Original article

J Nepal Health Res Counc 2022 Jan-Mar; 20 (54): 202-6

Marshall Computed Tomography Scoring System in Predicting Early Mortality in Patients with Traumatic Brain Injury

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ABSTRACT

Background: Traumatic brain injury is common neurological emergency worldwide associated with high rates of morbidity and mortality. Marshall scoring system is one of the several scoring systems that uses initial computed tomography findings to predict outcome. This study aims to determine the role of Marshall scoring system in predicting early mortality in patients with Traumatic brain injury in Nepalese patient population.

Methods: Patients admitted with diagnosis of Traumatic brain injury between August 2017 and July 2018 in our institution were studied prospectively. Clinical status of patient was noted and computed tomography scan of head was interpreted according to Marshall scoring system. Patients were monitored during the hospital stay and in-hospital mortality was correlated with different components of Marshall scoring system at discharge.

Results: The most common cause of Traumatic brain injury was road traffic accident (45%). Severe Traumatic brain injury was noted in 17% of patients and commonest intracranial mass lesion was contusion (24%). Surgery was performed in 29% of patients. There was significant correlation between increase in Marshall score and mortality ($p<0.001$). Degree of midline shift ($p<0.016$), status of basal cisterns ($p<0.001$), and combination of mass lesions ($p=0.005$) were independent predictors of early mortality.

Conclusions: Marshall scoring is highly reliable scoring system to predict early mortality in patients with Traumatic brain injury. Degree of midline shift, status of basal cisterns, and combination of mass lesions are independent parameters predicting early mortality in patients with traumatic brain injury.

Keywords: Basal cistern; CT scoring system; marshall scoring system; traumatic brain injury

INTRODUCTION

Traumatic brain injury (TBI) is a common neurological emergency worldwide associated with high rates of morbidity and mortality.[1-3] It can be classified as mild, moderate, or severe based on the Glasgow Coma Scale (GCS).[4] Increased use of sedation and early intubation has decreased the value of GCS, and initial clinical status of patient may not represent the exact outcome.[5,6] Many computed tomography (CT) classifications have been developed to address this problem such as Marshall, Rotterdam, and Helsinki systems.[7-9] Marshall CT classification focuses on the presence or absence of mass lesion, and differentiates diffuse injuries by signs of increased intracranial pressure (Table 1).[8]

The primary objective of this study was to determine the role of Marshall scoring system in predicting early mortality in patients with TBI in a university hospital in Nepal. Secondary objectives were to identify patterns of TBI on CT scan, determine the severity of TBI, and identify specific CT findings independently predicting early death.

METHODS

This is a prospective observational study conducted at the Department of Neurosurgery, Tribhuvan University Teaching Hospital (TUTH), Kathmandu, Nepal between August 2017 and July 2018. Approval from institutional review committee of Institute of Medicine (IOM), Nepal was obtained prior to patient recruitment. Informed written consent was taken from the patient or their legal guardian for participation in the study.

Adult patients (age≥16 years) presenting to Emergency

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Room (ER) with TBI and who were admitted as inpatients were enrolled in the study. Patients presenting with trauma with chronic pathologies unrelated to recent trauma e.g. chronic subdural hematoma, and patients or legal guardians not giving consent for participation were excluded. Indications for admission included patients with an alleged history of trauma with GCS <15 and patients with GCS = 15 with a history of loss of consciousness, amnesia, vomiting, seizure, focal neurological deficit, or signs of basal or calvarial fractures or positive findings on CT scan. Patients presenting to ER with TBI were initially evaluated by the ER team. History and examination findings were recorded. A CT scan of the head and other routine investigations, as needed were done before admission. Patients were treated by neurosurgery team independently or in combination with critical care team in the intensive care unit (ICU), or ward according to the severity of the injury. Sample size was calculated considering prevalence (p) of TBI as 7%, confidence interval (t) of 95% and an acceptable sample error (e) of 5%. Using the formula $n=t^2X\ 9(1-p)/e^2$, the sample size was 100 .

Categorical data were presented as percentages and differences analyzed using the Chi-squared test. Univariate and multivariate logistic regression analyses were performed. All associated variables which were significant in univariate analysis at 10% significance ($p \leq 0.1$) were analyzed by multivariate logistic regression to identify specific initial CT findings independently predicting early death. Early death was defined as morality during the hospital stay. Predictive accuracy of Marshall score was assessed by receiver operating characteristic (ROC) curve analysis. All data were analyzed using the Statistical Program of Social Sciences(SPSS) for Windows (version 24.0). A p-value of <0.05 was considered statistically significant.

RESULTS

One hundred forty-five patients who presented in ER with TBI and got admitted during the study period were evaluated for potential recruitment for the study. Forty-one patients who were under 16 years of age were excluded, two patients were excluded as they had chronic SDH and there were two dropouts. Hence 100 patients were available for analysis.

There were 84 males and 16 females. According to age distribution, 34% of patients were under 25 years of age, followed by 17% between 26-35 and 36-45 each, 10% were between 46-55 and 22% were above 56. The most common cause of TBI was a road traffic accident (RTA) which was seen in 45 patients, followed by a fall from height (noted in 38 patients). As per the severity, 56 patients had mild, 27 had moderate and 17 had severe TBI.

The most common mass lesion seen on CT scan was contusion (24%) followed by acute extradural hematoma (EDH) (20%) and acute subdural hematoma (SDH) (13%) as detailed in Table 2.

There was highest mortality in Score 6 (100%) followed by Score 4 (66.7%) with no mortality in Score 1 and 2 (Table 3). ROC curve was constructed to determine predictive value of Marshall CT score for determining early mortality in patients with TBI. Area under the curve (AUC) was 0.855 with a cut-off value of 3.5 (sensitivity=85.7%, specificity=73.3%) (Figure 1). Mortality in patients with severe TBI was 10 (41.2%), moderate TBI was 20 (25.9%) and no mortality was seen in patients with mild TBI (p<0.001). Univariate analysis of individual CT findings revealed that mortality in patients with a midline shift greater than 5 mm was 40.9% (p<0.001). In patients who had cisternal compression, the mortality was 21.9% and in those with absent cisterns mortality was 77.8%. There was no mortality in patients without cisternal compression (p<0.001). Mortality in patients with a volume of mass lesion more than 25ml was 35.7%, and 5.6% for a volume less than or equal to 25ml (p<0.001). Mortality in patients with the combination of mass lesions was 40% and that without it, was 11.1% (p=0.032). All associated variables which were significant at 10% significance ($p\leq0.1$) were analyzed by multivariate logistic regression. Multivariate analysis revealed midline shift (p=0.016, RR=10.353), status of basal cisterns (p<0.001, RR=23.581), and combination of mass lesions (p =0.005, RR= 7.944) to be significantly associated with early mortality.

Table 1. Marshall descriptive computed tomography scoring system

Category	Definition
Diffuse Injury (no visible pathology) I	No visible intracranial pathology on CT scan
Diffuse Injury II	Cisterns are present with 0–5 mm midline shift and/or lesion densities present; no high- or mixed-density lesion >25 ml include bone fragments or foreign bodies
Diffuse Injury (swelling) III	Cisterns compressed or absent with 0–5 mm midline shift; no high- or mixed-density lesion >25 mL
Diffuse Injury (shift) IV	Midline shift >5 mm; no high- or mixed-density lesion >25 mL
Evacuated mass lesion V	Any lesion surgically evacuated
Non evacuated mass lesion VI	High- or mixed-density lesion >25 mL; not surgically evacuated

Table 2.Radiological characteristics of patients.

Type of Mass lesion	Frequency/ Percentage (%)
EDH	20
SDH	13
Contusion	24
Intracerebral hemorrhage	6
Foreign body	2
Combination	10
Absent	25

EDH = extradural hematoma, SDH = subdural hematoma

Table 3. Significance between Marshall Score and mortality.

Marshall Score	Mortality		Mortality (%)	Inference
	No	Yes		
1	18	0	0	p< 0.001
2	39	0	0	
3	6	2	25	
4	1	2	66.7	
5	22	7	24.1	
6	0	3	100	
Total	86	14		

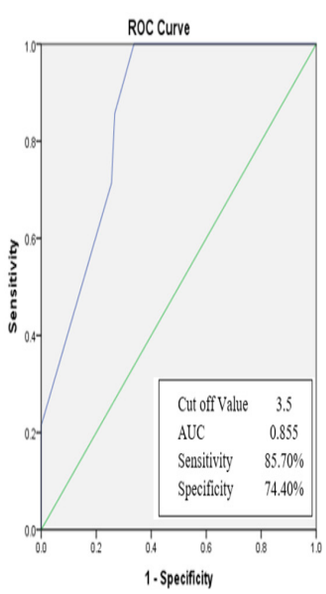

Figure 1. Receiver operating characteristic (ROC) curve showing prediction outcome based on Marshall scoring system.

DISCUSSION

A non-contrast CT of head is the investigation of choice for initial assessment of patients with TBI. It guides management decisions including the need for surgical decompression or intracranial pressure (ICP) monitoring and also helps in prognosticating outcome of the patient. It serves as a basis for counseling about outcome and treatment of TBI patients.[10, 11] This study was done in patients with TBI, to determine the role of Marshall CT scoring system to predict early mortality.

Our study showed male preponderance (84%), which is similar to the study by International Mission on Prognosis and Analysis of Clinical Trials (IMPACT) and also studies done in Nepal.[12-16] Male preponderance may be due to the fact that they are more active socially and involved in outdoor activities in pursuit of work. The commonest age group involved was 16 to 25 years (34 patients) and is consistent with other studies.[16-18] The most common cause of TBI was RTA (45%), followed by fall from height(38%) which is similar to other studies.[1, 11, 12, 19-21] There were 56% of patients with mild, 27% with moderate, and 17% with severe TBI which is similar to a study done by Bhattachan et al which had 18% severe and 18% moderate TBI.[16]

The most common mass lesion seen on CT scan was contusion (24%) followed by EDH in 20% and SDH in 13% which is similar to the results of other studies from Nepal.[12,14] But, the results are different from international studies which had predominance of SDH; Pargaonkar et al (54.14%) and Song et al (37.5%). This may be due to difference in the mode of injury and age distribution of patients in those studies.[22, 23]

There were 18 patients in Marshall score 1, 39 in score 2, eight in score 3, three in score 4, 29 in score 5, and three in score 6. It is consistent with report by Mata-Mbemba et al who also had fewer patients in score 4 and 6 compared to score 5.[21] Fewer patients in score 4 and 6 are explained by the fact that most patients with midline shift and volume of mass lesion >25ml were taken up for operative intervention regardless of GCS at presentation. This highlights the value of evacuation of mass lesion (Marshall score 5) in reducing mortality compared to non-evacuated lesions of >25ml with midline shift and compressed cisterns. This study showed that an increase in Marshall score increased prediction for mortality (p<0.001). The mortality in patients with Marshall score 1 and 2 was 0%, for score 3 was 25%, for score 4 was 66.7%, for score 5 was 24.1% and for score 6 was 100%. The overall operative mortality was 24.1% which may be because of the inclusion of severely injured patients and is consistent with previously published studies.[22, 24, 25]

In our study, Marshall CT scoring had AUC-0.855 which

is similar to studies by Mbemba et al (AUC-0.85), and Charry et al (AUC-0.814). However it is higher than that found by Deepika et al(AUC-0.707), and Pargaonkar et al(AUC-0.742) which may be due to difference in demographics between the studies.[21, 22, 26, 27] Mortality in patients with severe TBI was 41.2%, moderate TBI was 25.9% and no mortality was seen in patients with a mild TBI. Our results are consistent with the norm that an increase in severity of TBI is associated with an increase in mortality (p<0.001).[23, 28]

The mortality in patients with a midline shift greater than 5mm was 40.9% (p<0.001) which is similar to study by Mass et al which had a mortality of 49%.[9] The mortality in patients with compressed cisterns was 21.9% and in patients with absent cisterns was 77.8%. There was no mortality in patients with normal cisternal anatomy (p<0.001). The results are consistent with study done by Toutant et al which had a mortality of 77% and 39% among those with absent and compressed basal cisterns respectively.[29] Mortality in patients with volume of mass lesion more than 25ml was 35.7%, and 5.6% for a volume less than or equal to 25ml (p<0.001) which is similar to results of Maas et al.[30] Mortality in patients with a combination of mass lesions was 40% and that without it was 11.1%. (p=0.032). Multivariate analysis of univariate data revealed midline shift (p=0.016), status of basal cisterns (p<0.001), and combination of mass lesions (p<0.005) to be independent predictors of mortality with an odds ratio of 10.353, 23.581, and 7.944 respectively which is similar other studies.[21, 22]

In this study, majority of the patients had sustained mild and moderate TBI. Number of patients with severe TBI was low which may not reflect the true predictive value of CT scoring system in patients with severe TBI. Also, this is a single-center study and may not be truly generalizable.

CONCLUSIONS

This study demonstrates that Marshall CT scoring can be used to predict early mortality in patients with TBI in our patient population also. Our results suggest that the degree of midline shift, status of basal cisterns, and combination of mass lesions are independent CT parameters predicting early mortality. Further large-scale studies are recommended to validate this scoring system in the Nepalese population.

CONFLICT OF INTEREST

None

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