# Outcomes of traumatic brain injury in the patient of 60 years and above: a single centre retrospective study

**V Jeyaseelan G Vasanthakumaran, MMED[1], Abdul Rahman Izaini Ghani, MMED[1,2], Regunath Kandasamy, MMED[3], Mohamad Hasyizan Hassan, MMED[1,4], Laila Ab Mukmin, MMED[1,4], Wan Mohd Nazaruddin Wan Hassan, MMED[4]**

[1]Department of Neurosciences, School of Medical Sciences, Health Campus, Universiti Sains Malaysia, Kubang Kerian, Kelantan, Malaysia, [2]Brain and Behaviour Cluster, School of Medical Sciences, Universiti Sains Malaysia Health Campus, Kubang Kerian, Kelantan, Malaysia, [3]Department of Neurosurgery, Gleneagles Hospital, Jalan Ampang, Kuala Lumpur, [4]Department of Anaesthesiology and Intensive Care, School of Medical Science, Health Campus, Universiti Sains Malaysia, Kubang Kerian, Kelantan, Malaysia

## ABSTRACT

**Introduction: The elderly is at risk for traumatic brain injury (TBI), but local data on their morbidity and mortality outcomes was lacking. This study aims to assess the outcome in mortality and functional outcome, Glasgow Outcome Scale (GOS) and factors associated with poor outcomes in patients with TBI more than 60 years old.**

**Materials and Methods: This single centre retrospective cohort study was carried out involving patients age 60 years old and above with TBI between June 2018 to May 2021. The mortality and GOS at hospital discharge, 30th day, and 90th day of trauma were analysed. The simple logistic regression (SLR) and multiple logistic regression (MLR) were performed to determine factors associated with poor outcomes and mortality.**

**Results: A total of 248 patients were analysed. The mean age was 67.5 ± 6.31 years. 156 (62.9%), 26 (10.5%), and 66 (26.6%) had mild, moderate, and severe TBI, respectively. The overall mortality rate was 9.7% and the median(IQR) GOS score were 4(2); p<0.001 at hospital discharge, 30th day and 90th day. There was significant difference in GOS outcomes after 90 days $\chi 2(2) = 136.76$ p<0.001. Upon MLR, there was a significant association of polytrauma, Adj. OR 11.04 (2.503–48.711); p < 0.002 and TBI severity: moderate TBI, Adj. OR 71.44(13.028–391.782); p < 0.001 and severe TBI, Adj OR 2533.51 (213.050–30127.644); p<0.001 towards poor outcome. However, only severity of TBI: moderate TBI, Adj. OR 19.48 (1.899–199.094); p=0.012 and severe TBI, Adj OR 26.42 (2.864–243.722); p=0.004 is associated with mortality.**

**Conclusion: Polytrauma and moderate-severe head injury are associated with poor outcomes and moderate-severe head injury is associated with high mortality.**

**KEYWORDS:**
*traumatic brain injury, older age, mortality*

## INTRODUCTION

Traumatic brain injury (TBI) is regarded as one of the major causes of death and disability worldwide with increased risk in elderly patient.[1] According to Malaysian Institute of Road Safety Research (MIROS), total number of road accidents had increased approximately 15% from 2010 to 2013. For moderate to severe TBI survivors, the injury may cause long-standing deficits that interfere with independent living, reduced, level of functioning and restrictions on activities.[2] The incidence of TBI among elderly is increasing, with an increase in fatality rate.[3,4]

In Norwegian study, increasing age, reduction in presenting GCS and type of injury is associated with increased risk of in-hospital mortality.[4] The meta-analysis by McIntyre et al found among the elderly identified those elderly patients with comorbidities who presented with severe TBI have increased mortality rate.[4,7] Furthermore, the mortality was nearly twice as high among very old (>74 years) patients, compared to patients between 65 and 74 years.[5] In Canada, the long-term outcome and proportion of patients discharged with outpatient rehabilitation therapy are increased with advancing age.[6] This may be attributed to the consequences of biological ageing as well as chronic disease prevalence thus rendering the elderly more prone to complications.[7,8]

As for local data, Mazlan et al.[9] found fewer young adult patients with good functional outcome as compared to other studies. Ang BH and colleagues found very elderly (age >75 years) had doubled mortality rate as compared to those younger.[10] However, there were no studies determining the factors associated with poor functional outcome post TBI. This study aims to provide a comprehensive global picture of the outcomes of TBI in elderly patients who are subcategorized under mild, moderate, and severe. Its primary objectives are to determine the mortality rates and functional outcomes after TBI and factors associated with mortality and poor functional outcome in elderly patients.

## MATERIALS AND METHODS

*Study Design, Inclusion, and Exclusion Criterias*

This a single centre retrospective cohort study involves all TBI cases referred to and managed in Hospital Universiti Sains Malaysia from June 2018 until May 2021. The study was approved by the Human Research Ethics Committee of USM (USM/JEPeM/21110739). All elderly patients with the age of 60 years old or more presented with TBI were included in the

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*Corresponding Author: Dr Mohamad Hasyizan Hassan*
*Email: hasyizan@usm.my*

study. Those patients who defaulted clinic follow-up at 3 months' post-injury were excluded from the study.

*Method of Research*
Comprehensive details of all patients' admission characteristic from the case folders which comprises the patient demographics (age, gender, race), various aetiologies of brain injuries (traffic, fall, others), polytrauma, Glasgow Coma Scale (GCS) on admission, severity of TBI (mild, moderate, and severe), Computer Tomography (CT) findings (extradural haemorrhage (EDH), subdural haemorrhage (SDH), contusion, subarachnoid haemorrhage (SAH), others) and Glasgow Outcome Score (GOS), and mortality at hospital discharge, at 30 days and 90th day of trauma was studied and recorded.

*Data Collection*
The patients' registration number was obtained from data registry from general ICU, surgical ICU, trauma ICU and neuro ICU, wards and neurosurgery clinic. The registration number and the patient's particulars were traced using Hospital Universiti Sains Malaysia, Hospital Information System (HIS) via Patient Information Database and Eletronic Medical Record; LIFELINE. Subsequently, the case folders were traced from Medical Record Unit, (Level G and Level 1, Blok D, Hospital Universiti Sains Malaysia) and related data were obtained and recorded. The CT images and reports were reviewed from Radiology Information System and Picture Archiving & Communication System (RIS-PAC) via link https://pacszfp2.usm.my/zfp Hospital Universiti Sains Malaysia, Kubang Kerian.

*Outcomes Measurement*
We measured the primary outcome(mortality) and secondary outcome (poor functional outcome) based on the Glasgow Outcome Scale (GOS). The GOS score classifies patient functioning into five categories; and for reporting outcomes in clinical studies purposes, the GOS score is usually dichotomized into "good functional outcome" (5: Mild or no disability and 4: Moderate disability) and "poor functional outcome" (3: severe disability, 2: vegetative state and 1: death) outcomes.[11] The factors associated with the mortality and poor functional outcome were studied. Identified factors include age, gender, race, aetiology of TBI, polytrauma, GCS at presentation, and CT scan finding. The Mortality and Glasgow Outcome Score (GOS) at hospital discharge at 30 days and 90th day of trauma was reviewed.

*Statistical Analysis*
For statistical analysis, categorical data was presented as frequency and percentage while numerical data was presented as mean and standard deviation (SD) or median and Interquartile range (IQR). We applied simple logistic regression (SLR) tests in the univariate analysis. All variables in the univariate analysis were selected for the multivariate analysis. A forward, backward, and manual method were used to determine our final model. Then, we used multiple logistic regression test to analyse the multivariate analysis. All assumptions for the tests were met. Variables comparison with p-value less than 0.05 is considered as significant. The data were analysed using SPSS software version 26.

## RESULTS

*Demographic and Baseline Data of Patients*
A total of 248 patients fulfilled the criteria and the mean age of the TBI patients were 67.5 years, with majority sustained traffic injury (77.8%). Of the 248 patients, 156 (62.9%), 26 (10.5%), and 66 (26.6%) patient had mild, moderate, and severe TBI, respectively. 66.1% of the patient recovered with good GOS score at 3 months' post TBI. 9.7% of the patient died at hospital discharge and no additional mortality after hospital discharge to 3 months' post TBI. Patient demographic and clinical features are summarized in Table I.

*Outcomes of patients*
There was a statistically significant difference in GOS outcomes after 90 days $\chi^2(2) = 136.76$ ($p<0.001$). Post hoc analysis with Wilcoxon signed-rank tests was conducted with a Bonferroni correction applied, resulting in a significance level set at $p<0.017$. Median (IQR) of GOS outcome at discharge, 30 days and 90 days were 4 (2), 4 (2), and 4 (2), respectively. Also, there were significant differences between GOS at discharge and GOS after 30 days ($Z = -7.75$, $p<0.001$) or GOS at discharge and GOS after 90 days ($Z = -9.33$, $p<0.001$) or GOS at 30 days and GOS at 90 days ($Z = -5.20$, $p<0.001$). Table II summarizes the GOS comparison.

*Factors Associated with Poor Outcome*
There was a significant association of aetiology of TBI (Crude OR 5.54, 95% CI:2.23–13.56), $p<0.001$), polytrauma (Crude OR 5.54, 95% CI: 2.23–13.56), $p<0.001$), GCS level (Crude OR 0.27, 95% CI: 0.180.41), $p<0.001$), moderate TBI (Crude OR 145.44, 95% CI: 29.02–729.07), $p<0.001$), SDH (Crude OR 0.23, 95% CI: 0.13–0.43), $p<0.001$), and SAH (Crude OR 0.06, 95% CI:0.010.28), $p<0.001$) with poor outcomes. The rest were not significant and the factors and results for the SLR were summarized in Table III.

In the multivariate analysis, first we selected all variables for the selection process. The variables were processed by forward LR, backward LR, and manual methods to achieve a parsimonious model for the study. The final model consisted of polytrauma and TBI severity only. Polytrauma has a significant association with poor GOS outcome. A patient with polytrauma has 11.04 likelihood of poor GOS compared to non-polytrauma patient (Adj 95% CI (2.5048.71), $p=0.002$) when TBI severity was controlled (Table IV). TBI severity has a significant association with poor GOS outcome. A patient with moderate level of TBI has 71.44 likelihood of poor GOS compared to mild level patient (Adj 95% CI (13.03-391.78), $p<0.001$) when polytrauma was controlled. Also, a patient with severe level of TBI has 2533 likelihood of poor GOS compared to mild level patient (Adj 95% CI (213-30127), $p<0.001$) when polytrauma was controlled.

*Factors Associated with Mortality*
There was a significant association of polytrauma (Crude OR 16.40, 95% CI: 4.73–56.86), $p<0.001$), mortality (Crude OR 0.68, 95% CI: 0.59–0.79), $p<0.001$), moderate level TBI (Crude OR 36.91, 95% CI: 4.11–331.36), $p=0.001$), and severe level TBI (Crude OR 58.13, 95% CI: 7.56–446.81), $p<0.001$) and mortality among the patients. The rest were not significant and the factors and results for the simple logistic regression were summarized in Table V.

**Table I: Patients characteristics and clinical features (n=248)**

| Variable | | N | % | Mean | SD |
|---|---|---|---|---|---|
| Age | | | | 67.53 | 6.31 |
| Gender | Male | 189 | 76.2 | | |
| | Female | 59 | 23.8 | | |
| Race | Malay | 223 | 89.9 | | |
| | Chinese | 18 | 7.3 | | |
| | Other | 7 | 2.8 | | |
| Etiology | Traffic | 193 | 77.8 | | |
| | Fall | 54 | 21.8 | | |
| | Others | 1 | 0.4 | | |
| Polytrauma | Yes | 88 | 35.5 | | |
| | No | 160 | 64.5 | | |
| GCS | | | | 11.62 | 4.17 |
| TBI Severity | Mild | 156 | 62.9 | | |
| | Moderate | 26 | 10.5 | | |
| | Severe | 66 | 26.6 | | |
| Scan Finding | Contusion | 72 | 29.0 | | |
| | EDH | 17 | 6.9 | | |
| | SDH | 134 | 54.0 | | |
| | SAH | 25 | 10.1 | | |
| GOS | Good | 164 | 66.1 | | |
| | Poor | 84 | 33.9 | | |
| Mortality | Alive | 224 | 90.3 | | |
| | Death | 24 | 9.7 | | |

**Table II: GOS Comparison at hospital discharge, 30 days and 90 days**

| Variable | At Discharge | 30 Days | 90 Days | |
|---|---|---|---|---|
| | Median (IQR) | Median (IQR) | Median (IQR) | *p* value* |
| GOS | 4 (2) | 4 (2) | 4 (2) | <0.001 |

**Table III: Factors associated with poor outcomes using SLR (n= 248)**

| Variables | | Crude Odd Ratio (OR) | 95% CI | | |
|---|---|---|---|---|---|
| | | | (Lower, | Upper) | *p* value[a] |
| Age | | 1.02 | 0.978 | 1.062 | 0.376 |
| Gender | Male | 1.51 | 0.791 | 2.882 | 0.211 |
| | Female | 1 | | | |
| Race | Malay | 0.40 | 0.086 | 1.812 | 0.232 |
| | Chinese | 0.15 | 0.021 | 1.048 | 0.056 |
| | Other | 1 | | | |
| Aetiology | Traffic | 5.53 | 2.263 | 13.558 | <.001 |
| | Fall and Others | 1 | | | |
| Polytrauma | Yes | 35.11 | 16.831 | 73.222 | <.001 |
| | No | 1 | | | |
| GCS | | 0.27 | 0.182 | 0.410 | <.001 |
| TBI Severity | Mild | 1 | | | |
| | Moderate | 145.44 | 29.015 | 729.071 | <.001 |
| | Severe | 5005.00 | 445.989 | 56167.354 | <.001 |
| Scan Finding | Contusion | 1 | | | |
| | EDH | 0.50 | 0.171 | 1.463 | 0.206 |
| | SDH | 0.23 | 0.127 | 0.430 | <.001 |
| | SAH | 0.06 | 0.014 | 0.284 | <.001 |

[a]Simple Logistic Regression

**Table IV: Factors associated with Poor outcome using MLR (n=248)**

| Variables | | Adjusted OR | 95 % CI | | |
|---|---|---|---|---|---|
| | | | (Lower, | Upper) | *p* value* |
| Polytrauma | Yes | 11.04 | 2.503 | 48.711 | 0.002 |
| | No | 1 | | | |
| TBI Severity | Mild | 1 | | | |
| | Moderate | 71.44 | 13.028 | 391.782 | <.001 |
| | Severe | 2533.51 | 213.050 | 30127.644 | <.001 |

* Multiple Logistic Regression
Constant = - 5.06
Forward LR, Backward LR, and manual method were applied
No multicollinearity and no interaction
Hosmer Lemeshow test, *p* value= 0.821
Classification table 96.4.0% correctly classified
Area under Receiver Operating Characteristics (ROC) curve was 98.7 % (*p*<0.001)

**Table V: Factors associated with mortality using SLR (n=248)**

| Variables | | Crude Odd Ratio (OR) | 95 % CI (Lower, | Upper) | *p* value* |
|---|---|---|---|---|---|
| Age | | 1.04 | 0.977 | 1.103 | 0.231 |
| Gender | Male | 1.63 | 0.533 | 4.966 | 0.392 |
| | Female | 1 | | | |
| Race | Malay | 2.76 | 0.357 | 21.362 | 0.331 |
| | Chinese and Other | 1 | | | |
| Etiology | Traffic | 7.31 | 0.964 | 55.372 | 0.054 |
| | Fall and Others | 1 | | | |
| Polytrauma | Yes | 16.40 | 4.732 | 56.856 | <.001 |
| | No | 1 | | | |
| GCS | | 0.67 | 0.589 | 0.778 | <.001 |
| TBI | Mild | 1 | | | |
| | Moderate | 36.91 | 4.110 | 331.362 | 0.001 |
| | Severe | 58.13 | 7.561 | 446.807 | <.001 |
| Scan Finding | Contusion | 1 | | | |
| | EDH | 1.32 | 0.323 | 5.467 | 0.694 |
| | SDH | 0.56 | 0.223 | 1.376 | 0.204 |
| | SAH | 0.00 | 0.000 | . | 0.998 |

*Simple Logistic Regression

**Table VI: Factors associated with mortality using MLR (n=248)**

| Variables | | Adjusted OR | 95 % CI (Lower, | Upper) | *p* value* |
|---|---|---|---|---|---|
| Polytrauma | Yes | 3.21 | 0.790 | 13.047 | 0.103 |
| | No | 1 | | | |
| TBI | Mild | 1 | | | |
| | Moderate | 19.48 | 1.899 | 199.094 | 0.012 |
| | Severe | 26.42 | 2.864 | 243.722 | 0.004 |

* Multiple Logistic Regression
Constant = - 5.257
Forward LR, Backward LR and manual method were applied
No multicollinearity and no interaction
Hosmer Lemeshow test, *p* value= 0.335
Classification table 90.3.0% correctly classified
Area under Receiver Operating Characteristics (ROC) curve was 85.8 % (p<0.001).

In the multivariate analysis, first we selected all variables for selection process. The variables were processed by forward LR, backward LR and manual methods to achieve a parsimonious model for the study. The final model consisted of polytrauma and TBI severity only. TBI severity has a significant association with poor GOS outcome. A patient with moderate level of TBI has 19.48 risk of mortality compared to mild level patient (Adj 95% CI (1.90–199.10), *p*=0.002) when polytrauma was controlled. Also, a patient with severe level of TBI has 26.42 risk of mortality compared to mild level patient (Adj 95% CI (2.86–247.72), *p*=0.004) when polytrauma was controlled. However, polytrauma has no significant association with mortality when TBI severity was controlled.

## DISCUSSION

This study is a 3-year retrospective study of TBI sustained in 60 years old and above. The study assesses functional outcome of patient with GOS, as well as the mortality rate of the patient. Old age is recognised as a poor prognostic factor for mortality and morbidity with slower rates of functional and cognitive recovery.[11-13] There is a lot of prognostic factors which may influence the functional outcome of the patient.

In this study, polytrauma is associated with poor GOS. The associated injury to other system beside cranial injury complicated the functional recovery. Polytrauma patient especially those with open wound and long bone fracture are prone to get coagulopathy which will complicate the condition of the cranial injury. For patient with polytrauma especially to the chest causing pneumothorax, patient will be prone for chest infection and prolonged ventilation. Thus, it will hamper the recovery of the patient. The severity of TBI also influence the functional outcome of the patient. We found that moderate and severe TBI are associated with poor GOS. Functional outcome of all-severity and moderate-severe TBI in older patient is well studied and generally associated with poor functional outcome.[14] There is one small study that shows 80% of mild TBI patient with age more than 65 years old has good GOS.[15] Older adults when compared to younger patients with similar injury severity usually has a better initial GCS.[16] However, extra care need to be given also to old patients with initial mild head injury as their clinical condition might deteriorate abruptly. CT scan findings of SDH and SAH are significantly associated with poor GOS. Subdural haemorrhage, contusional bleed, and intracerebral hematoma are more common intracranial haemorrhage for older adults with TBI. Mechanism of injury for TBI for older adults are commonly due to fall. Thus, less commonly having

skull fracture and EDH. SDH and SAH are common, mainly due to brain volume reduction approximately by 6–11% by 60–80 years of age.[17] Hence, as the brain volume decreases, the volume of subdural space increases as well as the mobility of the cerebral hemisphere.

Mortality post TBI for older adults is high, and it is reported to be as high as 70–80%.[18,19] There is actually a lot of factors influencing the mortality rate, which are aggressive resuscitation, good premorbid health and independent prior to injury.[20,21] In our study, polytrauma as discussed previously in functional outcome is associated with high morbidity but not mortality. Severe and moderate TBI is associated with high mortality rate. It is reported that mortality post TBI among older adults is high especially for severe TBI patients. Despite that mild TBI patient should be paid attention to as well. There is reported old adult patient to present initially with good neurological condition initially but later on deteriorated to severe and moderate TBI within 48 hours. CT scan findings however does not have any association with high mortality, as compared to functional outcome.

## LIMITATIONS AND RECOMMENDATIONS

As with all other studies, this study also has some limitations. This is a relatively small population study from only one local neurosurgical institution. Therefore, it is recommended that future prospective and multicentre study to be conducted with longer observation periods to evaluate the long-term outcome of the elderly post-TBI.

## CONCLUSION

Moderate to severe head injury are associated with poor functional outcome and high mortality rate. In contrast, polytrauma was associated with poor functioning outcome but not mortality. Thus, optimising cerebral resuscitation, preventing secondary insult, and vigilance critical care is essential in reducing the mortality and improving the outcome of elderly with TBI.

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