measurement, and its lack of precision for prediction of a good outcome if the initial GCS score is low.

Pupillary reaction. The pupillary diameter and the pupilloconstrictor light reflex are the two parameters that have been studied extensively in relation to prognosis. Accurate measurement of pupil diameter or the constrictor response or the duration of the response has not been performed in studies on traumatic brain-injured individuals—for lack of a standardized measuring procedure. There was relation between absence of or abnormal pupillary reactions and worse outcomes in TBI [8, 15, 19]. Pupil abnormalities were noted more frequently in patients with mass lesions, compressed cisterns, shift, and in patients with CT class III/IV than in patients with CT class I/II [21].

Computer Tomography (CT) scan characteristics. CT scanning is routinely performed in all patients with severe TBI and provides information with important therapeutic implications for operative intervention or indications for intracranial pressure (ICP) monitoring, and may provide information concerning prognostic significance.

Computerized tomography (CT) scanning provides an objective assessment of structural damage to the brain and associated outcome following traumatic brain injury. The CT classification and individual CT characteristic is associated with outcome. The most common classification used after TBI was the Marshall classification, proposed in 1991 by Marshall et al. (Tab. 2) [21]. CT classifications III and IV were especially related to mortality, while CT classifications I or II were more frequent associated with a favourable outcome [21]. Strong evidence was found for the separate category mid-line shift [8, 21, 22, 23] and increasing size of the

shift associated with poorer outcome [21]. The prognosis in patients with mass lesions was better for patients with an epidural haematoma, and poorer for an acute subdural haematoma [21, 24]. Evidence for the prognostic value of subdural haematoma was strong [8, 21]. Presence of traumatic subarachnoid haemorrhage, obliteration of the basal cistern or third ventricle, and non-evacuated haematoma were associated with poorer outcome at 6 months [6, 8, 21, 25, 26]. There was strong evidence of no relationship between intraventricular haemorrhage and outcome [7, 20, 27].

Table 2. Marshall computerized tomography (CT) classification.

Category	Definition
Diffuse injury I (no visible pathology)	No visible intracranial pathology seen on CT scan.
Diffuse injury II	Cisterns are present with mid-line shift 0–5 mm and/or lesion densities present; no high or mixed density lesion >25 cc may include bone fragments and foreign bodies.
Diffuse injury III (swelling)	Cisterns compressed or absent with mid-line shift 0–5 mm; no high or mixed density lesion >25 mm.
Diffuse injury IV (shift)	Mid-line shift >5 mm; no high or mixed density lesion >25 cc
Evacuated mass lesion	Any lesion surgically evacuated.
– mass lesion	High or mixed density lesion >25 cc; not surgically evacuated

Vital signs. Vital signs are used to measure the body’s basic functions. TBI causes dysautonomia manifested by episodes of fluctuations in blood pressure (BP), pulse rate (PR), respiratory rate (RR), temperature, muscle tone, decorticate or decerebrate posturing, and profuse sweating. Dysautonomia occurs in 10% of patients surviving severe TBI who tended to have poorer outcomes [17, 28]. Most of these parameters were evaluated one-half hour (one and a half hours or half an hour) after the patient’s arrival in the emergency room. Hypotension and hypoxia following TBI is recognized as a significant secondary insult associated with adverse outcome [17, 29, 30]. There is a characteristic U-shaped relationship between systolic blood pressure (SBP) and TBI outcome. The best outcomes were observed for values of SBP between 135 – 90 mmHg. Values of SBP higher than 135 or lower than 90 mmHg were associated with poorer outcomes. Current guidelines for the management of blood pressure in TBI focus on the prevention of SBP < 90 mmHg (hypotension) [17, 31]. Diastolic blood pressure (DBP) of less than 50 mmHg was associated with higher mortality [17]. Hypoxia and oxygen saturation lower than 90% was associated with poor outcome [32]. Both increase and decrease in RR beyond normal range is associated with a poor outcome in TBI. There are similar findings about the association between PR and mortality in patients with TBI [17].

Laboratory parameters. This study describes the predictive value of various laboratory parameters routinely recorded on admission following TBI. Hyperglycaemia is a cause of secondary damage in patients after TBI, and is associated with poorer outcome [33]. Coagulopathy is a major determinant of disability and death in patients with traumatic intracranial haemorrhage. Coagulopathy, especially prothrombin time and platelets, is associated with the outcome in patients after TBI [33, 34]. Glucose and prothrombin time showed a positive linear relationship with outcome (increasing values associated with poorer outcome) [33]. Anaemia is a common problem in critically ill patients and it is associated with poorer outcome in TBI [33]. Haemoglobin, platelets, and pH showed an inverse linear to outcome (low values associated with poorer outcome) [33]. Both hypo- and hypernatraemia are associated with poorer outcome, but hyponatraemia is a relatively infrequent occurrence on admission following TBI. Sodium demonstrated a U-shaped relationship with outcome, but hyponatraemia is more strongly related to poorer outcome [33]. There is a weak relationship between hypernatraemia and outcome, which was primarily related to mortality [33].

TBI prognosis calculators. On the Internet there are two TBI Prognosis calculators available, which are based on prognostic models that combine data from patients involved in clinical trials to predict clinical outcome, but they should be used with caution [35]. The first of them could help in estimating mortality at 14 days, as well as death and severe disability at 6 months, and include the basic model, and also CT model [6]. The second could help estimate the 6-month outcome and includes 3 models of increasing complexity [36].

IV. Conclusion

Assessing prognosis after traumatic brain injury is both very important and difficult. There are a lot of different prognostic factors related to outcome that could help. The most powerful independent variables are: age, Glasgow Coma Scale, motor score, pupil response, Marshall CT classification and traumatic subarachnoid haemorrhage [8]. Other important prognostic factors included: hypotension, hypoxia, glucose, coagulopathy, haemoglobin and category of CT characteristic, such as mid-line shift, mass lesion and basal cistern [8, 21]. Gender and intraventricular haemorrhage do not have predictive value [7]. On the Internet there are 2 TBI Prognosis calculators available which could help to assess outcome, but should be used with caution. This subject requires a lot of research in new prognostic factors which would be better associated with outcome after traumatic brain injury. Patients with head injury with an admission Glasgow Coma Scale score of 3 have a poor

prognosis. Mechanism of injury, hypotension on admission, and age play a critical role in outcome. These patients are an important source of organ donation and should be evaluated and resuscitated aggressively.

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