An evolution of trauma care evaluation: A thesis on trauma registry and outcome prediction models
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Citation for published version (APA):
Chapter 3

OUTCOME AND PROGNOSTIC FACTORS OF TRAUMATIC BRAIN INJURY IN A
JAKARTA UNIVERSITY HOSPITAL; A PROSPECTIVE EVALUATION OF 49 PATIENTS.

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ABSTRACT

Objective
The aim of this study was to report management and outcome of traumatic brain injury (TBI) in a Jakarta University hospital, and to determine prognostic factors.

Methods
All consecutive patients with an Abbreviated Injury Score (AIS) head ≥ 4 or an AIS head score ≥ 3 combined with an AIS score of ≥ 2 in any other body region were analysed on patient characteristics and outcome. Prognostic factors evaluated were Glasgow Coma Scale (GCS) score, pupil reactions and probability of survival based on the Trauma and Injury Severity Score (TRISS) method.

Results
A total of 49 patients were included; overall mortality was 37%. The GCS and abnormal pupil reactions were associated with mortality with an odds ratio of 0.78 and 6.90, respectively.

Conclusions
Thus, TBI has a poor prognosis in the population under study. The TRISS has limitations in evaluating trauma care for this selected group of patients. GCS and pupil reactions are valuable and simple for usage as prognostic factors.
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INTRODUCTION

Traumatic brain injury (TBI) is a major cause of death and disability among trauma patients. Although official figures are lacking, TBI is a particular problem in developing countries. For instance, safety regulations for traffic, or to prevent work-related accidents, have a poor compliance. The management of TBI is complicated and demands adequate prehospital care, a rapid diagnostic process and a high level of (intensive) care. Once the patient has survived, aggressive rehabilitation is of importance for the longterm outcome. These conditions are generally suboptimal in developing countries.

In Indonesia in 2005, intracranial injury was the fifth most common cause of in hospital death, with a total number of 3,021 deaths (3.13%). In a previous study, we found a remarkable high incidence of brain injury (74% with AIS head ≥ 4) in the trauma population of the University Kristen Indonesia in Jakarta. This finding prompted us to focus on the specific conditions of TBI in a developing country.

In order to predict outcome, prognostic factors should be identified. Both simple physiological parameters and more advanced technologies, such as CT imaging, are used as prognostic factors. Given the circumstances under which trauma care is delivered in developing countries, simple clinical parameters as prognostic factors are preferred.

The aim of this study was to report the outcome of TBI in a University hospital, and to determine prognostic factors. A glossary of trauma scoring is found in Table 1, in order to facilitate reading the article.

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Meaning</th>
<th>Description</th>
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<tbody>
<tr>
<td>AIS</td>
<td>Abbreviated Injury Score</td>
<td>An anatomical classification of injury severity per body region (head and neck, face, chest, abdomen, extremity, external).</td>
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<tr>
<td>GCS</td>
<td>Glasgow Coma Score</td>
<td>The GCS is scored between 3 and 15. It is composed of three parameters: best eye response, best verbal response and best motor response.</td>
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<tr>
<td>GOS</td>
<td>Glasgow Outcome Score</td>
<td>Scores five states of recovery: good recovery, moderate disability, severe disability, persistent vegetative and death.</td>
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<tr>
<td>ISS</td>
<td>Injury Severity Score</td>
<td>An anatomical scoring system for patients with multiple injuries. Only the highest AIS score in each body region is used. The three most severely injured body regions have their score squared and added together to produce the ISS score.</td>
</tr>
<tr>
<td>MTOS</td>
<td>Major Trauma Outcome Study</td>
<td>A historical database of over 80,000 North American trauma patients that was used to create the coefficients for the TRISS method.</td>
</tr>
<tr>
<td>Ps</td>
<td>Probability of survival</td>
<td>Expresses an individual's probability of survival as calculated by the TRISS method.</td>
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<tr>
<td>RTS</td>
<td>Revised Trauma Score</td>
<td>A physiologic classification of injury severity, scoring GCS, systolic blood pressure and respiratory rate.</td>
</tr>
<tr>
<td>TRISS</td>
<td>Trauma and Injury Severity Score</td>
<td>A combination of ISS and RTS multiplied by weighted coefficients, depending on age and mechanism of injury (sharp or blunt).</td>
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</tbody>
</table>

Table 1 | Glossary of trauma scoring
PATIENTS AND METHODS

Setting
The prospective study was conducted at the Universitas Kristen Indonesia (UKI) in Jakarta, Indonesia, one of the University hospitals. The hospital is accredited as a Level II trauma centre, and is situated on the intersection of two major highways in south-east Jakarta.

The hospital has a well-equipped emergency department. A surgical staff member is readily available, and X-ray, ultrasound and CT facilities are available around the clock. A neurosurgeon is either in hospital or on call. The hospital also has an intensive care unit (ICU) that can house 10 patients. Continuous monitoring of vital body functions, drug treatment and respiratory support are the major interventions that take place.

Patients were admitted to the hospital either directly from the accident site or transferred from a local healthcare centre. Patients were resuscitated according to Advanced Trauma Life Support (ATLS®) protocol. If TBI was suspected, a CT scan of the brain and an X-ray of the cervical spine was performed. Results were evaluated by the surgeon or neurosurgeon, and later confirmed by a radiologist. In general, indications for surgical interventions were a significant intracranial haematoma and/or the presence of a midline shift.

Throughout the process of admission, diagnostics and treatment data were registered using special trauma charts. These charts were continually updated until the patient was transferred to either the operation theatre or ICU. The charts were a record of vital physiological bodily functions/parameters and neurological parameters. Information about time and mechanism of the accident, as well as further patient information, were also noted.

All charts were reviewed and discussed by a surgeon, a neurosurgeon and the authors of this study (GS, RA, SS). Diagnoses were adjusted if necessary, and treatment and outcome were evaluated. Every month, surgical staff attended a separate meeting to discuss those patients who had died.

Patients
From 1 October 2000 until 1 March 2001, data were collected from all consecutive patients admitted to the emergency department of UKI Hospital. All patients were screened and coded as severe or multi-trauma according to the Abbreviated Injury Score criteria (1990 revision, AIS). Inclusion criteria were an AIS head score of ≥ 4, or an AIS head score of 3 combined with an AIS score of ≥ 2 in another body region. An AIS head score of 4 means "severe", with the scale ranging from 1, "minor", to 6, "unsurvivable".

Those patients who were dead on arrival, had penetrating trauma to the head or severe burns were excluded. Similarly, children under the age of 12 years, patients who were transferred to another hospital and patients with incomplete data with respect to outcome were also excluded.

Prognostic Factors, Outcome and Statistical Analysis
The Glasgow Coma Scale (GSC) score was determined on arrival at the emergency department before the patient was intubated. Scores were determined every hour during admission to the emergency department. If deterioration was observed in the hours before the patient was transferred or operated on, the lowest score was used to predict outcome. Pupil reactivity was also measured on admission, as well as in the first few hours after
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the initial admission. Pupil reactions were considered normal if pupils were isocore and reactive. Abnormal pupil reactions were defined as a pupil diameter difference ≥ 1 mm or not responding to light. If pupil reactions could not be estimated because of damage to the eyes or swelling of the eyelid, data considering pupil reactions were not used for analyses.

Injury severity was scored by the Injury Severity Score (ISS). In combination with the Revised Trauma Score (RTS), the ISS was used to calculate the probability of survival (Ps) of a patient using the Trauma and Injury Severity Score (TRISS) method.

Mortality, as well as the Glasgow Outcome Scale (GOS) score was used to describe outcome. The GOS score differentiates outcome into five groups: total recovery, mild disability, severe disability, vegetative state and death. The first two states are considered as a favourable outcome, the latter three unfavourable. A definitive score was appointed at discharge.

Categorical data were expressed in terms of proportions. Continuous variables were expressed as means ± standard deviations. Odds ratios were obtained by an univariate logistic regression analysis with 95% confidence intervals. A p-value of less than 0.05 was considered statistically significant. The Ps and GCS were analyzed using receiver operating characteristics (ROC) curves.

RESULTS

Of 107 severely injured trauma patients, 54 patients with severe head injury met the inclusion criteria for the study. Due to missing data, 5 patients could not be included; therefore, outcome analysis was completed for 49 patients. Table 2 shows the mechanism of injury of the 49 patients included in this study. A total of 18 (37%) patients died. None of the patients ended up in a permanent vegetative state, and 8 were discharged with a severe disability, resulting in a total of 26 (53%) patients with an unfavourable outcome. Sixteen patients made a full recovery and 7 patients left the hospital with a minor disability, therefore 23 (47%) patients with a favourable outcome.

<table>
<thead>
<tr>
<th>Type of incident</th>
<th>No. patients</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorcycle</td>
<td>18</td>
<td>37</td>
</tr>
<tr>
<td>Car accident</td>
<td>10</td>
<td>21</td>
</tr>
<tr>
<td>Fall</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Violence</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>49</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 2 | Mechanism of injury

In our study population, 82% of patients were coded as having an AIS head score ≥ 4, with 8 cases of isolated TBI. AIS head scores of 3 were most frequently accompanied by injury to
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the abdomen or the extremities. The maximum ISS score is 59 and the minimal score was 13. Almost one third of the patients (n = 14; 29%) presented at the emergency department with ventilatory support (either intubated or bag-valve support). The diagnosis made by CT scan was cerebral oedema (n = 24), subdural haematoma (n = 11), epidural haematoma (n = 6), intracerebral haematoma (n = 17) and fractures of the skull or skull base (n = 13). Frequently, several diagnoses were reported for one patient. Almost half of the patients (n = 22; 45%) underwent craniotomy.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Total cohort</th>
<th>Deaths</th>
<th>Survivors</th>
<th>Odds ratio (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>28.7 ± 10.7</td>
<td>29.8 ± 12.2</td>
<td>28 ± 10.0</td>
<td>1.17 (0.68- 2.03)</td>
<td>0.57</td>
</tr>
<tr>
<td>Male</td>
<td>38 (79%)</td>
<td>13 (76%)</td>
<td>25 (81%)</td>
<td>1.28 (0.31- 5.37)</td>
<td>0.73</td>
</tr>
<tr>
<td>GCS</td>
<td>9.9 ± 3.9</td>
<td>7.7 ± 4.1</td>
<td>11.1 ± 3.3</td>
<td>0.78 (0.65- 0.93)</td>
<td>0.006*</td>
</tr>
<tr>
<td>RTS</td>
<td>6.3 ± 1.7</td>
<td>5.2 ± 2.1</td>
<td>6.9 ± 1.1</td>
<td>0.49 (0.31- 0.79)</td>
<td>0.003*</td>
</tr>
<tr>
<td>ISS</td>
<td>22.4 ± 9.5</td>
<td>27.9 ± 13.5</td>
<td>19.4 ± 4.2</td>
<td>1.13 (1.03- 1.25)</td>
<td>0.014*</td>
</tr>
<tr>
<td>Abnormal pupil reactions</td>
<td>20 (42%)</td>
<td>12 (71%)</td>
<td>8 (26%)</td>
<td>6.90 (1.85-25.76)</td>
<td>0.004*</td>
</tr>
<tr>
<td>Ps</td>
<td>0.86 ± 0.25</td>
<td>0.70 ± 0.34</td>
<td>0.96 ± 0.09</td>
<td>0.48 (0.26- 0.88)</td>
<td>0.018*</td>
</tr>
</tbody>
</table>

Table 3 | Univariate analysis of prognostic factors in 48 patients with traumatic brain injury. Data are given as number (%) or mean ± standard deviation (SD). Odds ratios are calculated in 10-year increments for age, per 1.0 for GCS, RTS and ISS, and per 0.1 Ps (10% increments in probability of survival). *Significant association with mortality in univariate analysis. CI = confidence interval, GCS = Glasgow Coma Scale, ISS = Injury Severity Score, Ps = Probability of survival, RTS = Revised Trauma Score.

Figure 1 | ROC curves of the Glasgow Coma Scale (GCS) score (solid line) and the Probability of survival (Ps) (dashed line) as prognostic factors for mortality.
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TRISS analysis and determination of prognostic factors influencing mortality was performed for 48 patients. The expected mortality as calculated by the TRISS method was 10%. Definitive outcome-based evaluation using the TRISS method revealed 12 unexpected deaths and no unexpected survivors, with a misclassification rate of 25% (12/48). In univariate analysis, death was significantly associated with RTS, ISS, and Ps, and with the clinical parameters GCS and abnormal pupil reaction (Table 3). The characteristics of GCS and Ps as prognostic factors for mortality are given in a ROC-curve (Figure 1). The area under the curve is 0.756, and 0.796 respectively.

DISCUSSION

The study describes the outcome of 49 patients from a developing country who have TBI, and reports a mortality of 37% percent. As mentioned previously, TBI is the most common cause of death and disability in young people. National TBI data for the USA reports 51,000 deaths in 2003.10 A descriptive study of 131 patients with severe head injury in Northern Ireland (ISS ≥ 16 with a minimum AIS head of 3) reported a 38% overall mortality and a 32% mortality for isolated brain injury patients.11 Literature about TBI in developing countries is limited. Wu et al. described 489 consecutive patients with traumatic intracranial haematoma who underwent surgery in a Taiwanese regional hospital, and found an overall mortality rate of 12%.12 Bahloul et al. reported an overall mortality rate of 29% in a Tunisian population of 437 adults with head injury who were admitted to the ICU and had a mean ISS of 35.13 A nationwide study from Pakistan, conducted over a 4-year period, found a mortality rate of 18% in 260,000 patients.14 The specific conditions of TBI in a developing country is illustrated by Ahmad et al., who described a cohort of 325 “unknown” head injury patients with a mortality of 46% among severely injured patients.15 In densely populated India, it is estimated that 200,000 people die due to TBI every year.16 These figures indicate the magnitude of this health problem in developing countries. Although the number of patients in our study is small, to the best of our knowledge these are the first prospective data published about TBI in Indonesia.

TBI is graded as mild, moderate or severe, based on the GCS after resuscitation. All these categories are represented in the study population. In this study, we focussed on severe TBI. The inclusion of patients with AIS of 3 in combination with of AIS ≥ 2 for another body region seems to be in conflict with this statement. However, of the 9 patients included who had an AIS of 3, all showed cerebral oedema on CT scan except one, who had a cranial vault fracture without concomitant intracranial injury.

The outcome of TBI is dependent on rapid early resuscitation and direct transport to a facility capable of surgical treatment of TBI, monitoring intracranial pressure and maintaining adequate cerebral perfusion. The implementation of scientific evidence-based guidelines and the institution of trauma hospital systems is key in order to improve the outcome of TBI.1 In the region, the UKI hospital is regarded as a “centre of excellence” for trauma patients, and patients are often referred from other hospitals. Resuscitation follows the ATLS® principals, and reasonable effort is made to educate residents and nurses in these principals and maintain a high level of care. However, the prehospital care is a weakness of the trauma care system in the UKI region, and long patient delays are common. In the majority of cases, people were brought in by police, relatives or bystanders rather than by ambulance. Data on delay to admission or operation were incomplete and therefore not provided in this paper.
In-hospital care was inadequate with respect to the impossibility of monitoring intracranial pressure, while (aggressive) rehabilitation is virtually non-existent. The influence of these limitations on the outcome of TBI cannot be expressed in figures, yet it should be taken into account while judging the relatively high mortality rate.

The population varies in mechanism of injury in comparison with Western country populations. In comparison with the Major Trauma Outcome Study (MTOS), the number of motorcycle-related accidents was high; 37% versus 7% in the MTOS. Of 59,713 head-injured patients of the MTOS, only 7.7% involved motorcycle riders. Although helmets are compulsory for motorcyclists in Indonesia, law-enforcement is minimal, and riding without head protection is common practice. Enforcement of head protection in the state of California, USA resulted in a 30% decrease in head injuries among non-fatally injured motorcyclists.

The discrepancy between observed and expected mortality is of special interest in this study. Gennarelli et al., analysed the MTOS data set and found that overall mortality of patients with head injury was three times higher than if no head injury occurred. The inability of the TRISS method to properly predict outcome in head-injured patients has been an important factor in the development of alternative outcome prediction models, such as A Severity Characterization of Trauma (ASCOT), which reaffirms the importance of head injury. In a previous study in the same institution, we found a misclassification rate of 16% in 97 consecutive multiple (ISS ≥ 13) and severely (ISS ≥ 4 in a single body region) injured trauma patients. The results presented here describe a patient group with TBI and, therefore, the misclassification rate of 25% is predictably higher than in the previous study.

Numerous studies have described prognostic factors for mortality and morbidity following head injury. These factors range from simple clinical parameters to complex neurophysiologic parameters or to radiological classifications such as CT scans. GCS and pupil score are “classical” predictors of outcome after TBI. The GCS proved to have significant agreement between health care workers. We confirm the value of these simple, clinical parameters for outcome prediction under basic circumstances, as are encountered in developing countries.

This study has several limitations. Treatment and scoring could be subject to bias, since standardized protocols for management of patients with TBI were lacking and no independent peer review of diagnosis and outcome was conducted. Craniotomy was frequently performed for a variety of indications (e.g. epidural, subdural and intracerebral haematoma, or fracture). The suggestion of over-treatment can be due to lack of sophisticated monitoring equipment (e.g. ICP monitoring) in the assistance of assessing indication for craniotomy. The patient group was relatively small, making interpretation of the statistical analysis troublesome. Structure of health care and patients attitude in Indonesia makes it difficult to perform a reliable follow-up over a longer period. These circumstances forced us to define outcome at discharge, possibly influencing results in a negative way by ignoring further recovery outside the hospital. However, few data on outcome of TBI in developing countries are available and, therefore, this study adds to the information on this subject. The data can give scientific support to the necessary investments in order to improve trauma care systems in developing countries.

In summary, this study of 49 head-injured patients in a Jakarta University Hospital found that TRISS has limitations in evaluating the outcome of trauma care for this group of patients. Given the circumstances in developing countries, GCS and pupil reactions are valuable clinical outcome predictors.
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REFERENCES

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