

Predictors of Long-term Outcome in Severe Head Injury

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Abstract

Severe head injury is associated with significant morbidity and mortality. We conducted a retrospective study to assess the long-term outcome of these patients using the Glasgow Outcome Score (GOS) and evaluate the variables that might predict outcome. Data were collected from all post-traumatic neurosurgical patients with severe head injury (Glasgow Coma Scale 8 or less) admitted to the Surgical Intensive Care Unit over a 29-month period. The long-term outcome was assessed one year after the injury by a telephone interview or a review of the hospital records. Seventy patients satisfied the criteria for the study. The male to female ratio was 9:1. The mean age of the patients was 37 (range 17 to 84) years. The overall mortality was 50%. Patients with a poor outcome (defined as GOS scores of 1 to 3) had a significantly higher mean age, higher Acute Physiology and Chronic Health Evaluation (APACHE) II score and a lower Glasgow Coma Scale than those with a good outcome (GOS 4 to 5). The APACHE II score correlated better with outcome than the Glasgow Coma Scale or age. The APACHE II score may be used to prognosticate the long-term outcome in severe head injury.

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Key words: Age, Correlation, Glasgow Coma Scale, Glasgow Outcome Score, Physiological scoring

Introduction

Injuries form the fifth commonest cause of death locally.¹ They accounted for 27 out of 100 000 deaths in 1993.² Head injury is the single most important cause of post-traumatic morbidity and mortality.³ Severe head injury, in particular, is a major health problem as it often leads to physical or psycho-social disability and loss of economic viability. Healthcare costs are increased due to the need for intensive management of the head or other associated injuries and also a prolonged hospital stay if patients survive the initial injury.

The use of predictors of outcome in the intensive care setting would facilitate optimal utilisation of limited resources and aid in complex management decisions which are commonly encountered in the severe head-injured patient.

The Acute Physiology and Chronic Health Evaluation (APACHE) II classification is a scoring system commonly used in many intensive care units to classify the severity of disease.⁴ It has been evaluated in various intensive care populations and shown to be a good

predictor of hospital or intensive care mortality. However, its use as a predictor in long-term outcome in severe head injury is less known.

The objective of this study was to evaluate the usefulness of the APACHE II score in predicting long-term outcome in patients with severe head injury and compare it with other traditional predictors e.g. age and the Glasgow Coma Scale (GCS).

Materials and Methods

The study involves a retrospective study of severe head-injured patients admitted to the Surgical Intensive Care Unit (SICU) of the National University Hospital over a 29-month period ending 31 December 1995. During the study period, the intensive care management of all the patients was under the care of one ICU consultant while the surgical management was supervised by two neurosurgical consultants. Since the SICU is a multidisciplinary surgical unit, all admission records during the study period were screened for patients with relevant head or associated trauma. The patients' par-

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ticulars were noted and their case records retrieved from the medical records office. The records were then reviewed to select the study group proper.

For inclusion into the study, all patients must have had a severe head injury as defined by a GCS of 8 or less on admission to the SICU. The GCS was the post-resuscitation score and it was reviewed by the neurosurgical registrar. The data collected from this study group included the following: bio-data, date of admission, duration of stay in the SICU and hospital, initial GCS and APACHE II score. The APACHE II score was derived from the patient's age, chronic health status and the worst values obtained from 12 physiological parameters in the first 24 hours of SICU admission. This APACHE score was computed by one of the authors. The type of head injury as determined by a computerised tomographic (CT) head scan was recorded in the following categories: intracerebral haematoma, subdural haematoma, extradural haematoma and others (which include diffuse cerebral oedema and mixed lesions). The outcome (dead or alive) of the patients on discharge from hospital was also noted.

Assessment of the long-term outcome was done one year after discharge from hospital. This was done by a telephone interview with the patient or close relative. In cases where patients could not be contacted, for example for those foreign patients who have left the country, a further review of any recent follow-up case records was done to determine outcome. Patients with missing data were excluded from the study. The Glasgow Outcome Score (GOS)⁵ was used to categorise the various outcomes as follows:

1. Death
2. Persistent Vegetative State
3. Severe Disability (conscious but disabled)
4. Moderate Disability (disabled but independent)
5. Good Recovery

Statistical analysis was done using the Statistical Package for Social Studies (SPSS) program. The independent sample t-test was used to compare differences between group means. The Spearman rank correlation coefficient was used to determine the correlation between variables and the GOS. All results were accepted as statistically significant at $P < 0.05$ level. The accuracy of the APACHE scoring system in predicting mortality was assessed using two-by-two decision matrices with the decision criteria of 0.5 and 0.7 as cut-offs. At a decision criteria of 0.5, patients with a calculated risk of death (R) > 0.5 were predicted to die while those patients with $R < 0.5$ were predicted to survive. R was calculated from the following APACHE equation:

$\ln(R/1-R) = (\text{APACHE II score} \times 0.146) - 3.517 + 0.603$
(postoperative admission) + diagnostic category weightings for trauma.

A two-by-two matrix was constructed from the predicted and observed data. The sensitivity, specificity, positive and negative predictive values were then calculated.

Results

Over a 29-month period ending 31 December 1995, 70 patients satisfied the criteria for the study. Eleven cases had missing data and hence were excluded from the study. The male to female ratio was 9:1. The mean age was 37 ± 17 (SD) years (range 17 to 84 years). Neurosurgical intervention (therapeutic evacuation of haematoma) was performed in 44 patients (63%). The average length of stay in the intensive care unit was 6 ± 4 (SD) days (range 1 to 18 days) while the average stay in hospital was 21 ± 28 (SD) days (range 1 to 167 days).

Thirty-five patients died (mortality rate 50%). All non-survivors died while in hospital within 16 days of admission. In the patients who were discharged and assessed 1 year after head injury, 1 patient was in a persistent vegetative state (GOS of 2), 5 had severe disability (GOS 3), 15 had moderate disability (GOS 4) and 14 had a good recovery (GOS 5).

Figure 1 shows the distribution of mortality rates over a range of APACHE II scores. There was no mortality in the lowest APACHE score group (6 to 10) while the mortality rate was 100% in the highest score group (> 30). The group of non-survivors (GOS 1) had a mean APACHE II score of 25.4 as compared to the survivors (GOS 2 to 5) who had a mean APACHE II score of 16.9 ($P < 0.005$). A generally similar trend is noted in Figure 2 where the mortality rate decreases with a better GCS. The mean GCSs in the non-survivor and survivor groups was 3.6 and 5.1, respectively. The mortality rates by age groups as shown in Figure 3 showed that the mortality rates were highest in the older age group such that there were no survivors in patients above 60 years of age.

Figure 4 shows the distribution of cases by the type of severe head injury. Subdural haemorrhage was the commonest brain haematoma and had a high mortality rate of 80%. Extradural haematoma, on the other hand, was associated with a 22% mortality rate.

The long-term outcome of the patients was also divided into two groups: poor outcome (GOS 1 to 3) and good outcome (GOS 4 to 5). The data as shown in Table I showed a statistically significant difference between the two outcome groups in terms of APACHE II, GCS and age.

Correlation coefficient analysis showed that of the three variables, age, GCS and the APACHE II score, the APACHE II score had the best correlation with the GOS ($r = -0.56$) followed by the GCS ($r = 0.38$) and finally the patient age ($r = -0.24$).

Table II shows the predictive ability of the APACHE

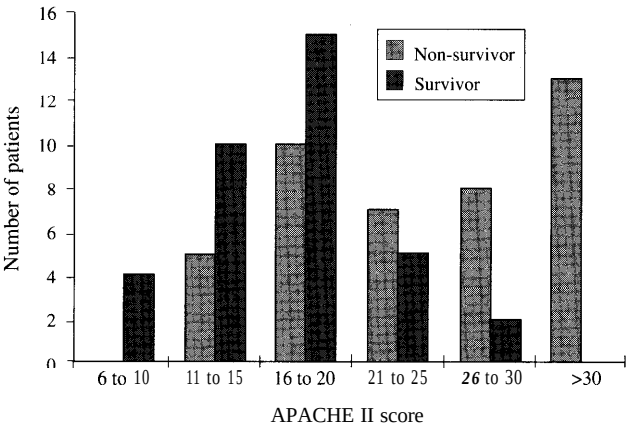


Fig. 1. Mortality and APACHE II score.

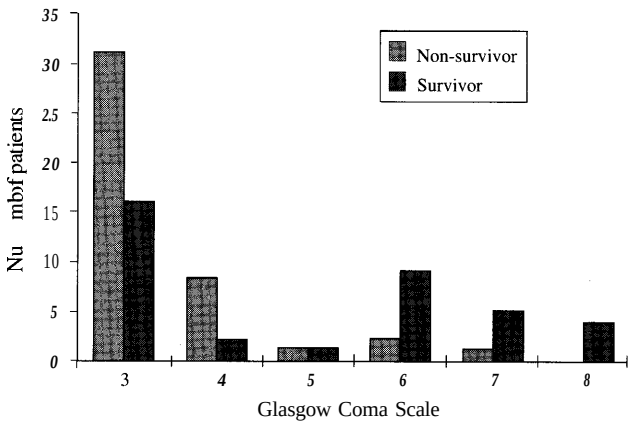


Fig. 2. Mortality and Glasgow Coma Scale.

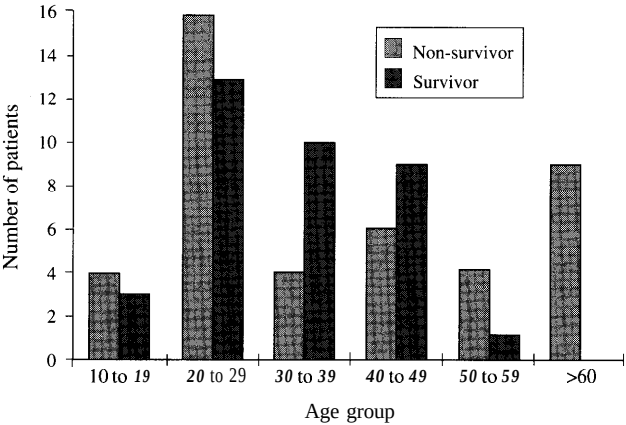


Fig. 3. Mortality and age groups

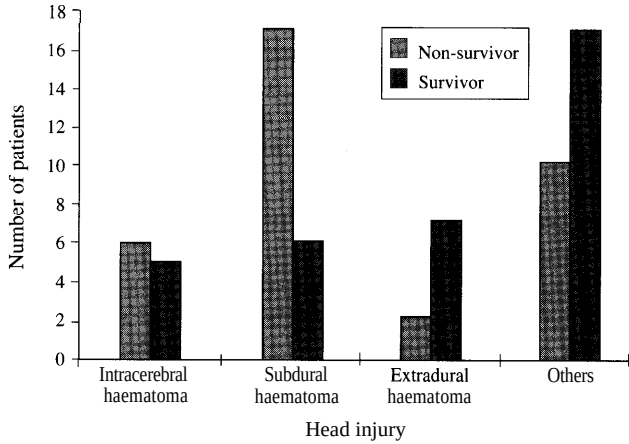


Fig. 4. Mortality and type of head injury.

TABLE I: COMPARISON BETWEEN POOR AND GOOD OUTCOMES IN SEVERE HEAD INJURY

	Poor outcome (GOS 1 to 3) n = 41	Good outcome (GOS 4 to 5) n = 29
Age (y)	41 ± 19	30 ± 8*
Sex		
Male	41	28
Female	8	2
Neurosurgical intervention	28	16
Length of intensive care stay (days)	5 ± 3	8 ± 5
Length of hospital stay (days)	11 ± 26	35 ± 24
APACHE II score	24 ± 8	17 ± 5*
Glasgow Coma Score	3.6 ± 1.0	5.4 ± 2.0*

Values are mean ± SD or number
*P <0.005 compares between groups

TABLEII: PREDICTIVE ABILITY OF APACHE SCORING SYSTEM (ALL VALUES EXPRESSED AS PERCENTAGES)

	Decision Criterion 0.5	Decision Criterion 0.7
Sensitivity	51	28.5
Specificity	97.1	100
Correct prediction outcome	74.3	64
Positive predictive value	94.7	100
Negative predictive value	66.7	58.3

positive predictive value increased to 100% but the trade-off was a lower sensitivity of only 28.5% (Figs. 5-7).

Discussion

The use of predictive systems in the ICU may help guide therapy,⁶ such as in establishing priorities and shifting care from patients with a poorer prognosis to those who are predicted to have a better prognosis or quality of life. This would optimise the utilisation of limited resources in the ICU. The University Hospital

scoring system. At a decision criterion of 0.5, mortality was correctly predicted in 74.3% of cases. The APACHE II had a high specificity and positive predictive value of 97.1% and 94.7% respectively but its sensitivity was only 51%. At a decision criterion of 0.7, the specificity and

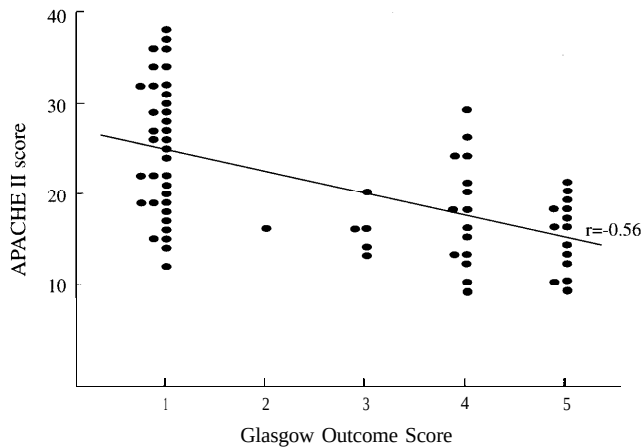


Fig. 5. Scattergram of APACHE II and Glasgow Outcome Score.

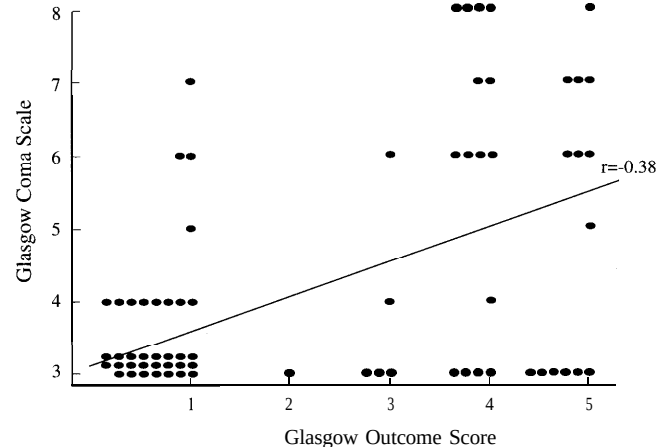


Fig. 6. Scattergram of Glasgow Coma Scale and Glasgow Outcome Score.

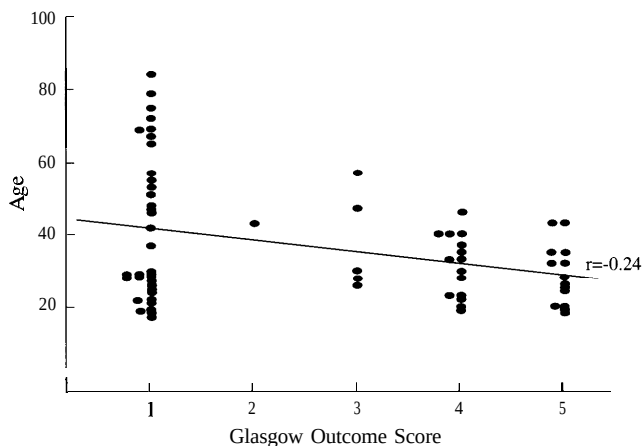


Fig. 7. Scattergram of age and Glasgow Outcome Score.

has a multidisciplinary SICU. As in many intensive care units worldwide, the APACHE II scoring system can be used to assess the severity of disease, predict outcome in the critically ill, or even facilitate quality assurance in patient management.⁷ With this in mind, we set out to evaluate some outcome predictors of severe head injury and determine if the APACHE II system could predict the long-term outcome in the group of critically ill patients who had severe head injury.

Age is a predictor of severe head injury.⁸⁻¹⁰ Our study showed that no patient above 60 years of age survived. Patients with a good long-term outcome were significantly younger than those with a poor outcome. This is consistent with the poorer physiological reserves in the older age group.

The GCS has traditionally been used as the "gold standard" in the assessment of neurological conditions. It consists of assessing and assigning scores to the degree of eye opening, verbal and the motor responses of the patient.¹¹ It has been shown to correlate well with outcome.^{9,10,12} Our results also showed that a better GCS is

associated with a lower mortality and a better outcome. However, some problems may exist in the assessment of the GCS in the severely head-injured patient. The use of intubation/ hyperventilation to manage increased intracranial pressure, paralysis/sedation and concomitant injuries like peri-orbital oedema may limit assessment of the verbal, motor and eye responses, respectively. A nationwide survey has also demonstrated a lack of uniform guidelines and a substantial variation in the assessment by different groups of healthcare professionals.¹³ The GCS, though very useful in neurological assessment, also does not take into account other physiological changes in the severely head-injured patient which may have a significant impact on the long-term outcome.

The APACHE II score integrates age, chronic health evaluation and 12 easily measured physiological parameters: temperature, mean arterial pressure, heart rate, respiratory rate, oxygenation, arterial pH, serum sodium, potassium, creatinine, haematocrit, white cell count and the GCS. Our results showed a significant difference in mean APACHE II scores, whether we compared between the survivor/non-survivor groups or the good/poor outcome groups. At a decision criterion of 0.5, the APACHE II was highly specific and had a low false-positive rate of about 6%. This implies that the APACHE II may be a useful scoring system in mortality outcome prediction in the severely head-injured patient. Although various scoring systems have specifically been proposed for use in the trauma patient,¹⁴⁻¹⁷ the APACHE II system, being more commonly adopted in the general intensive care setting, would also allow for comparison of outcome or management among various disciplines or intensive care units.

Several recent studies have compared the APACHE and GCS scores in head injury. Cho and Wang¹⁸ studied 200 patients with acute head injury and concluded that the APACHE II and III scoring systems were both better

predictors of late mortality (defined as after 14 days of admission) than the GCS, although they may not replace the role of the GCS in early mortality. Hartley et al¹⁹ showed that both the APACHE II and GCS were good predictors of outcome, although the predictive ability of the APACHE II was weakened if the neurological weighting was removed, implying the importance of the neurological status. However, their study of neurosurgical patients included non-traumatic cases which formed the majority of the patients. All the patients were also self-ventilating and admitted to the high-dependency area rather than the ICU, suggesting that few, if any, of the patients had severe head injury.

Our study on severe head injury showed that the APACHE II score correlated better than the GCS in predicting outcome. This suggests that although the GCS has traditionally been used in neurological assessment, in the context of severe head injury, other parameters may contribute significantly to outcome. Severe head injury is frequently associated with many physiologic and metabolic derangements like hypoxia, hypotension,⁸ acidosis and other organ injury. Indeed, Niskanen et al²⁰ have shown in their study of over 900 patients that the non-neurologic derangements in acute physiology have a prognostic significance in head injury. The APACHE II score, having age, GCS and acute physiological parameters incorporated within, may thus be well-suited to prognosticate outcome in severe head injury.

The moderate correlation of APACHE II with long-term outcome may be explained by some of the limitations to its use in the trauma patient. Problems inherent in the assessment of the GCS as a component of the APACHE II score are still present. The data collection also involves many variables and is thus more complex and time consuming when compared to the GCS.²¹ The APACHE II score may also have limited use in acute trauma as it does not incorporate the anatomic component²² that is a vital part of some injury severity scores. The use of anatomical based scoring systems may provide additional predictive ability in head injury outcome. The Trauma-Injury Severity Score (TRISS),¹⁵ a very widely used system for trauma outcome assessment, combines GCS, respiratory rate, age and blood pressure with the Injury Severity Score,¹⁴ which is an anatomic-pathological scoring system for trauma patients. One study has shown TRISS to correlate better with outcome than the GCS in head injury¹⁷ while another showed that both TRISS and APACHE II accurately predicted group mortality in ICU trauma patients.²³

Other limitations in our study include its retrospective design and the relatively small number of patients studied. The one-year outcome, as assessed by the GOS, essentially evaluates the functional status of the patient which may be influenced by other factors not related to

the APACHE II, such as the period of rehabilitation after trauma. Outcome assessment is influenced by the timing of assessment after injury as shown in a study where there was an improvement in the quality of life from 1 year to 2 years post-injury.²⁴ Finally, although scoring systems can help predict outcome in a group of patients, they cannot substitute for the clinical acumen required to manage each individual with his own unique set of problems. The need to design a convenient and consistent predictive scoring system still remains.

Conclusion

A high APACHE II score, low GCS and increased age are associated with a poorer long-term outcome in severe head injury. The APACHE II scoring system, which incorporates physiological parameters, correlates better with outcome than the GCS and age. It may be used to predict the long-term outcome of these patients.

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