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TO ASSESS THE ACCURACY OF PREDICTIVE MORTALITY OF ROTTERDAM VERSUS MARSHALL CT SCORE FOLLOWING SEVERE TRAUMATIC BRAIN INJURY

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ABSTRACT:
Background: Rapid and appropriate identification and prognostic prediction of traumatic brain injury (TBI) in the emergency department (ED) are essential for decreasing the risk of mortality. Computed tomography (CT) diagnostic methods developed by Rotterdam and Marshall have been shown to be quite helpful in predicting the likely outcome of TBI patients.
Objective: To compare the diagnostic accuracy of the Rotterdam CT score with the Marshall CT score in predicting death after severe TBI.
Methods: A longitudinal research on adult severe TBI patients was conducted in the ED of Ziauddin University Hospital, Karachi. Ninety severe TBI patients, aged over 18 years, were consecutively enrolled from 23-08-2023. To 22-02-2024 Vitals were recorded after demographic and trauma information was obtained. To confirm severe TBI, each patient's GCS score was calculated, and a CT scan was performed at admission. The Marshall and Rotterdam CT scores were calculated to predict their likelihood of death. The Statistical Package for the Social Sciences (SPSS) was used to analyze the data.
Results: Of the 90, 68.9% (n=62) were male patients, and 31.1% (n=28) were female patients, with a median age of 34.0 years. The predicted mortality from severe TBI with Rotterdam and Marshall CT scores ≥4 was 31.1% (n=28) and 44.4% (n=44), respectively. The actual mortality from severe TBI within 30 days of diagnosis was 41.1% (n=37). The Rotterdam and Marshall CT scores ≥4 predicted the mortality with a sensitivity of 62.2% and 83.8%, specificity of 90.6%

and 83.1%, PPV of 82.2% and 77.5%, NPV of 77.5% and 88.0%, and DA of 78.9% and 83.4%, respectively.

Conclusion: Severe TBI patients have a higher chance of mortality if they score ≥4 on the Rotterdam and Marshall CT scores. These scoring methods are supported by the results of our study, which showed that a cutoff score of ≥4 was associated with poor survival and <4 with better survival.

Keywords: Traumatic brain injury, prognosis, emergency, mortality.

INTRODUCTION:

Today, traumatic brain injury (TBI) is the most common problem faced by emergency physicians in hospital EDs. Traumatic brain injury is the term used to describe brain damage that results from head injury [1, 2]. These injuries can be caused by physical trauma (such as road traffic accidents (RTAs), penetrating trauma (such as knife or missile injuries) or falls. Traumatic brain injury is thought to be the most often reported cause of ED visits. An estimated one million or more individuals with TBI visit a hospital's ED annually [3. 4].

Globally, traumatic brain injury is an important threat to public health. Globally, about 27 to 69 million people are identified with traumatic brain injury each year, with a projected incidence of 351-939 per 100,000 people [5, 6]. It is estimated that 5.48 million people (73 per 100,000) experience severe traumatic brain injury annually [7]. Traumatic brain injury is a major cause of hospitalization and death, with about 214,110 hospitalizations and 69,473 deaths in 2020 and 2021, respectively [8]. In Pakistan, the prevalence of severe TBI was 4.7%, and the incidence rate was 50 per 100,000 cases [9, 10].

Considering all these facts about the burden of traumatic brain injury on EDs, it is extremely challenging to identify and classify the severity and prognosis of traumatic brain injury. Initial diagnosis in EDs relies mostly on the Glasgow Coma Scale (GCS) and CT of the brain. The GCS is the most widely used tool in EDs to identify and classify the severity of traumatic brain injury. A CT scan of the brain confirms traumatic brain injury in the presence of a range of abnormalities including intracranial bleeding [11, 12]. It is essential to predict the prognosis of TBI severity early and accurately in order to decrease the risk of mortality. The Marshall and Rotterdam CT scores are widely utilized in EDs to predict the risk of mortality. These scores utilize all CT scan results and aid in clinical decision-making and prognosis prediction, especially in cases of severe TBI. In comparison to the Marshall scoring system, the Rotterdam scoring system aimed to improve patient outcome prediction. However, a combination of diagnostic and clinical methods must be used because it is very challenging for a physician to determine severity using a single diagnostic tool [13-15].

As we know, early and appropriate prediction of mortality risk can enhance treatment decisions and resource allocation in EDs and also reduce the risk of mortality in severe traumatic brain injury patients. Therefore, this study was designed to compare the diagnostic accuracy of the Rotterdam CT score with the Marshall CT score in predicting death after severe TBI. Results of research will help to find which score offers better prognostic accuracy.

METHODOLOGY:

A longitudinal research on adult severe TBI patients was conducted in the ED of Ziauddin University Hospital, Karachi. The study was conducted for a period of six months, from 23-08-2023. To 22-02-2024. Open EPI, an online sample size calculator, was utilized with different variables for the sample size calculation of this research. A previous study of Rodrigues de Souza et al. [16] was used, who predict the mortality in 73.5% of patients with a Rotterdam CT score of ≥4 and in 37.7% of patients with a Marshall CT score of ≥4 in TBI patients. The significance level and power for the calculation were 95% and 80%, respectively. The calculated sample size for selecting severe TBI patients in the study was 90.

The research strictly follows the inclusion and exclusion criteria. The research includes (1) adults of either gender, (2) aged over 18 years, (3) diagnosed with severe TBI, (4) a CT scan was done within 24 hours of injury, (5) CT scan finding interpretable for Marshall and Rotterdam scores, and (6) admitted to the ED. The research excludes (1) severe TBI with polytrauma, (2) severe TBI due to penetrating injuries, (3) patients with a history of neurosurgery, (4) patients with a history of use of anticoagulant drugs, (5) patients who died before a CT scan, (6) patients with an incomplete CT scan, and (7) pregnant women.

The current research was carried out with permission from the Institutional Review Board (IRB) of the Ziauddin Medical University Hospital, Karachi, via letter number 23-08-2023. To 22-02-2024. Additionally, the patient or a family member provided written informed permission after receiving all information about the study, including objectives and significance. Vitals were recorded after demographic and trauma information was obtained. To confirm severe TBI, each patient's GCS score was calculated, and a CT scan was performed at admission. The Marshall and Rotterdam CT scores were calculated to predict their likelihood of death.

Severe TBI was confirmed during early rehabilitation with a GCS score of 3 to 8 and the presence of several abnormalities, including intracranial hemorrhage, on a brain CT scan. Evaluation was performed using the GCS score, Rotterdam CT score, and Marshall CT score standard criteria. Rotterdam and Marshall CT scores of <4 indicate higher survival, and scores of ≥4 indicate a higher risk of mortality. Death in patients was confirmed due to severe TBI within 30 days of injury.

The Statistical Package for the Social Sciences (SPSS) was used to analyze the data. Quantitative and qualitative variables were presented in the form of mean ± standard deviation and frequency (percentages), respectively. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and diagnostic accuracy for Marshall and Rotterdam CT scores were calculated. Receiver Operating Characteristic (ROC) curves were generated for both the Marshall CT classification and the Rotterdam CT score to evaluate and compare their diagnostic accuracy in predicting mortality among patients with severe TBI.

RESULTS:

Of the 90, 58.9% (n=53) of the patients were alive, and 41.1% (n=37) died due to severe TBI. About 68.9% (n=62) were male patients, and 31.1% (n=28) were female patients. The mean age was 34.3 years with a standard deviation of ±12.7 years. The majority of severe TBI patients were in the age category of 18-30 years (42.2%, n=38), followed by 31-40 years (27.8%, n=25), 41-50 years (17.8%, n=16), and >50 years (12.2%, n=11). The most common intent of injury was unintentional (96.7%, n=87), and the mechanism of injury was RTAs (75.6%, n=68), followed by falls (21.1%, n=19) and violence (3.3%, n=3) [Table 1].

The GCS score was significantly high in patients who were alive as compared to those who died (6.68±1.07 vs. 4.49±1.35, p-value <0.001). The Rotterdam and Marshall CT scores were significantly low in patients who were alive as compared to those who died (2.70±1.01 vs. 3.89±1.35, p-value <0.001, and 3.04±1.09 vs. 4.57±1.19, p-value <0.001), respectively [Table 2].

The Rotterdam and Marshall CT scores predict the death in 31.1% (n=28) and 44.4% (n=44) and survival in 68.9% (n=62) and 55.6% (n=50) of severe TBI patients, respectively [Table 3]. The Rotterdam and Marshall CT scores ≥4 predicted the mortality with a sensitivity of 62.2% and 83.8%, specificity of 90.6% and 83.1%, PPV of 82.2% and 77.5%, NPV of 77.5% and 88.0%, and DA of 78.9% and 83.4%, respectively [Table 4].

The ROC curve of the Rotterdam and Marshall CT scores for predicting mortality in severe TBI patients with a score of ≥4 indicates an AUC of 0.753 (95% CI: 0.644-0.861, p-value <0.001) and 0.819 (95% CI: 0.753-0.861, p-value <0.001) (Figure 1).

Table 1: Demographics, Injury, and Management in Severe TBI (n=90)				
Variables	**Total (n=90)**	**Death (n=37)**	**Alive (n=53)**	**P-Value**
Gender				
Male	62 (68.9%)	28 (75.7%)	34 (64.2%)	0.245
Female	28 (31.1%)	9 (24.3%)	19 (35.8%)	
Age (Years)				
18-30	38 (42.2%)	13 (35.1%)	25 (47.2%)	0.288
31-40	25 (27.8%)	14 (37.8%)	11 (20.8%)	
41-50	16 (17.8%)	5 (13.5%)	11 (20.8%)	
>50	11 (12.2%)	5 (13.5%)	6 (11.3%)	
Intent of Injury				
Intentional	3 (3.3%)	3 (8.1%)	0 (0.0%)	0.035*
Unintentional	87 (96.7%)	34 (91.9%)	53 (100.0%)	
Mechanism of Injury				
RTAs	68 (75.6%)	27 (73.0%)	41 (77.4%)	0.106
Falls	19 (21.1%)	7 (18.9%)	12 (22.6%)	
Violence	3 (3.3%)	3 (8.1%)	0 (0.0%)	
Management				
Conservative	69 (76.7%)	29 (78.4%)	40 (75.5%)	0.748
Surgery	21 (23.3%)	8 (21.6%)	13 (24.5%)	
* Statistically Significant P-Value				

Table 2: Comparison of GCS, Rotterdam and Marshall CT Score (n=90)				
Variables	**Total (n=90)**	**Death (n=37)**	**Alive (n=53)**	**P-Value**
GCS	5.78±1.61	4.49±1.35	6.68±1.07	<0.001*
Rotterdam CT Score	3.19± 1.30	3.89±1.35	2.70±1.01	<0.001*
Marshall CT Score	3.67±1.36	4.57±1.19	3.04±1.09	<0.001*
* Statistically Significant P-Value				

Table 3: Comparison of Predicted Mortality with Rotterdam and Marshall CT Score (n=90)			
Variables	**Predicted Death**	**Predicted Alive**	**P-Value**
	Rotterdam CT Score ≥4		
Death	23 (25.6%)	14 (15.6%)	<0.001*
Alive	5 (5.6%)	48 (53.3%)	
Total	28 (31.1%)	62 (68.9%)	
Marshall CT Score ≥4			
Death	31 (34.4%)	6 (6.7%)	<0.001*
Alive	9 (10.0%)	44 (48.9%)	
Total	40 (44.4%)	50 (55.6%)	
* Statistically Significant P-Value			

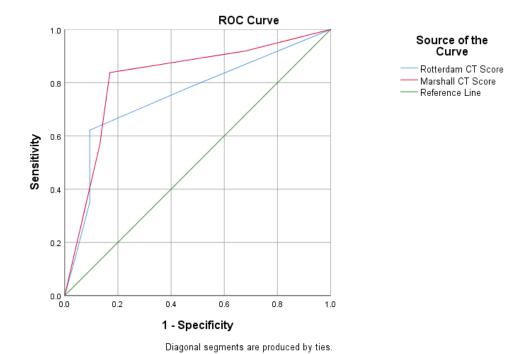| Table 4: ROC Curve Analysis For Rotterdam and Marshall CT Score (n=90)		
Variables	**Rotterdam CT Score**	**Marshall CT Score**
Sensitivity	62.2%	83.8%
Specificity	90.6%	83.1%
PPV	82.2%	77.5%
NPV	77.5%	88.0%
DA	78.9%	83.4%
AUROC	0.753	0.819
P-Value	<0.001*	<0.001*
* Statistically Significant P-Value		

Figure 1: ROC Curve of Rotterdam and Marshall CT Score for Predicting Mortality

DISCUSSION:

Traumatic brain injury is an enormous worldwide health concern that significantly affects death, disability, and economic cost. There is significant diversity in the underlying pathophysiology, extent and severity of injury, and prognosis. This variability often makes prognosis difficult in TBI. However, prognostication is crucial for helping emergency physicians in order to get accurate and immediate data that can assist in critical therapeutic decisions [17-19].

There is a lot of research available around the world that emphasizes how important it is to predict patient death after suffering a severe TBI using the Marshall or Rotterdam scoring systems [15, 20-25]. Research that compares two scoring systems to predict death in patients with severe TBI has not been conducted in our local context. Therefore, this study was designed to compare the diagnostic accuracy of the Rotterdam CT score with the Marshall CT score in predicting death after severe TBI. In this research, 68.9% (n=62) were male patients, and 31.1% (n=28) patients were female. The mean age was 34.3 years with a standard deviation of ±12.7 years. The majority of severe TBI patients were in the age category of 18-30 years (42.2%, n=38), followed by 31-40 years (27.8%, n=25), 41-50 years (17.8%, n=16), and >50 years (12.2%, n=11). Similar findings of a higher male proportion and mean age were also reported by different other researchers. Elkbuli et al. [15], Goswami et al. [20], and Mohammadifard et al. [21] report the percentages of male patients suffering from TBI as 75.5%, 85.8%, and 60.0%, respectively. Elkbuli et al. [15] report the higher mean age of 52 years, whereas

Mohammadifard et al. [21] report the mean age as 43.36 years. Goswami et al. [20] report approximately 50% of patients in the age group of 18-39 years. These findings are similar to our findings because most of the young adult males are involved in high-risk activities.

These high-risk activities include reckless driving, over speeding, not wearing a helmet or breaking traffic rules, which mostly lead to RTAs. Our study also reports that the most common mechanism of injury was RTAs (75.6%, n=68), followed by falls (21.1%, n=19) and violence (3.3%, n=3). These findings were similar to Goswami et al. [20] and Mohammadifard et al. [21], who reported 84.3% and 74.5% of cases of TBI because of RTAs, followed by 11.0% and 21.4% because of falls, respectively.

In this research, 58.9% (n=53) of the patients were alive, and 41.1% (n=37) died due to severe TBI. Similarly, high mortality in severe TBI patients was reported by various other researchers. Goswami et al. [20] report an overall mortality rate of 32.2% in TBI cases, of which 37.3% of deaths occurred in severe TBI cases. Liu et al. [22] conducted the meta-analysis of 33 cohort studies and reported the overall mortality of 27.8% in severe TBI cases. Okidi et al. [23] report an overall mortality rate of 33.0% in TBI cases, of which 72.0% of deaths occurred in severe TBI cases. The mortality rate is high in severe TBI patients due to severe damage to the brain, advanced age, comorbidities, lack of facilities in EDs, and delayed or inadequate provision of care.

In this research, the Rotterdam and Marshall CT scores were significantly low in patients who were alive as compared to those who died (2.70±1.01 vs. 3.89±1.35, p-value <0.001, and 3.04±1.09 vs. 4.57±1.19, p-value <0.001), respectively. The Rotterdam and Marshall CT scores predict the death in 31.1% (n=28) and 44.4% (n=44) of severe TBI patients, respectively. The Rotterdam and Marshall CT scores ≥4 predicted the mortality with a sensitivity of 62.2% and 83.8%, specificity of 90.6% and 83.1%, PPV of 82.2% and 77.5%, NPV of 77.5% and 88.0%, and DA of 78.9% and 83.4%, respectively. Goswami et al. [20] reported a sensitivity of 60.98% and 82.93% and a specificity of 90.70% and 75.58%, respectively, in predicting mortality in the Rotterdam and Marshall CT scores. Asim et al. [24] reported a sensitivity of 61.2% and 74.3% and a specificity of 85.6% and 74.3%, respectively, in predicting mortality in the Rotterdam and Marshall CT scores. Siahaan et al. [25] reported the good and worse outcomes in 53.9% and 46.1% of TBI patients, respectively. The Rotterdam and Marshall CT scores of ≥4 predicted the worse outcomes in 27.4% and 40.2%, respectively. These results were similar to those of our study, where a significant increase in mortality was observed in patients with severe TBI who had Rotterdam and Marshall CT scores of 4 or higher, demonstrating the prognostic value of both scoring systems.

This research is associated with a few limitations, such as the short study duration and follow-up, which is necessary to find worse outcomes for severe TBI. Other limitations of the research include the small sample size, single center, and only inclusion of patients with severe TBI.

Conclusion:
Severe TBI patients have a higher chance of mortality if they score ≥4 on the Rotterdam and Marshall CT scores. These scoring methods are supported by the results of our study, which showed that a cutoff score of ≥4 was associated with poor survival and <4 with better survival. The Marshall CT score is better than the Rotterdam CT score for predicting mortality in patients with severe TBI.

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