Article published online: 2022-09-22

ORIGINAL ARTICLE

Factors prognosticating the outcome of decompressive craniectomy in severe traumatic brain injury: A Malaysian experience

Priya Sharda, Saffari Haspani[1], Zamzuri Idris

Department of Neurosurgery, Hospital Kuala Lumpur, Jalan Pahang, Kuala Lumpur. [1]Department of Neurosciences, Universiti Sains Malaysia Health Campus, Kubang Kerian, Kelantan, Malaysia

ABSTRACT

Objective: The objective of this prospective cohort study was to analyse the characteristics of severe Traumatic Brain Injury (TBI) in a regional trauma centre Hospital Kuala Lumpur (HKL) along with its impact of various prognostic factors post Decompressive Craniectomy (DC).

Materials and Methods: Duration of the study was of 13 months in HKL. 110 consecutive patients undergoing DC and remained in our centre were recruited. They were then analysed categorically with standard analytical software.

Results: Age group have highest range between 12-30 category with male preponderance. Common mechanism of injury was motor vehicle accident involving motorcyclist. Univariate analysis showed statistically significant in referral area ($P = 0.006$). In clinical evaluation statistically significant was the motor score ($P = 0.040$), pupillary state ($P = 0.010$), blood pressure stability ($P = 0.013$) and evidence of Diabetes Insipidus ($P < 0.001$). In biochemical status the significant statistics included evidence of coagulopathy ($P < 0.001$), evidence of acidosis ($P = 0.003$) and evidence of hypoxia ($P = 0.030$). In Radiological sector, significant univariate analysis proved in location of the subdural clot ($P < 0.010$), location of the contusion ($P = 0.045$), site of existence of both type of clots ($P = 0.031$) and the evidence of edema ($P = 0.041$). The timing of injury was noted to be significant as well ($P = 0.061$). In the post operative care was, there were significance in the overall stability in intensive care ($P < 0.001$), the stability of blood pressure, cerebral perfusion pressure, pulse rates and oxygen saturation (all $P < 0.001$)seen individually, post operative ICP monitoring in the immediate ($P = 0.002$), within 24 hours ($P < 0.001$) and within 24-48 hours ($P < 0.001$) period,along with post operative pupillary size ($P < 0.001$) and motor score ($P < 0.001$). Post operatively,radiologically significant statistics included evidence of midline shift post operatively in the CT scan ($P < 0.001$). Multivariate logistic regression with stepwise likelihood ratio (LR) method concluded that hypoxia post operatively ($P = 0.152$), the unmaintained Cerebral Perfusion Pressure (CPP) ($P = 0.007$) and unstable blood pressure (BP) ($P = <0.001$). Poor outcome noted 10.2 times higher in post operative hypoxia [OR10.184; 95% CI: 0.424, 244.495]. Odds of having poor outcome if CPP unmaintained was 13.8 times higher [OR: 13.754; CI: 2.050, 92.301]. Highest predictor of poor outcome was the unstable BP, 32 times higher [OR 31.600; CI: 4.530, 220440].

Conclusion: Our series represent both urban and rural population, noted to be the largest series in severe TBI in this region. Severe head injury accounts for significant proportion of neurosurgical admissions, resources with its impact on socio-economic concerns to a growing population like Malaysia. This study concludes that the predictors of outcome in severe TBI post DC were postoperative hypoxia, unmaintained cerebral perfusion pressure and unstable blood pressure as independent predictors of poor outcome. Key words: Decompressive craniectomy, prognostication of decompressive craniectomy, prognostication of severe head injury, prognostication of traumatic brain injury, severe head injury, severe traumatic brain injury, traumatic brain injury.

Key words: Decompressive craniectomy, prognostication of decompressive craniectomy, prognostication of severe head injury, prognostication of traumatic brain injury, severe head injury, severe traumatic brain injury, traumatic brain injury

Introduction

Traumatic Brain Injury (TBI) demands a broad definition as patients may sustain an apparently minor injury on presentation, but, in future, may demonstrate evidence of brain injury, intracranial hematoma or skull fracture. Role of Decompressive Craniectomy (DC), a surgical method of reducing raised intracranial pressure, was first popularized by Kocher (1901) for surgical decompression traumatic brain swelling. A large unilateral fronto-temporoparietal craniectomy/hemispherectomy for lesions or swelling confined to one cerebral hemisphere with dural augmentation or bifrontal

Address for correspondence:
Dr. Priya Sharda, Department of Neurosurgery, Hospital Kuala Lumpur, Jalan Pahang 50586, Kuala Lumpur, Malaysia.
E-mail: resharda@hotmail.com

craniectomy from the floor of the anterior cranial fossa to the coronal suture to the pterion for diffuse swelling with its bone temporarily stored in the abdominal subcutaneous tissue or the bone bank. In managing TBI, primary management are targeted towards the rise of intracranial pressure (ICP) such as surgical removal of a mass lesion. First tier of treatments that included the general principles of physiologic homeostasis, cerebrospinal fluid (CSF) drainage, head of bed elevation, analgesia and sedation, neuromuscular blockade, usage of diuretics, and controlled hyperventilation. In second tier of management, the usage of barbiturate coma can be advocated, optimized hyperventilation, moderate hypothermia, and lastly, DC. This was a prospective cohort study aiming to identify with the factors associated with poor outcome post DC in a tertiary setting, like ours, in the context of developing country, further enabling to come up with guidelines that would in turn influence management, especially with the growing population. Children less than 12 years were not included in the study as the pediatric age group responds differently to TBI.

Results

Description

There were a total of 235 DCs done between August 2010 and October 2011, out of which only 112 cases comprised of the reason for trauma purely due to subdural, contusion hemorrhages, and edema. Trauma cases with extradural hematoma (EDH), the pediatric population, and other notable reasons such as tumor, subarachnoid, arteriovenous malformation (AVM) bleed and abscesses were excluded in the study. Out of which two cases were done and sent back to their respective hospitals, leaving us with 110 cases. Majority of these patients were Malaysians (89%), while others were foreigners (11%). The median age of these patients was 28 years with the mean of 35.7 years and standard deviation of 18.3 years. Categorically, the age group 12-30 showed the highest rates of accidents with 54% [Figure 1], with a majority of males (86%) as compared to females (14%). The source of referral were predominantly from outside referral sources comprising of 82 cases (75%), followed by direct admission from the emergency department of Hospital Kuala Lumpur (ED HKL) of 28 cases (25%). The commonest mechanism of injury was the road traffic accident, whereby motorbikes accounted for the most number of injuries in 72 cases (65.6%), falls 13 cases (11.8%), and assaults eight cases (7.3%) came close by next, after which the others comprised of unknown mechanism of injury (predominantly found by the road side in seven cases (6.4%). Other mechanisms of injury in three cases (2.7%), lorry driving, and pedestrian in one case each (0.9%).

The majority of 72 cases had no other injuries (65.5%). However, in the other percentage noted, largest is purely orthopedic injury in 24 cases (21.8%). No comorbidities noted in the bulk of these patients (72%)

In analyzing the timing of injury, firstly, we noted that on 71 cases were known of its timing of accident, and only 34 cases noted in its documentation of time of referral. The timing of accident to operation was only known in 70 cases. We noted that the median time taken from accident to ED HKL was 9 hours, time of referral to ED HKL was 2 hours and 47 minutes, and the time of accident to operation was 13 hours and 38 minutes [Table 1]. When we looked at the mean, it was 579.68 minutes with a standard deviation (SD) of 432.67 minutes in the accident to ED HKL analysis, 1211.16 minutes with a SD of 2302.12 for the referral analysis to ED HKL group and 2188.18 minutes with a SD of 1902.10 in the accident to operation analysis.

The coma scale (GCS) was measured and tabulated as a summation of eye, verbal and motor component post resuscitation, and further categorized into three groups. In the primary referral centre, it was noted that 35 (31.8%) patients were in the severe head injury group, 35 (31.8%) in the moderate head injury group and 16 (14.5%) in the mild head injury group. In the secondary referring centre, the severe group showed 28 patients (25.5%), the moderate group showed nine patients (8.2%), and the mild head injury group, two patients (8.2%). Upon arrival to the emergency department HKL, the severe group was noted to have 87 patients (79.1%), the moderate group 17 patients (15.5%), and mild group six patients (5.5%). Focusing on only the patients motor

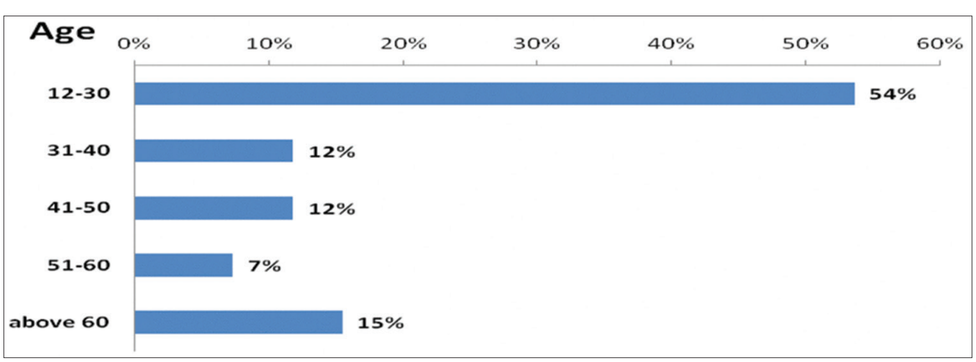

Figure 1: Age in categorical group

Table 1: Demographical data analysis for prognosticating factors of severe TBI treated in Kuala Lumpur Hospital during this study period

	Alive *n* (%)/ mean (SD)	Dead *n* (%)/ mean (SD)	*P* value
Demographics			
Referral area			0.006[a]
Direct admission	13 (17.6)	15 (41.7)	
Other hospitals	61 (82.4)	21 (58.3)	
Pre-hospital care (Arrival to ED HKL)			
Motor score			0.040[a]
1	14 (18.8)	14 (38.9)	
2	2 (2.7)	4 (11.1)	
3	9 (12.2)	4 (11.1)	
4	15 (20.3)	2 (5.6)	
5	29 (39.2)	11 (30.6)	
6	5 (6.8)	1 (2.8)	
State of pupils			0.001[a]
Equal and reactive	49 (66.2)	14 (38.9)	
Unequal	24 (32.4)	15 (41.7)	
Dilated bilaterally	1 (1.4)	7 (19.4)	
BP stability (on arrival)			0.013[a]
Stable	67 (90.5)	26 (72.2)	
Not stable (hypotension)	7 (9.5)	10 (27.8)	
Timing of surgery			0.061[a]
<6 h	13 (18.1)	3 (8.3)	
6-12 h	13 (18.1)	2 (5.6)	
>12 h	19 (26.4)	17 (47.2)	
Not applicable	27 (37.5)	14 (38.9)	

a – Chi-square test; b – Independent *t*-test; c – Fisher exact test;
BP – Blood pressure; ED – Emergency department; TBI – Traumatic brain injury;
SD – Standard deviation

score (M), we noted, in the ED HKL, the best M was six in six patients (5.5%), M of five in 40 patients (36.4%), M of four in 17 patients (15.5%), M of three in 13 patients (5.5%), M of two in six patients (5.5%), and finally the M of one in 28 patients (25.5%). The pupillary response was 5%), and dilated bilaterally (7.3%). Mannitol was given for 46 (42%) of these patients.

In the laboratory investigations, we noted evidence of Diabetes insipidus (DI) preoperatively in three patients (3%), post operatively in 27 patients (25%), both pre- and postoperatively evidence of DI in four patients (4%),. Coagulation profile for its derangement was noted categorically in as evidence of preoperative derangement in three patients (3%), postoperative derangement in 46 patients (42%), both pre- and postoperative derangement in 10 patients (9%). Dissemination intravascular coagulation in 16 patients (15%), no derangement in 30 patients (27%) and not done in four patients (4%) and missing in one patient (1%). In the blood gases analysis, we noted evidence of acidosis in 11 patients (10%) preoperatively, in 27 patients (25%) postoperatively and in both preoperative and postoperative acidosis, there were nine patients (8%). As for hypercapnia, there were 18 patients (16%) with pre operative hypercapnia, 40 patients (36%) with postoperative hypercapnia and four patients (4%) with both pre and postoperative hypercapnia. The other 48 patients (44%) had no evidence of hypercapnia during the study period. Hypoxia was seen in three patients (3%) preoperatively, in 12 patients (11%) post operatively, in one (1%) patient both in the pre and postoperative period. The other 94 patients (86%) had no evidence of hypoxia in the study period.

The radiological evidence of a subdural hemorrhage contusional hemorrhage, and both types were noted along with the evidence of subarachnoid hemorrhage, intraventricular hemorhage, edema and midline shifts. The Marshall Classification was then put into tabulation after which, these info was picked up. Contusional hemorrhage was seen in 81 patients (74%) with it being in the right hemisphere for 30 patients (27%), left hemisphere in 31 patients (28%), and in 20 patients (18%) seen in both areas. Its location was also identified and further classified in the areas of frontal, parietal, temporal, and occipital or in the combination of these areas for the univariate analysis. Both these types were clots (Subdural hematoma (SDH) and contusion) were commonly seen together in 54 (49%) of these patients and noted to be in the right hemisphere for 23 patients (21%), left hemisphere for 21 patients (19%), and in both areas in six patients (6%). Edema was noted in most of our cases, where by 108 (98%) were noted to have this feature. There was also brainstem compression see in 99 patients (90%). Other findings noted, was subarachnoid hemorrhage in 77 (70%) patients and intraventricular hemorrhage in six patients (6%). Midline shift was then tabulated and seen in 32 patients (29%). Marshall scoring was then used and four patients (4%) were seen with a Marshall score of 2, 27 patients (25%) with a Marshall score of 3, and 79 (72%) patients with a Marshall score of 4.

The decision for DC as an immediate way of reducing raised intracranial pressure was seen in 92 patients (84%). In the timing of surgery, 16 patients (14.5%) were done in less than 6 hours, 15 patients (13.6%) in the timing of 6-12 hours and in 38 patients (34.5%) done in more than 12 hours. The other 41 (37.3%) patients could not be countrified or were planned for ICP catheter insertion. Seventeen patients (15.5%) had ICP catheter placement prior to needing a DC.

In intensive care unit (ICU), the few parameters were noted namely, the overall stability, blood pressure measurement, cerebral perfusion pressures (CPP), pulse rates, oxygen saturation and the ICP measurement immediate post operation, within 24 hours and within 48 hours. The overall stability was seen in 73 patients (67%). Breaking down the parameters the blood pressures were noted stable in 62 patients (56%) only. The pulse rates were noted stable in larger amount, which was seen in 87 patients (79%). The Oxygen saturation was noted stable in these 102 (92.7%) ventilated patients. In the measurement of the CPP, only 70 patients (64%) noted to have it maintained.

In the measurement of ICP, we noted that in the immediate postoperative period, it was high in 30 patients (27%), within normal range in 60 patients (55%) and not inserted in 20 patients (18%). ICP was measured within 24 hours and noted to be in the high range in in 27 patients (25%), within normal limits in 58 patients (53%) and either not inserted or removed in 25 patients (23%).

These patients had been cerebral protected for less than 24 hours in 24 patients (22%), within 24-48 hours in 47 patients (43%) and more than 48 hours in 39 patients (36%).

Postoperatively, the pupils were categorized in the same manner as pre operatively. There were 63 patients (57%) with equal and reactive pupils, 26% for 28 patients with unequal pupils, and 16.5% for 18 patients in one patient (1%) the eyes were too swollen to note this finding.

After the computed tomography (CT) scan was done and sedation weaned off, the motor score of each patient was noted, 22 patients (20%) had a motor score of 1, 16 patients (15%) had a motor score of 2, four patients (4%) had a motor score of 3, 16 patients (15%) had a motor score of 4, 29 patients (26%) had a motor score of 5, and 23 patients (21%) had a motor score of 6.

These patients were cerebral protected for less than 24 hours in 24 patients (21.8%), cerebral protected within the 24-48 hour range in 47 patients (42.7%), and cerebral protected for more than 48 hours in 39 patients (35.5%).

The repeated scan showed a corrected midline shift in 87 patients (79%). The length of ICU stay was calculated. Median stay was 6.50, its mean was 6.2 with SD of 3.485.

In our analysis, the immediate outcome was noted as 74 alive patients (67.3%), and 36 patients had passed away within the immediate post operative period (32.7%) [Figure 2]. Post operatively we noted in the Glasgow outcome score (GOS) that only 7% had good recovery prior to discharge, 21% at 3 months, and 28% at 6 months. In the moderate disability group, GOS noted to be 21% upon discharge, 22% at 3 months, and 16% at 6 months. The GOS in the severe disability group was 32% at discharge, 10% at 3 months, and 7% at 6 months. The GOS in the persistent vegetative group was 7% at discharge, 4% at 3 months, and 2% at 6 months. Death was 34% at 3 months and 35% in 6 months.

At follow up after discharged from the intensive units, these patients were followed to see if any complications had risen, and 50 patients (45.5%) were not recorded to have any. The rest had a varied array of complications that included cardiac in origin for three patients (2.7%), renal in origin in one patient (0.9%), ventilator associated pneumonia (VAP) in 22 patients (20.0%), seizures in two patients (1.8%), post traumatic hydrocephalus in seven patients (6.4%), wound infection in three patients (2.7%), ventilator associated pneumonia with a cardiac issue in two patients (1.8%), major post traumatic infarct seen in seven patients (6.4%), ventilator associated pneumonia with a wound infection in two patients (1.8%), renal impairment with sepsis in four patients (3.6%), cardiac issue with hydrocephalus in one patient (0.9%), VAP with post traumatic hydrocephalus in one patient (0.9%), VAP with major post traumatic infarct in one patient (0.9%).

In the univariate analysis of prognostic factors the associations between categorical variables with outcome were tested using Chi-Square or Fisher's exact test wherever appropriate. The differences between numerical data were tested with independent samples *t*-test. *P* value of less than 0.05 was taken as significant at 95% Confidence Interval (CI).

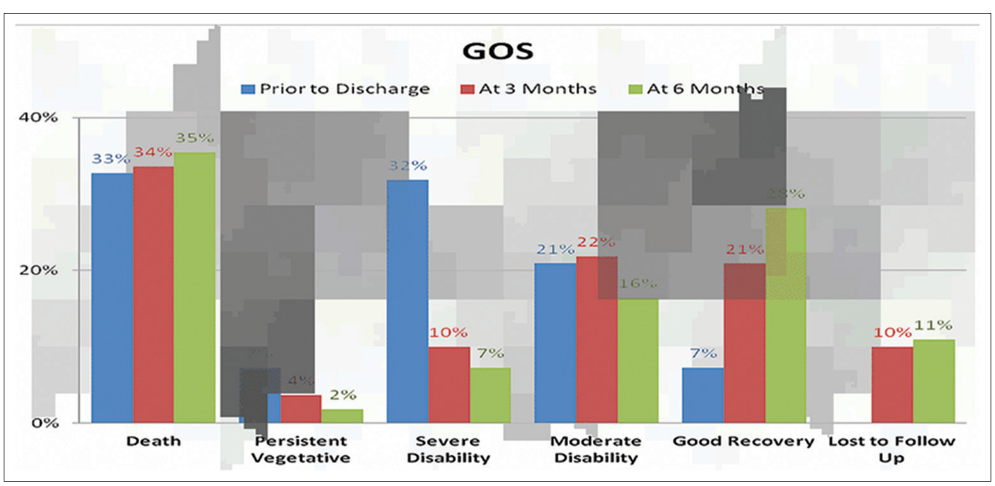

Figure 2: Immediate outcome assessment

Table 2: Laboratorical data analysis for prognosticating factors of severe TBI treated in Kuala Lumpur Hospital during this study period

	Alive *n* (%)/ mean (SD)	Dead *n* (%)/ mean (SD)	*P* value
Laboratory			
Evidence of DI			<0.001[c]
Evidence of DI preop	2 (2.7)	1 (2.8)	
Evidence of DI postop	9 (12.2)	18 (50.0)	
Evidence of DI pre op and post op	1 (1.4)	3 (8.3)	
No evidence of DI	62 (83.8)	14 (38.9)	
Coagulation			<0.001[c]
Pre op derangement	3 (4.1)	0 (0)	
Post op derangement	31 (41.9)	15 (42.9)	
Both pre+post op derangement	2 (2.7)	8 (22.9)	
DIVC	8 (10.8)	8 (22.9)	
Not done	2 (2.7)	2 (5.7)	
No derangement	28 (37.8)	2 (5.7)	
Acidosis			0.003[c]
Pre op acidosis	6 (8.1)	5 (13.9)	
Post op acidosis	13 (17.6)	14 (38.9)	
Both pre op and post op acidosis	4 (5.4)	5 (13.9)	
No Acidosis	51 (68.9)	12 (33.3)	
Hypoxia			0.03[c]
Pre op hypoxia	2 (2.7)	1 (2.8)	
Post op hypoxia	3 (4.1)	9 (25.0)	
Both pre op and post op hypoxia	1 (1.4)	0 (0)	
No evidence of prolonged hypoxia	68 (91.9)	26 (72.2)	

a – Chi-square test, b – Independent *t*-test, c – Fisher exact test, DI – Diabetes insipidus, DIVC – Disseminated Intravascular Coagulopathy

The analysis demonstrated that the following factors were significantly associated with outcome [Tables 1-7]. In the demographic category [Table 1], we noted a significant *P* value in the referral area, the motor score on arrival, the state of pupil on arrival, the blood pressure stability on arrival and the timing of surgery. In the laboratory category [Table 2], we noted the evidence of clinical Diabetes insipidus (DI), coagulopathy, evidence of acidosis, and hypoxia to have significance in its outcome. We also tried to note if there was a correlation of difference in preoperative and postoperative values (day 3) in haemoglobin, white cell counts, platelet counts, coagulation profiles as well as the glucose levels to prognosticate its outcome. In the category of radiological data [Table 3], the *P* value was noted significant in the areas of SDH presence of in location, presence of contusion in location, the site of presence of both subdural and contusions, presence of edema and the midline shifts noted. In the ICU care data [Table 4], significance of *P* value was noted in the overall stability in the parameters of blood pressure, cerebral perfusion pressure, pulse rates and saturation. Also noted were significant values in ICP in the immediate post operative period, within 24 hours post operation and finally 24 to 48 hours, postoperatively. The immediate outcome analysis revealed its significance in the pupils and motor score [Table 5].

Table 3: Radiological data analysis for prognosticating factors of severe TBI treated in Kuala Lumpur Hospital during this study period

	Alive *n* (%)/ mean (SD)	Dead *n* (%)/ mean (SD)	*P* value
Radiological investigation			
Presence of SDH			
In location			<0.01[c]
F	1 (1.8)	0 (0)	
P	1 (1.8)	0 (0)	
O	0 (0)	1 (3.2)	
F and T	1 (1.8)	4 (12.9)	
F and P	2 (3.6)	1 (3.2)	
T and P	4 (7.3)	0 (0)	
P and O	2 (3.6)	3 (9.7)	
FTPO	16 (29.1)	18 (58.1)	
F, T and P	28 (50.9)	4 (12.9)	
Presence of contusion			
In location			0.045[c]
F	18 (31.6)	4 (16.7)	
T	5 (8.8)	3 (12.5)	
P	4 (7.0)	1 (4.2)	
F and T	8 (14.0)	2 (8.3)	
F and P	6 (10.5)	2 (8.3)	
T and P	5 (8.8)	1 (4.2)	
P and O	1 (1.8)	4 (16.7)	
FTPO	0 (0)	3 (12.5)	
F, T and P	8 (14.0)	2 (8.3)	
T, P and O	1 (1.8)	1 (4.2)	
Right P, O and Left F, P	1 (1.8)	0 (0)	
Right F, T and Left F, T, P	0 (0)	1 (4.2)	
Both (SDH and contusion)			
Its site			0.031[c]
Right	17 (51.5)	6 (35.3)	
Left	15 (45.5)	6 (35.3)	
Both	1 (3.0)	5 (29.4)	
Edema			0.041[a]
Yes	74 (100)	34 (94.4)	
No	0 (0)	2 (5.6)	
Midline Shift (post operative CT scan)			<0.001[c]
Corrected	68 (91.9)	19 (52.8)	
Still present	8 (8.1)	13 (36.1)	
Not done	0 (0)	4 (11.1)	

a – Chi-square test; b – Independent *t*-test; c – Fisher exact test; SD – Standard deviation; TBI – Traumatic brain injury; CT – Computed tomography; FTPO – Frontal temporal parietal occipital; SDH – Subdural hematoma , F – Frontal, T – Temporal, P – Parietal, O – Occipital

The prognostic value of outcome was tested using multiple Logistic regression models with forward LR (likelihood ratio) method [Table 8]. The $P < 0.05$ was interpreted as significant at 95% Confidence Interval (CI). The significant prognostic factors were Hypoxia in the postoperative period ($P = 0.152$), the unmaintained CPP ($P = 0.007$) and the unstable Blood Pressure (BP) ($P < 0.001$). The odds of having poor outcome were 10.2 times higher in those who post operative hypoxia

Table 4: ICU care data analysis for prognosticating factors of severe TBI treated in Kuala Lumpur Hospital during this study period

	Alive *n* (%)/ mean (SD)	Dead *n* (%)/ mean (SD)	*P* value
ICU care			
Overall stability (vital signs)			<0.001[c]
Specific parameters			
BP			<0.001[c]
CPP			<0.001[c]
Pulse			<0.001[c]
Saturation			<0.001[c]
ICP			
immediate			0.002[a]
high	13 (17.6)	17 (47.2)	
within range	48 (4.9)	12 (33.3)	
not inserted	13 (17.6)	7 (19.4)	
within24 h			<0.001[a]
high	11 (14.9)	16 (44.4)	
within range	47 (63.5)	11 (30.6)	
not inserted	16 (21.6)	9 (25.0)	
24-48 h			<0.001[a]
high	3 (4.1)	11 (30.6)	
within range	29 (39.2)	5 (13.9)	
not inserted	42 (56.8)	20 (55.6)	

a – Chi-square test; b – Independent *t*-test; c – Fisher exact test; IP – Intracranial pressure; ICU – Intensive care unit; BP – Blood pressure; SD – Standard deviation

Table 5: Outcome analysis for prognosticating factors of severe TBI treated in Kuala Lumpur Hospital during this study period

	Alive *n* (%)/ mean (SD)	Dead *n* (%)/ mean (SD)	*P* value
Immediate outcome			
Pupil size			<0.001c
Equal	53 (71.6)	10 (27.8)	
Unequal	17 (23.0)	11 (30.6)	
Dilated bilaterally	3 (4.1)	15 (41.7)	
Swollen	1 (1.4)	0 (.0)	
Motor score			<0.001a
1	1 (1.4)	21 (58.3)	
2	9 (12.2)	7 (19.4)	
3	4 (5.4)	0 (.0)	
4	12 (16.2)	2 (5.6)	
5	27 (36.5)	2 (5.6)	
6	21 (28.4)	2 (5.6)	

a – Chi-square test; b: Independent *t*-test; c – Fisher exact test; SD – Standard deviation; TBI – Traumatic brain injury

following TBI (odds ratio [OR]: 10.184; 95% confidence interval [CI]: 0.424, 244.495). The odds of having poor outcome, if the CPP was not maintained is 13.8 times (OR: 13.754; CI: 2.050, 92.301). The blood pressure (BP) was the biggest predictor of poor outcome where by unstable BP predicted 32 times higher (OD: 31.600; CI: 4.530, 220.440).

Table 6: Difference between preoperation and post operation for the laboratorial data

Variable	Alive mean (SD)	Dead mean (SD)	*t* statistics	*P* value
Hemoglobin difference	−4.18 (2.34)	−3.54 (3.62)	−0.888 (40)	0.380
WCC difference	−3.31 (5.56)	−4.59 (7.25)	0.912 (89)	0.364
Platelet difference*	−68.00 (99.0)	−98.00 (93.75)	−1.127 (97)	0.260[a]
INR difference	0.18 (0.29)	0.38 (0.50)	−1.901 (34)	0.066
PT difference	1.48 (2.78)	3.12 (4.47)	−1.765 (35)	0.086
APTT difference	1.56 (2.17)	3.16 (5.21)	0.009 (108)	0.993
DXT difference	8.43 (2.95)	9.99 (2.96)	−1.065 (14)	0.305

Median (IQR); WCC – White cell count; INR – International Normalized Ratio; APTT – Activated partial thrombiplastin time; DXT – Dextrostix count; a – Wilcoxon signed rank test; PT – Prothrombin time; SD – Standard deviation

Table 7: *P* values for timing (Continuous variable)

Variable	Alive mean (SD)	Dead mean (SD)	*t* statistics	*P* value
Time duration				
Accident to emergency (ED)	586.59 (476.26)	564.27 (324.35)	0.200 (69)	0.842
Referral to emergency (ED)	150.00 (107)	204.50 (127)	−1.173a	0.241a
Accident to operation (OP)*	760.00 (505)	876 (697)	−1.154a	0.249a

ED – Emergency department; SD – Standard deviation

Table 8: Factors associated with disposition status of patients using multiple logistic regressions among severe traumatic brain

Variable	B	Adjusted OR (95% CI)	*P* value
Hypoxia			
Pre-op	−21.919	0.000 (0.000, -)	>0.995
Post-op	2.321	10.184 (0.424, 244.495)	0.152
No	1.0	-	-
CPP			
Maintained	1.0	-	-
Not maintained	2.621	13.754 (2.050, 92.301)	0.007
BP			
Stable	1.0	-	-
Not stable	3.453	31.600 (4.530,220.440)	<0.001

Constant – −4.243; B – Beta coefficient; OR – Odds ratio; CI – Confidence interval; BP – Blood deviation

Forward LR stepwise multiple logistic regression models applied.

Final model was tested with Hosmer-Lameshow Goodness-of-fit test ($P = 0.843$)

Discussion

This study attempted to prognosticate the factors affecting outcome of DC in severe traumatic head injury. In a growing population, the census also show increase in the number of motor vehicle accidents and TBI is the leading cause of death and disability worldwide (Ma Junpeng Jan 2011, MRC CRASH Trial Collaborators 2007; Geofrey S.F. Ling 2008; Kah Keow Lee

2008; Perel P 2010; T M McMillan 2011; Wipassakornwarawut S November 2011; Hoang HT Aug 2008)).[8,10,13,15,16,17,19,20]

In this study, road traffic accident (RTA) involving motorbike was the most common mechanism of injury seen in the most productive age group of 12-30 followed by falls and assaults. There were 6,872 deaths out of 28,269 injuries in a 2010 data on accidental brain injuries (Abdullah June 2011).[11] Since the official age to obtain a licence is 17 in this country, yet we see many of these patients riding in the rural areas ending up with a TBI due to no helmet wearing and in the urban areas due to 'rempit'. The term refers to the motorcyclist using stunts associated with speed to show off their talent. This in a problem faced by policy makers also as they have no way to control these youngsters. In 2010, the Royal Malaysian Police registry along with Malaysian Institute of Road Safety Research (MIROS) presented in their meeting on status on road safety under the Ministry of Transport Malaysia, noting that the highest vehicle registry in this country was the motorcycle being 9,441,907 vehicles (Royal Malaysian Police 2010).[18] This was worrying in concordance with the rate of RTA highest involving motorbikes. Neighbouring country Vietnam shared the same point of view as the rates of non-helmet motorbikes were hazardous and high in costing to their families with significant impact on health related quality of life (Hoang Aug 2008).[10]

This study did not find any significance in gender in predicting outcome as did some studies. However, in our sample-size, was not significantly strong of the female gender as only 15 females noted in our study as compared to the 95 males. This was probably due the fact that females are generally slower on the road and more careful or these patients had the adversity of not making it into the nearest hospital for further modality or even that the severity-matched injury did not represent as compared to the male population. Recent advances in trauma neurosurgery indicate progesterone as a potential neuro-protective drug in TBI. However, current clinical evidences are still insufficient as it only involved small random control trials (RCTs). Progesterone has been shown to reduce the consequences of injury by decreasing brain oedema, enhancing antioxidant mechanisms and also reducing excitotoxicity in animal models research (Ma Junpeng Jan 2011).[14]

Hospital Kuala Lumpur is the tertiary referral centre for Klang-valley from five different states, which comprised of Selangor, Negeri Sembilan, Malacca, Pahang, and Kuala Lumpur city. Importantly to note that the percentage of referrals were predominantly from other hospitals which was 75%, whereby, most referrals came from Hospital Seremban, which was more than the hospitals own emergency departments' referral. Considering this, perhaps there should be a recommendation towards policy makers to open up more neurosurgical centres in the near future to adapt to the growing numbers of the country's population. In a paper published by our very own neurosurgeon, Professor J. M. Abdullah in 2011 in his editorial note, stressed the importance of the number of dedicated intensive care beds in Malaysia needs to increase to meet the demands of the number of RTA patients with TBI (Abdullah June 2011).[11]

The level of ICU care in Malaysia has improved over the years. We now have state of art equipment for the management of traumatic brain injury. However, this modality is not available in all major hospitals with neurosurgical consult team including ours. As it may decrease mortality and be cost effective as well in the long run, this would be a good in the prospective of our healthcare system to consider. In our setting, the struggle faced in the general wards comprise of, having to share oxymeters for ventilated patients, inability to do invasive monitoring, a high nurse-patients ratio and inability to provide treatments based on ICP and CPP protocol. To emphasize this further, the turnover is deemed very high, and frequently, these patients would be ventilated in the ward basis on a portable ventilator. This study did not note the difference in outcome between the patients warded in the neuro ICU versus in the common ward. Hence, this could be suggested for further studies to enhance the management system in this setting.

In the pre-hospital care, the motor score was a good predictor in our study ($P = 0.04$). A study in Taiwan also noted the same findings as ours (Hsein-Wei Ting 2010).[11] Patients with a motor score of 1 undergoing DC came out with 18.8% with the alive outcome and 38.9% as poorer outcome (dead) in this study. The motor score is easier tabulated in a tertiary centre, whereby, the patients are already ventilated for airways protection as a mean of primary step management in severe traumatic head injury, and most of the time, even sedated prior to sending from the referring hospitals. The state pupils also was a good predictor of outcome ($P = 0.001$). This was in concordance with other studies (MRC CRASH Trial Collaborators 2007).[16] However, the issue arising in the matters where both pupils are fixed whether the decision to go in was appropriate or not as seven out of the eight patients with bilaterally fixed pupils had passed away as an immediate outcome. DC was probably done on them as they were in the younger age group and or these findings were recent and occurring abruptly as they were transported from peripheral hospitals to ED HKL.

Blood pressure stability or the presence of hypotension at preclinical level measured at the ED HKL was also a significant prognostic factor in our univariate analysis. This was in concordance with the fact that most hospitals were more than 10 km radius and stability being an issue in transportation further enhances the fact of the need for development of other tertiary centres. Transfer time to definitive care remained lengthy in context to developing country. Surgery within four hours has been noted to reduce mortality by 60% among patients with trauma SDH (Ginelle Thibault-Halman May 2011).[21] It's known that direct transport to a tertiary care centre after head injury has been related to reduced mortality and morbidity (Dubose 2008).[2] This is a good prospective for developing Malaysia to emulate and to go a step further in the measurement of times taken for a severe TBI patient to reach the tertiary neuro-centre, hence forth a good research idea, especially, for policy makers in this country as in the long run as it may save on costing.

This study noted that patient with severe TBI developed Diabetes insipidus (DI) within 3 days post trauma have mortality rate of 61.1%. Most of the patients were noted to have DI postoperatively, there were only 11.1% of these patients that were noted to have it preoperatively. This brings to wonder if there were more unnoticed cases or under diagnosed. Evidence of DI is a well-known prognosticator in severe TBI, hence the laboratory findings needed to be much efficient in allowing these laboratory studies to be readily available. The other fact is the recognition of it by clinician makes it a more treatable cause.

The importance of coagulopathy in TBI is well recognized as a prognostic factor in both the pediatric and adult age group. In view of high incidence of coagulopathy seen in severe TBI laboratory screening of coagulopathy was considered cost effective and done as a standard routine procedure. In our centre, the base line coagulation tests were done with TBI were PT ratio, INR and a PTT ratio with platelet count. Studies have suggested to that D-dimer, Fibrinogen degradation product (FDP) and fibrinogen to be included as initial screening test (Bayir A. 2006; Engstrom 2006).[1,3] In this study, the derangement of coagulation was noted to be associated with poor outcome in the univariate analysis but not in the logistic model. It is known that the brain tissues release the highest level of thromboplastin level as compared to any other tissues in the body. Being a tertiary level centre with the highest patient turnover, consideration should be made in conjoint with other setting such as the universities that predominate in Klang Valley, as grants doing research in this area are easily obtainable as comparatively to the government hospitals to use multimodality treatment for such patients.[12]

Radiology statistically important findings were the location of both the subdural ($P < 0.01$) and contusional clots ($P = 0.045$) and the site whether it being in the right, left or both hemisphere to be significant ($P = 0.031$). Other findings were the evidence of edema ($P = 0041$). However, these findings also did not fit into the logistic regression model. Contrary to the more popular evidence of subarachnoid bleed and the Marshall classification prognosticating outcome in severe TBI (Wardlaw 2002),[28] this study did not show any statistical importance.

In ICU setting, it cannot be more emphasized that the importance of ICU care in TBI patients is pertinent towards its outcome. The significant prognostic factors that fit into this study's multivariabte model were Hypoxia in the post operative period ($P = 0.152$), the unmaintained CPP ($P = 0.007$) and the unstable Blood Pressure (BP) ($P < 0.001$). The odds of having poor outcome was 10.2 times higher in those who post operative hypoxia following TBI (odds ratio [OR]: 10.184; 95% confidence interval [CI]: 0.424, 244.495). The odds of having poor outcome if the CPP was not maintained is 13.8 time (OR: 13.754; CI: 2.050, 92.301). The BP was the biggest predictor of poor outcome where by hypotension predicted 32 times higher.(OD: 31.600; CI: 4.530, 220.440). Ideally all these measurements should be carried out in an ICU setting which was not in our case in a fraction of these patients

In our outcome, the mortality post severe traumatic brain injury was also noted as seen in 35% of the study group. In measuring the Glasgow Outcome Scores at 6 months, we noted that the patients who had good recovery were only 28% of these patients. There were 2% of patients with persistent vegetative state and 23% (both moderate and severe) disabilities. This was an indirect effect towards the country's economy as they become dependent on the Welfare Department in each hospital. It is also a burden to families that come in with many difficulties of varied effects towards the change of lifestyle they have had to adapt.

Several limitations of our analysis should be acknowledged. First, this prospective cohort studies although a primer is the first one done in this tertiary setting, longer duration to capture a bigger sample size would provide a better picture. In order to create a similar logistic model as developed countries, perhaps a 5-year study would have created a better logistic model in comparison with large trials.

The incomplete data, especially seen in the laboratory section was significant. If these missing data was available perhaps, the more popular risk factors such as coagulation profile and the other biochemical markers like serum calcium level, which are undergoing research by various other institutions, could be included. This would be invaluable data as well creating more precise guidelines when managing the traumatic brain patient. Here the cause of it was probably because HKL system is not computerized as compared to other newer hospitals such as Hospital Sungai Buloh.

Our neurosurgical department did not control the timings from accident to surgery. In fact, there was many times a second emergency operational theatre opened to compensate for the prolonged transport time. In our study is quite glaring that time from accident to referral then subsequently into our setting took a vicious longer period. More than often, the reasons given were the inadequacy of ambulances to transport these patients often taking double the stipulated time.

Our series represents one of the largest series of severe TBI in our region and comprising of mostly urban Malaysian population, this study concludes that the evidence of hypoxia, blood pressure instability, and inadequate cerebral perfusion pressures serves as a useful indicator in predicting outcome of patients with severe TBI. This in turn brings us back to the fact that ideally, standard ICU care is needed for the proper management of these patients. Henceforth, more ICU bed dedicated to the neurosciences proper would be ideal and should be a recommendation towards the policy makers of this country.

These results have the potential of affecting future patient management protocols in severe TBI and further designing neuro-protective trials. There are considerable trials that are worth using in this setting and the best approach would ideally be the multidisciplinary approach.

Experience plays a significant entity in outcome. Henceforth, the level of expertise the surgeon performing the operating should be taken into consideration for further hospital-level studies so that there is reduction of operator errors and further intensifying the teaching methods especially towards the younger upcoming generation. HKL is well-known for its training ground in neurosurgery. There are many tiers of surgeons standing from the consultant, specialist, registrars, master's student, and then the potential master's candidate.

In view of population increasing steadily over the last 10 years, it is apt to put forward the idea to the Ministry of Health a few ideas. Firstly, in view of 75% of these patients being referred from various other hospital, each state should ideally have a 'neuro' centre is the states' main hospital. This is to minimize the travel time severe TBI patients having to go through lengthy hours of wait prior to the surgery. This study noted only 14.5% had surgery done below 6 hours of accident to surgery. Majority had surgery done after 12 hours (34.5%). Getting each state its own neuro centre would indefinitely take time. Henceforth, we could suggest increasing the ICU bed setting in HKL and the number of ambulances in these peripheral hospitals as a start.

HKL hosts a two yearly Neurotrauma Symposium. This is one way to educate clinicians and other medical staffs involved in challenges of head injury. More talks by neurosurgeons as seen in our National Heart Centre should be emulated, as prevention is better than cure. Education begins at the grass roots especially in the rural or primary referral centre helped minimalize secondary brain injury.

The Royal Malaysian Police in their website have been commended to iron out the enforcement of safety belts, helmets, drunk driving, and child chair safety measures. Having said so, this is unfortunately seen only in the urban areas. There are still adolescents between the age of 12-17, whereby, it is still illegal to ride a motorbike, getting involved in accidents in the rural areas. Many of times, their parents attribute this to the fact that they were in the villages, hence, the roads were rather small and unassuming. The police should also patrol in these rural areas to enforce the law as a significant amount of patients did come from rural ares. Education here, especially by previous accident victims, would help increase the rate of responsibility so they may learn from others. Here is where both the police and media should have a hand in hand play to dissipate the information.

Acknowledgment

Ms. Mariana Mohamed Ali, Clinical Research Centre (CRC), Hospital Kuala Lumpur.

References

1. Bayir A, Kalkan E, Koçak S, Ak A, Cander B, Bodur S. Fibrinolytic markers and neurologic outcome in traumatic brain injury. Neurol India 2006;54:363-5.
2. DuBose JJ, Browder T, Inaba K, Teixeira PG, Chan LS, Demetriades D. Effect of trauma centre designation on outcome in patients with severe traumatic brain injury. Arch Surg 2008;143:1213-7.
3. Engström M. The coagulation system: A vulnerable system and potential therapeutic aimpoint in treatment of brain injury. Neurol India 2006;54:347.
4. Engström M, Romner B, Schalén W, Reinstrup P. Thrombocytopenia predicts progressive hemorrhage after head trauma. J Neurotrauma 2005;22:291-6.
5. Eastridge BJ, Salinas J, McManus JG, Blackburn L, Bugler EM, Cooke WH, *et al*. Hypotension begins at 110 mm Hg: Redifining hypotension with data. J Trauma 2007;63:291-7.
6. Steyerberg EW, Mushkudiani N, Perel P, Butcher I, Lu J, McHugh GS, *et al*. Predicting outcome after traumatic brain injury: Development and international validation of prognostic scores based on admission characteristics. PLoS Med 2008;5:e165.
7. Clausen F, Hillered L, Gustafsson J. Cerebral glucose metabolism after traumatic brain injury in rat studied by 13C-glucose and microdialysis. Acta Neurochir (Wien) 2011;153:653-8.
8. Ling GS, Marshall SA. Management of traumatic brain injuryin the intensive care unit. Neurol Clin 2008;26:409-26.
9. Thibault-Halman G, Tallon JM, Ackroyd-Stolarz S, Fenerty L, Karim SA, Sealy B, *et al*. Major traumatic brain injury: Time to tertiary care and the impact of a clinical guidelines. J Trauma 2011;70:1134-40.
10. Hoang HT, Pham TL, Vo TT, Nguyen PK, Doran CM, Hill PS. The costs of traumatic brain injury due to motorcycle accidents in Hanoi, Vietnam. Cost Eff Resour Alloc 2008;6:17.
11. Abdullah JM. Improving the management of brain injuries in Malaysian hospitals. Med J Malaysia 2011;66:83.
12. Wardlaw JM, Easton VJ, Statham P. Which CT features help predict outcome after head injury? J Neurol Neurosurg Psychiatry 2002;72:188-92.
13. Lee KK, Ng I, Ang BT. Outcome of severe head injured patients admitted to intensive care during weekdays shifts compared to night and weekdays. Ann Acad Med Singapore 2008;37:390-6.
14. Junpeng MA, Siqing Huang, Shu Qin. Progesterone for acute brain injury. Cochrane Database Syst Rev 2011;1:CD008409.

15. Mayo Clinic Staff (2010) Traumatic Brain Injury Diseases and conditions 4th ed. Available from: http://mayoclinic.com/Diseases and condition. Traumatic Brain Injury. [Last retrieved on 2012 May 27].
16. MRC CRASH Trial Collaborators. Predicting outcome after traumatic brain injury: Practical prognostic models based on large cohort of international patients. BMJ 2011:1-10.
17. Perel P, Roberts I, Shakur H, Thinkhamrop B, Phuenpathom N, Yutthakasemsunt S. Haemostatic drugs for traumatic brain injury. Cochrane Database Syst Rev 2010;1:CD007877.
18. Royal Malaysian Police, MIROS data on road accidents; 2010. "Unpublished data": Data on road accidents."
19. McMillan TM, Teasdale GM, Weir CJ, Stewart E. Death after head injury: The 13 year outcome of a case control study. J Neurol Neurosurg Psychiatry 2011;82:931-5.
20. Wipassakornwarawut S, Suwonmontri P, Thokaow S. Risk factors for mortality in head-injured patients with probability of survival greater than 0.5. J Med Assoc Thai 2011;11:1365-72.

Access this article online	
Quick Response Code:	Website: www.asianjns.org
	DOI: 10.4103/1793-5482.146605

How to cite this article: Sharda P, Haspani S, Idris Z. Factors prognosticating the outcome of decompressive craniectomy in severe traumatic brain injury: A Malaysian experience. Asian J Neurosurg 2014;9:203-12.

Source of Support: Nil, **Conflict of Interest:** None declared.