IeJSME 2021 15 (3): 27-36

Original Article

Association between pre-injury and injury-related factors and cognitive impairment of post-traumatic brain injury patients in a Hospital Universiti Sains Malaysia cohort

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Introduction: Traumatic brain injury (TBI) is one of the major global issues as it causes a serious health threatening condition for the injured persons, increased mortality rates, increased physical and cognitive impairment, as well as affecting the health care systems.

Method: The aim of this study was to predict the association between the pre-injury socio-demographic, injury-related factors and cognitive impairments in post-TBI patients. Self-administered questionnaires were used for descriptive correlational study. Three instruments used included (1) pre-injury socio-demographic characteristics (age, gender, race, religion, education level, occupation) (2) injury-related factor characteristics (location of brain injury and GCS) and (3) Montreal Cognitive Assessment (MoCA) questionnaire to estimate cognitive impairment.

Result: In this study, forty patients were recruited through purposive sampling from surgical based wards and 60.0% of TBI patients had cognitive impairments. This study found an association between injury factors (severity of TBI from GCS result) with cognitive impairment post-TBI among patients. However, there is no association between socio-demographic characteristics (age, gender, race, religion, education level, occupation) and cognitive impairment.

Conclusions: The study provided a better understanding on the association between pre-injury socio-demographic characteristics, injury related characteristics of the severity of TBI and cognitive impairments in post-TBI patients during hospitalisation. The results of this study can potentially be used as baseline information to improve the care and treatment needs of patients with cognitive impairment post-TBI during hospitalisation in relation to enhanced quality of life.

Keywords: *Traumatic brain injury, Pre-injury related factors, Injury related factors, Cognitive impairment post-TBI, Montreal Cognitive Assessment (MoCA).*

INTRODUCTION

Traumatic Brain Injury (TBI) is an acquired brain or head injury. It occurs when a sudden trauma damages the brain and disrupts normal brain function of the individual.[1] TBI is also known as an important medical, public health, and societal problem worldwide making it one of the leading causes of death and disability among children, adolescents, and adults.[2] TBI frequently occurs following motor vehicle-traffic crashes, impact or sport injuries, violence (gun and knife wounds) and falls, particularly in the elderly population. In addition, for those engaged in sports, mild TBI in the form of a concussion with or without loss of consciousness is a significant risk. While in military populations, blast-induced TBI has become the most common injury.[3]

Cognitive impairment following TBI is related to severity of TBI, location of brain injury, complications, concomitant injuries to other body regions, and chronicity of the injury.[4] Therefore, it is necessary to know how pre-injury (socio-demographic), injury related factors such as location of brain injury and severity of TBI could affect cognitive functions of TBI patients. Moreover, it is important to understand

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that cognitive impairment following TBI not only has profound effects on injured individuals but also their families, because long term disability makes the patients dependent on others.[5] Cognitive impairment caused by TBI also interferes with work, relationship, leisure, and activities of daily living, exacting a personal and economic cost that is difficult to quantify.[6] Therefore, understanding about the disease process following TBI will eventually help the injured individuals and families towards a positive recovery.

A previous study reported that males were at higher risk of TBI than females and the average age of TBI ranged from 27 to 58 years.[7] Therefore, studies on how socio-demographics (i.e. age, gender, races, religion, education and occupation) and injury related factors associated with cognitive impairment among TBI patients. This will help in a better understanding of post-TBI management, hence preventing this statistic from increasing by taking intensive prevention and precautionary steps.[4,6] Previous studies reported that there were relationships between demographic factors and cognitive impairment following TBI, for example the location of brain injury was found to be associated with effects on memory, attention, processing speed, and executive functioning of TBI patients and were mostly resolved within 3-6 months after injury.[4,6,7] A study also reported that severity of TBI associated with cognitive impairments, which found that moderate and severe TBI were associated with cognitive deficits, communication, visuospatial processing, intellectual ability, and awareness of deficit.[4] In addition, cognitive impairment following TBI was associated with location of brain lesion and severity of TBI. Therefore, this study aims to describe the association between demographic characteristics of injury related factors after TBI and risk of cognitive impairment by enhanced awareness among TBI patients and how their families sought early treatment and better care following TBI.

In addition, it is important to conduct this research because the nation needs to recognise that these injuries are preventable and are not the result of random events.[8] Besides that, there is a need to clarify groups at risk and risk factors to prevent TBI.[9] Since TBI patients require ongoing medical care, therefore good care management is required to ensure a better quality of life among post-TBI patients.[10] In summary, this study seeks to ensure that TBI patients can have good treatment and care in relation to enhanced quality of life post-TBI.

METHODOLOGY

Study design

A cross-sectional descriptive-correlational design was used in this study to determine the association between pre-injury socio-demographics, injury related factors and cognitive impairments of post traumatic brain injury patients in a Hospital Universiti Sains Malaysia cohort.

Sample and setting

This study was conducted at the surgical ward, Hospital Universiti Sains Malaysia (Hospital USM). Hospital USM is a sub-urban tertiary referral center for neurological disorders in the east coast of Peninsular Malaysia.

Sample size estimation and patients' recruitment

The participants of this study were TBI patients who were admitted to Hospital USM during data collection from February-March 2018. The inclusion criteria were male and female TBI patients who were hospitalised at surgical wards in Hospital USM, > 18 years old and who were conscious with mild (Glasgow Coma Scale

{GCS}: 13 – 15) to moderate (GCS: 9 – 12) GCS scores, were selected between days 5 to 14 following TBI. Meanwhile, the exclusion criteria included patients with severe neurological condition (GCS score: < 9), severe with other medical or mental illnesses. The estimation of sample was done using Raosoft calculation of sample size software based on the total admission of stroke patients per-year (2017) at Hospital USM. With the confidence level was 95% and margin error set at $p < 0.05$, the sample size recommended was 94. However, only forty patients were included in this analysis due to time limitations.

Pre-injury data collection

Pre-injury data included patient's socio-demographic characteristics including age, gender, race, religion, occupation, and education.

Injury related characteristics data

In this study, injury related characteristics data (severity of TBI score and location of brain injury) were collected. GCS was assessed during admission to determine the severity of TBI by measuring the patient's best eye responses, motor responses, and verbal responses. The score was classified as mild (GCS: 13 – 15), moderate (GCS: 9 – 12), and severe (GCS: < 9).[11] The location of the brain lesion was obtained from initial computed tomography (CT) scan report aided by an experienced radiologist. A Malay version of the Montreal Cognitive Assessment (MoCA)[12] was used to assess the level of cognitive impairment post-TBI in between after the patient gained full level of consciousness (GCS - 15) during in-patient setting. The agreement between BM MoCA and English MoCA was strong (intra-class correlation coefficient = 0.81, 95% CI 0.68-0.90).[12] MoCA is generally valid to measure the different cognitive domains (i.e. attention and concentration, executive functions, memory, language, visuo-constructional skills, conceptual thinking, calculations, and orientation) among study patients. The total possible score of MoCA are 0 to 30 points and a score of 26 or above is considered normal.[13]

Statistical analysis

The data were analysed using Statistical Package for Social Science (SPSS) version 24.0 (IBM Corp., Armonk, New York, USA). Alpha (α) was set at < 0.05 and for all analyses, $p < 0.05$ was considered statistically significant with confidence interval (CI) of 95%. Descriptive statistical analysis such as mean and standard deviation applied to all data. Frequency and percentage were applied to determine the pre-injury related factors (socio-demographic) and injury factors related to clinical characteristics (GCS, location of brain injury) among study patients. Chi-square analysis was used to identify the association between pre-injury (socio-demographic and injury factors (GCS, location of brain injury) and cognitive impairments in post-TBI patients.

Ethical consideration

Ethics approval was obtained from the Human Research Ethics Committee - Universiti Sains Malaysia (JEPeM-USM).

RESULTS:

Pre-injury socio-demographic profiles

A total of 40 patients, aged between 18 to 80 years (mean age: 34.18 ± 15.39) with TBI were recruited. Whereby, 18 (45%) of them were within 18 – 25 years of age, followed by 12 (30%) patients from 25 – 36 years. The lowest number of patients (4) were in the age group

IeJSME 2021 15 (3): 27-36

36 – 45 years (10.0%). In this study, the total number of patients were mainly males (92.5%), Malay and Muslim (95%), employed (62.5%), and with higher education (92.5%). Table I summarises the frequency distribution of pre-injury socio-demographic profiles among the study patients.

Table I: Frequency, percentage and association between socio-demographics and post-injury cognitive impairments among TBI patients in Hospital USM

Socio-demographic	Frequency	Percentage %	Cognitive dysfunctions, n (%)		*p* value
			Normal	Dysfunctions	
Age					**.33**
18-25	18	45.0	8 (20.0)	10 (25.0)	
26-35	12	30.0	3 (7.5)	9 (22.5)	
36-45	4	10.0	1 (2.5)	3 (7.5)	
46-80	6	15.0	4 (10.0)	2 (5.0)	
Gender					**.26**
Male	37	92.5	16 (40.0)	21 (52.5)	
Female	3	7.5	0 (0.0)	3 (7.5)	
Race					**.51**
Malay	38	95.0	16 (40.0)	22 (55.0)	
Chinese	2	5.0	0 (0.0)	2 (5.0)	
Religion					**.51**
Islam	38	95.0	16 (40.0)	22 (55.0)	
Buddha	2	5.0	0 (0.0)	2 (5.0)	
Education Level					**1.00**
High Education	37	92.5	15 (37.5)	22 (55.0)	
Low Education	3	7.5	1 (2.5)	2 (5.0)	
Occupation					.74
Employed	25	62.5	11 (27.5)	14 (35.0)	
Unemployed	15	37.5	5 (12.5)	10 (25.0)	

* In all analyses, *p*-value of <.05 was considered as significant, all null hypothesis will be rejected.

IeJSME 2021 15 (3): 27-36

Injury factors characteristics

This study found that 24 (60%) patients (mean age: 28.96 ± 12.15) had brain lesions at more than one cerebral region. Whereas, nine (22.5%) patients (mean age: 34.11 ± 14.99) had a brain lesion in the frontal lobe of the brain and one (2.5%) had a lesion in the occipital lobe. In terms of severity of TBI, this study found that 23 (57.5%) of the patients (mean age: 31.78 ± 13.31) fell in the mild GCS category and 17 (42.5%) patients (mean age: 31.94 ± 14.733) were in the moderate GCS category (Table II).

Table II: Frequency and percentage of clinical characteristics of participants (n=40)

Characteristics	Frequency	Percentage (%)
Location of brain injury		
Frontal lobe	9	22.5
Parietal lobe	3	7.5
Occipital lobe	1	2.5
Temporal lobe	3	7.5
Combination	24	60.0
GCS		
Mild	23	57.5
Moderate	17	42.5

Cognitive impairments post-TBI score using the Montreal Cognitive Assessment (MoCA)

The cognitive impairment post-TBI score was determined using the Bahasa Malaysia Montreal Cognitive Assessment (MoCA). The Cronbach alpha value for MoCA questionnaire for this study was tested and the result was 0.74, indicating that this questionnaire was valid and reliable. The analysis of cognitive impairments post-TBI found that the mean and standard deviations of the executive category was 2.58 ±1.99, attention category was 5.23 ± 0.70, language was 2.90 ± 0.30, abstraction was 1.58 ± 0.55, recall memory was 4.00 ± 1.01 and lastly orientation was 6.00 ± 1.48. The cognitive impairments post-TBI variables of MOCA were then classified into Cognitive Impairment post-TBI and Normal Cognitive Function post-TBI. The results revealed that 24 (60.0%) participants (mean age: 32.08 ± 13.33) had Cognitive Impairment post-TBI whereas only 16 (40.0%) participants (mean age: 31.50 ± 14.79) were in the Normal Cognitive Function post-TBI category.

Association between pre-injury socio-demographic, injury related factors and cognitive impairments post-TBI in Hospital USM patients.

The results revealed that there was no significant association between pre-socio-demographic and cognitive impairment post-TBI (MoCA) (Table I). However, there is a significant association between severity of TBI (GCS) and cognitive impairments post-TBI (MoCA) ($p > 0.05$) (Table III). There was no association between location of brain injury and cognitive impairments post-TBI (MoCA) ($p > 0.05$).

IeJSME 2021 15 (3): 27-36

Table III: Association between clinical characteristics for GCS and post-injury cognitive impairments

Clinical Characteristics	Cognitive impairments n (%)		*p* value
	Normal	Impairment	
GCS			.01
Mild	13 (32.5)	10 (25.0)	
Moderate	3 (7.0)	14 (35.0)	

Impairment among TBI patients in Hospital USM

* In all analyses, p-value of <.05 was considered as significant, all null hypothesis will be rejected.

DISCUSSION

Association between socio-demographic characteristics, injury related factors and cognitive impairments Post-TBI in Hospital USM patients

This study successfully recruited 40 patients with TBI in the Neuro Unit at Hospital USM. Based on this study, the highest group of participants (45.0%) were in between the ages 18-25 years, followed by the groups aged between 26-35 years (30.0%), and between 46-80 years (15.0%); the lowest was 36-45 years (10.0%). A previous study reported that higher incident rates for TBI were among those age between 15-25 years old (31.7%), followed by those between 26-35 years (22.5%), and the lowest was amongst the ages 36-45 years (19.5%).[10] However, there was no significant association between age and post injury cognitive impairment. It means that age group is not associated with post injury cognitive impairment.

In terms of gender, the majority (92.5%) of the participants were male whilst 7.5% were female. Majority of the male TBI patients were diagnosed as due to motor vehicle accident, however some of them were due to falls or assaulted with sharp objects. Other study also showed that the majority of participants were males (97.5%)[14] and 55.0-66.0% of male participants were diagnosed with TBI due to motor vehicle accident.[15-16] However, there was no significant association between gender and post injury cognitive impairment. It means that gender is not associated with post injury cognitive impairment, as majority of previous studies had mixed results on the gender association with post injury cognitive impairment[17] and it is not gender specific.[18]

Furthermore, participants in this study showed that majority (92.5%) had adequate education. Other studies also reported that TBI patients (62.0%) had adequate education.[15] Besides that, through this study it could be explained that the majority of TBI patients were employed (62.5%) compared to unemployed (37.5%). A previous study identified that 81.0% of TBI patients were employed.[19] It was important to know about education level and occupation among TBI patients because either being employed or unemployed and having adequate education level at the time of injury is not related to post injury cognitive impairment post-TBI.[20]

IeJSME 2021 15 (3): 27-36

In addition, this study found no significant association between socio- demographics and post injury cognitive impairments. Previous study also reported that there is no significant association in occupation[21], level of education[22], gender and age.[9]

Therefore, the findings of this study and previous study results could explain that socio-demographics would not affect participants with post-TBI cognitive impairments. Although one longitudinal study (10-years follow-up)[15] had argued that participants with less education had performed poorly in post-TBI cognitive assessment. Therefore, a follow-up study needs to be done to further elucidate the outcome from our study.

Association between injury factors related to clinical characteristics and cognitive impairments post-TBI in Hospital USM patients

This study explained that the clinical characteristics involved were severity of TBI using GCS and location of brain injury. In this study, mild GCS had the highest frequency with 23 (57.5%) while moderate GCS had 17 (42.5%). Besides that, severe GCS was excluded as stated in exclusion criteria. In addition, it was important to describe that mild severity of TBI was significantly associated with negative effect or disruption on physical, emotion and cognition.[10] Furthermore, other studies also found that mild GCS (n=31), moderate GCS (n=12) and severe GCS (n=8) may contribute to post cognitive impairment.[11]

Next, this study found an association between clinical characteristics of GCS and cognitive impairments among traumatic brain injury patients at Hospital USM. Up to 35.0% of moderate (GCS = 14) and mild (GCS = 10) had cognitive impairments. Previous study also explained the significant association of severity of TBI with cognitive impairments.[24] Besides that, it was also stated that persistent symptoms even from mild GCS could be associated with long-term impairment in areas such as cognitive functions.[14] Therefore, GCS is an important clinical characteristic because it was stated about TBI severity leads towards cognitive impairments as shown in this study.

In comparison, moderate-to-severe TBI is associated with significant impairments in sensorimotor, cognitive, and psychosocial functioning. Cognitive impairments include problems with executive functioning, memory, and attention, which is reduced capacity for new learning and decreased speed of information processing.[6] While deficits typically improve spontaneously in the early months after injury, most patients with moderate-to-severe injury have lifelong challenges that have a tremendous influence on everyday independence, work, and social life.[25] Moreover, cognitive impairments due to moderate and severe TBI effects are particularly prominent in terms of information processing, speed and attention, memory and executive functioning.[6]

The results revealed that 60.0% of TBI patients experienced more than one location of brain injury. While injury in the frontal lobe of brain (22.5%) and parietal lobe and temporal lobe (7.5%) of brain should be given high consideration because injury in these locations contribute to post injury cognitive impairment. However, no significant association between clinical characteristics for location of brain injury and cognitive impairments were found among traumatic brain injury patients at Hospital USM may be due to small sample size.

This suggestion is supported by findings of another study whereby majority of TBI cases had brain injury at the frontal lobe (33.4%) and had cognitive impairment.[23] This study also showed that participants had more cognitive impairment due to combination brain injury (40.0%) compared to only frontal lobe (10.0%) and temporal lobe (7.5%). In contrast, there was a study finding that reported significant associations between cognitive impairments and frontal lobe brain injury which resulted in impairments of verbal episodic memory (delayed recall and recognition) but presented normal performance on visuospatial episodic memory (recognition), short- term memory and non-verbal skills.[23]

Given the high prevalence of executive deficits in TBI patients, it is not surprising that the frontal lobes and their related circuitry (subcortical white matter, basal ganglia, and thalamus) are particularly vulnerable to TBI. Working memory and planning deficits may be associated with the focal injury to the dorsolateral prefrontal cortex affecting the projections between the lateral frontal and posterior regions. Apathy has been associated with subcortical lesions and right hemisphere dysfunction. Impaired awareness is characteristic of patients with focal frontal injury, and the post-injury level of self-referential insight has been associated with the integrity of right dorsal prefrontal cortex. Decision-making is a complex cognitive function and correlates to its component skills in patients with moderate to severe TBI. Deficits in risk adjustment were associated with abnormalities in subcortical structures such as the thalamus, the dorsal striatum and the caudate. Impulsivity was associated with abnormal diffusion tensor imaging findings in the bilateral orbital frontal gyri, insula, and caudate whereas impaired rational choice related to changes in the bilateral dorsolateral prefrontal cortex, the superior frontal gyri, and the right and ventromedial prefrontal cortex, ventral striatum, and hippocampus. This pattern of results suggests that the emotional components of decision-making will risk adjustment and impulse control; predominantly involve subcortical structures and the interplay between frontal and subcortical systems. Then, cognitive components of decision -making, such as rational choice, rely heavily on the prefrontal cortex.[4]

Strength and limitations

The main strength of this study is of the related factors such as socio-demographic and clinical characteristics that contribute to cognitive impairments due to TBI. In addition, Cronbach alpha for MoCA questionnaire at 0.74 indicated that this questionnaire was valid and reliable. Thus, it provided a good and reliable measuring tool for assessing cognitive impairments. Although this research was carefully prepared, the researchers were still aware of its limitations and shortcomings. The limitations of this study were mainly due to small sample size and follow-up sessions needed.

Implications and recommendations

This finding has essential implication to health care providers of TBI patients. The healthcare providers especially medical doctors and nurses have an important role in ensuring TBI patients' access to quality care and treatment management to ensure a better quality of life post-TBI. Besides that, the information from this study will help nurses and other healthcare providers become more prepared to care for TBI patients and participate more to ensure that the patients could recover and return to their daily life. Care of TBI patients with cognitive impairment post-TBI requires long term rehabilitation to achieve better cognitive and physical functioning in relation to gaining high quality of life post-TBI.

The study presents better understanding on the association between pre injury socio-demographics, injury related characteristics and cognitive impairments among post-TBI patients at Hospital USM. However, further studies are strongly recommended. Hence, further research should include a larger number of participants and assessment on the severe level of GCS. The design of this study can be used in further advanced research to achieve a high significant result and hencean increased number of samples is recommended.

CONCLUSION

This study was aimed to analyse, identify the pre-injury, injury related to clinical characteristics, and cognitive impairments among post-TBI patients at Hospital USM. Therefore, more than half of the participants were found to have post injury cognitive impairments due to TBI. In this study, the researchers identified that there were no association between pre-injury socio-demographics, injury related characteristics (location of brain injury) and cognitive impairments among post-TBI patients at Hospital USM. The analysis revealed that there were associations between clinical characteristics of severity of TBI using GCS and cognitive impairments among TBI patients at Hospital USM. Limited understanding about TBI patient health condition could contribute towards poor care and treatment for them. Therefore, having adequate understanding about their health conditions could help healthcare providers especially medical doctors and nurses become more prepared in giving the best care and participating in TBI patient recovery process.

ACKNOWLEDGEMENT

AUTHOR CONTRIBUTION STATEMENT

NMR contributed to the entire part of the research and manuscript preparation.

MNCMY contributed to manuscript preparation **SH** contributed to study conception, funding, supervision and manuscript preparation.

DISCLOSURE / CONFLICT OF INTEREST

The author(s) declare no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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