ROLE OF THE ROTTERDAM COMPUTED TOMOGRAPHY SCORE IN THE PROGNOSTIC OUTCOME OF TRAUMATIC BRAIN INJURY

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Abstract-

Background: One of the most frequent causes of morbidity, disability and mortality in young adults is traumatic brain injury (TBI). Early recognition of TBI is critical for clinical decision-making and determining prognosis. The primary goal of the development of Rotterdam Computerized Tomography (RCT) scan grading system was to foresee prognostic outcomes pf TBI patient.

Objective: To find out the prognostic outcomes of TBI patients by using RCT scoring system.

Methods: A cross-sectional study was conducted from June 2022 to November 2022 at Ziauddin University Hospital Karachi. One hundred and sixty-two traumatic brain injury patients were consecutively selected from Emergency Department (ED). Each patient was clinically evaluated, vitals were measured and GCS scores were calculated at admission. Each TBI patient's RCT score was calculated to predict the prognostic outcome (mortality) and followed up to six months for the final outcome.

Results: Of the 162 TBI patients, male and female patients were 112 (69.1%) and 50 (30.9%) with a mean age of 41.4±18.4 years. Most of the TBI patients (96.3%) were presented with unintentional intent of injury and due to road traffic accidents (55.6%) and falls (37.7%). Mean GCS score was 12.4±3.5 and TBI severity was mild in most of the patients (72.8%) followed by moderate TBI (12.3%) and severe TBI (14.8%). Mean RCT score was 3.2±0.9 and six-month predicted mortality was 27.8%, while six-month mortality was 15.4%.

Conclusion: In the emergency department; the RCT grading system was found to be a reliable independent factor for predicting six-month mortality in patients presented with TBI.

Index Terms- Morbidity, injury, prognosis, mortality.

I. INTRODUCTION

A traumatic brain injury (TBI) is brain damage caused by a blow or jolt to the head, either as a result of blunt or penetrating trauma. A TBI patient presents with a variety of clinical conditions ranging from altered level of consciousness to death [1, 2].

TBI is a leading cause of increased emergency department (ED) visits. TBI is also considered as a leading cause of increased morbidity, mortality, and permanent disability. Furthermore, it places greater strain on patient resources and the health care system as a whole [3, 4].

TBI has also been called the "silent epidemic" because of its influence in global disability and mortality. TBI affects approximately 27–69 million people worldwide each year. According to the Centers for Disease Control and Prevention (CDC); approximately 2.53 million people visit the emergency department, 288,000 people hospitalized, and 56,800 people died each year from TBI [5-7]. A study by Dewan MC, et al. reports a global incidence of 939 TBI cases per 100,000 [8]; while Ahmed from Pakistan reports 50 TBI cases per 100,000 [9].

In TBI patients, the Glasgow Coma Scale (GCS) score is widely used to define altered level of consciousness and severity. The GCS evaluates TBI patients based on their visual, motor, and verbal responses [10]. However, GCS may not be applicable in case of severe head trauma unconsciousness, sedated or intubated. In that case; Computerized Tomography (CT) of brain is widely used to confirm TBI and its severity [10, 11]. A CT scan of the brain is the emergency physician's most reliable and important tool for diagnosing TBI, grading the severity of TBI, differentiating the injury (diffuse or focal), and predicting outcome [12, 13]. TBI patients admitted to the emergency department require immediate prognostic evaluation to reduce the risk of mortality and lifelong disability. In order to improve prognostic evaluation of patients hospitalized with moderate to severe TBIs, the Rotterdam CT score was developed in year 2006. The RCT score is widely used to classify TBI patients based on different CT findings. The RCT score also used to predict prognostic outcome in TBI patients [14, 15].

Therefore, this study was designed to explore the prognostic outcomes of TBI patients presenting with TBI to the emergency department using the RCT scoring system in a local population.

II. METHODOLOGY:

This was a cross-sectional study, conducted at emergency department of Ziauddin University Hospital Karachi from June 2022 to November 2022. During the study period traumatic brain injury patients were consecutively selected from emergency department and evaluated for RCT scoring system for predicting six-months mortality.

A sample size of 162 was calculated using the online Open EPI software, with 29.13% of reported TBI deaths [16], 7.0% confidence limit and 95.0% confidence level. Diagnosed patients of TBI, male or female having age ≥ 18 years were included in study, while diagnosed patients of TBI having age < 18 years,

previous history of TBI or patients or their relatives who were not willing to be a part of study were excluded from the study.

A TBI patient was confirmed on presence of head injury, GCS score ≥ 3 and intracranial bleeding detected on CT scan. RCT score was distributed from 1 to 6 with six-month predicted mortality of 5-61% (Table 1). Study permission was obtained from Ziauddin University Hospital Karachi Synopsis committee (Letter No:) and Ethical review committee (Letter No:). A written informed consent was also obtained from patient or their relatives. Each patient was clinically evaluated, vitals were measured and GCS scores were calculated at admission. Each TBI patient's RCT score was calculated to predict the prognostic outcome (mortality) and followed up to six months for the final outcome.

Statistical Package for Social Sciences (SPSS) Statistics, version 25 was used for statistical analysis. Mean and frequency was calculated for quantitative and qualitative data respectively. Kaplan Meier survival analysis was used for predicting mortality and chi-square test was applied for stratification and p-value of ≤ 0.05 was used as statistically significant.

ROTTERDAM COMPUTED TOMOGRAPHY SCORE (RCT SCORE)		
Rotterdam Score Element	**Score**	**Obtained Score**
Basal Cisterns		
Normal	0	
Compressed	1	
Absent	2	
Midline Shift		
No Shift or shift ≤ 5-mm	0	
Shift > 5-mm	1	
Epidural Mass Lesion		
Present	0	
Absent	1	
Intraventricular Blood or tSAH		
Absent	0	
Present	1	
Sum Score	+1	
Total Score		
RCT SCORE INTERPRETATION		
Score	**Six-Month Mortality Rate**	
1	5%	
2	7%	
3	16%	
4	26%	
5	53%	
6	61%	

Table 1: RCT Score

RESULTS:

Of the 162 TBI patients, male and female patients were 112 (69.1%) and 50 (30.9%) with a mean age of 41.4±18.4 years. Majority of TBI patients 31.5% were in 18-30 years age group followed by 20.4% in 31-40 years, 19.1% in 41-50 years, 15.4% in 51-60 years and 13.6% in > 60 years. Mean of vitals in TBI patients were; temperature 98.4 ± 1.0°F, pulse 91.5 ± 18.5 beats/min, systolic blood pressure 137.6 ± 31.7 mmHg, diastolic blood pressure 82.2 ± 13.5 mmHg and respiratory rate 20.9 ± 2.2 breaths/min [Table 2].

Most of the TBI patients (96.3%) were presented with unintentional intent of injury and due to road traffic accidents (55.6%) and falls (37.7%). Mean of GCS score was 12.4 ± 3.5 and TBI severity was mild (72.8%) followed by moderate (12.3%) and severe (14.8%) [Table 3].

In most of the TBI patients (51.2%), six-months mortality rate was 16% followed by 19.1% patients in 7%, 15.4% patients in 26%, 12.3% patients in 53% and 1.9% patients in 5%. RCT score six-month predicted mortality was 27.8% [Table 4] and six-month mortality was 15.4% [Figure 1].

Kaplan Meier survival analysis for six-month mortality showed a direct relationship between predicted mortality rate and mortality. None of the TBI patients died with mortality rates between 5% and 7%. TBI patients died within 5.5, 3.0, and 1 month with mortality rates of 16%, 26%, and 53%, respectively [Figure 2].

Six-month mortality association was non-significant with gender (P=0.419) and age (P=0.135) and significant with intent (P<0.001), mechanism (P=0.003), severity (P<0.001), six-month mortality rate (P <0.001) and six-month predicted mortality (P<0.001) [Table 5].

Table 2: Baseline of TBI Patients (n=162)			
Variables		**Frequency**	**Percentage**
Gender	Male	112	69.1%
	Female	50	30.9%
Age (Years)	Mean ± SD	41.4 ± 18.4	
	18-30	51	31.5%
	31-40	33	20.4%
	41-50	31	19.1%
	51-60	25	15.4%
	> 60	22	13.6%
Vitals	Temperature	98.4 ± 1.0°F	
	Pulse	91.5 ± 18.5 beats/min	
	Systolic Blood Pressure	137.6 ± 31.7 mmHg	
	Diastolic Blood Pressure	82.2 ± 13.5 mmHg	
	Respiratory Rate	20.9 ± 2.2 breaths/min	

Table 3: Injury Details in TBI Patients (n=162)			
Variables		**Frequency**	**Percentage**
Intent of Injury	Intentional	6	3.7%
	Unintentional	156	96.3%
Mechanism of Injury	RTAs	90	55.6%
	Falls	61	37.7%
	Violence	11	6.8%
Severity of Injury	GCS Score	12.4 ± 3.5	
	Mild	118	72.8%
	Moderate	20	12.3%
	Severe	24	14.8%

Table 4: Six months Predicted Mortality in TBI Patients (n=162)			
Variables		**Frequency**	**Percentage**
RCT Mortality Rate	RCT Score	3.2 ± 0.9	
	5%	3	1.9%
	7%	31	19.1%
	16%	83	51.2%
	26%	25	15.4%
	53%	20	12.3%
RCT Predicted Mortality	Yes	45	27.8%
	No	117	72.2%

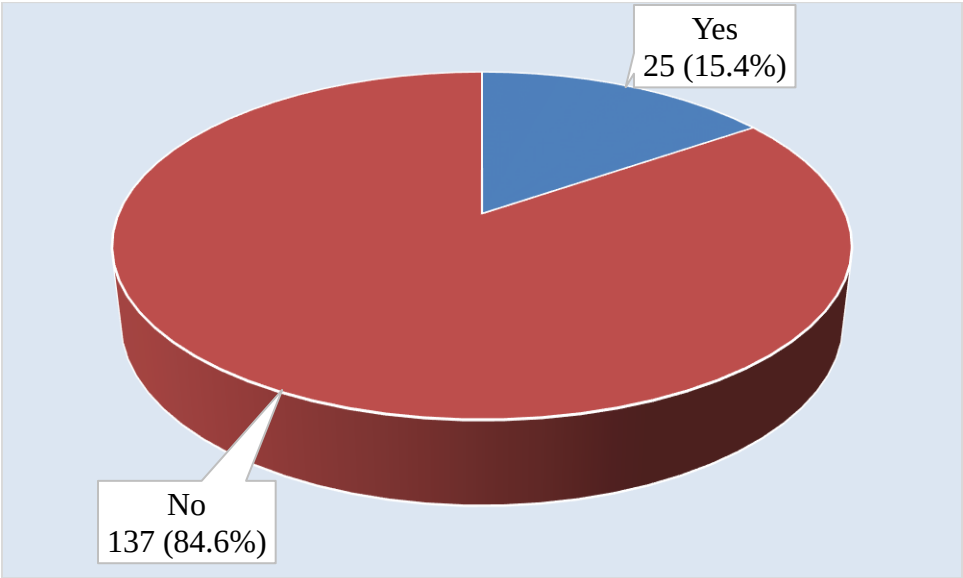

Figure 1: Six-months Mortality in TBI Patients

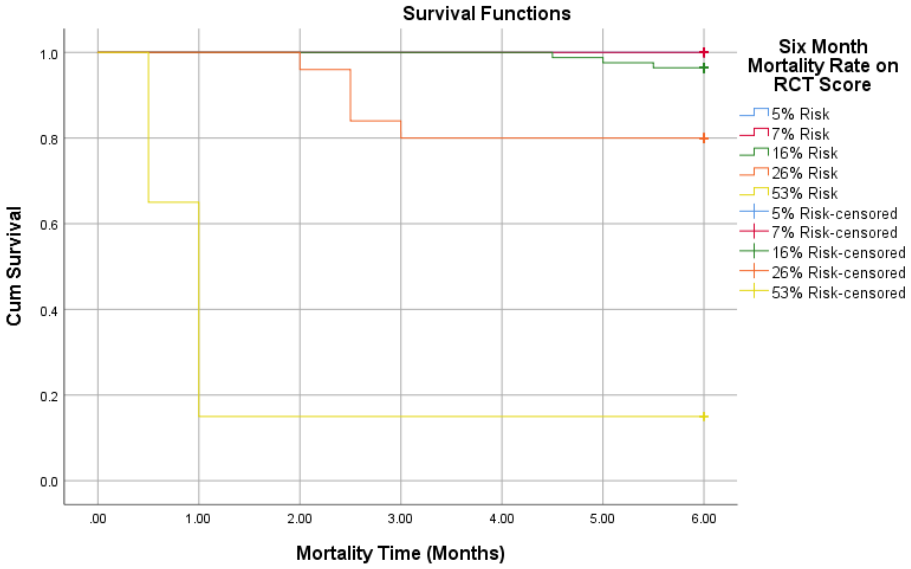

Figure 2: Kaplan Meier Survival Analysis for Six-Month Mortality

Table 5: Mortality Stratification with Risk Factors (n=162)

Variables		Mortality		P-Value
		Yes	No	
Gender	Male	19 (76%)	93 (67.9%)	0.419
	Female	6 (24%)	44 (32.1%)	
Age (Years)	18-30	3 (12.0%)	48 (35.0%)	0.135
	31-40	8 (32.0%)	25 (18.2%)	
	41-50	6 (24.0%)	25 (18.2%)	
	51-60	3 (12.0%)	22 (16.1%)	
	> 60	5 (20.0%)	17 (12.4%)	
Intent of Injury	Intentional	4 (16%)	2 (1.5%)	<0.001
	Unintentional	21 (84%)	135 (98.5%)	
Mechanism of Injury	RTAs	6 (24%)	84 (61.3%)	0.003
	Falls	16 (64%)	45 (32.8%)	
	Violence	3 (12%)	8 (5.8%)	
Severity of Injury	Mild	4 (16%)	114 (83.2%)	<0.001
	Moderate	6 (24%)	14 (10.2%)	
	Severe	15 (60%)	9 (6.6%)	
RCT Mortality Rate	5%	0 (0%)	3 (2.2%)	<0.001
	7%	0 (0%)	31 (22.6%)	
	16%	3 (12%)	80 (58.4%)	
	26%	5 (20%)	20 (14.6%)	
	53%	17 (68%)	3 (2.2%)	
RCT Predicted Mortality	Yes	22 (88%)	23 (16.8%)	<0.001
	No	3 (12%)	114 (83.2%)	

DISCUSSION:

Traumatic brain injury (TBI) is a primary cause of morbidity, disability and death in trauma patients, and is a serious public health problem worldwide as it mostly affects young people [7, 8]. Early diagnosis of TBI is critical in the emergency department; not only to reduce the risk of patient death, but also to reduce the additional burden on emergency physicians and the economic burden on the health care system and patients [17, 18]. The short- and long-term results of TBI patients depend on a number of variables such as patient age, GCS score, pupil reactivity, and substantial extracranial injuries. CT scan visualization of the affected brain region is also very much important for determining the severity and outcome of brain injury [19, 20].

A variety of predictive and prognostic models are used for TBI patients to allocate emergency resources, predict prognostic outcomes at the time of hospitalization, make decisions, and provide family counseling. In most cases; emergency physicians use the GCS score to classify the severity of TBI because of its ease of use, effectiveness, and diagnostic utility, whereas RCT score was considered to determine the prognostic outcome [21, 22]. Therefore, this study was designed to explore the prognostic outcomes of TBI patients using the RCT scoring system in a local population in the emergency department.

In this study, male TBI patients 112 (69.1%) were predominated compared to female TBI patients 50 (30.9%). A similar male predominance was reported by various other authors studying TBI patients, such as Zimmerman A, et al. *82.2% male TBI patients [18],* Rahman U, et al. *84.2% male TBI patients [23],* Bhatti JA, et al. *79.0% male TBI patients [24],* Yaqoob U, et al. *73.1% male TBI patients [25] and* Umar A, et al. *66.0% male TBI patients [26].* According to all comparative studies, the majority of TBI patients are male.

In this study majority of TBI patients 31.5% were in 18-30 years age group followed by 20.4% in 31-40 years, 19.1% in 41-50 years, 15.4% in 51-60 years and 13.6% in > 60 years with mean age of 41.4±18.4 years. Various authors studying TBI patients have also reported a similar predominance of younger patients with lower mean age such as Zimmerman A, et al. 32.1±16.5 years *[18],* Rahman U, et al. *28.9 years [23]* and Umar A, et al.

35.9 ± 16.0 years *[26], while* Bhatti JA, et al. *report that the majority of TBI patients (46.4%) were < 25 years [24].* According to all comparative studies, the majority of TBI patients are *young adults.*

In this study most of the TBI patients (96.3%) were presented with unintentional intent of injury and due to road traffic accidents (55.6%) and accidental falls (37.7%). Various authors studying TBI patients have also reported that TBI is mostly caused by RTAs followed by falls such as; Zimmerman A, et al. *reprots* 67.7*% RTAs [18],* Rahman U, et al. *reprots* 93.2*% RTAs [23],* Bhatti JA, et al. *reprots 48.6% RTAs and 22.4% falls [24],* Yaqoob U, et al. *reprots 39.0% RTAs and 32.4% falls [25] and* Umar A, et al. *reprots 55.0% RTAs and 38.0% falls [26].* According to all comparative studies, the majority of TBI is caused by RTAs.

When considering gender, age, and TBI causes, it is extremely important to keep in mind that young males are mostly involved in RTAs and suffer from brain injuries because males drive more often in developing countries. Young adult males often drive too fast and irresponsibly, resulting in RTAs and brain injuries that can be fatal or cause lifelong disability.

In this study, mean of GCS score was 12.4 ± 3.5 and TBI severity was mild (72.8%) followed by moderate (12.3%) and severe (14.8%). Various authors studying TBI patients have also reported a higher percentage of mild TBI such as; Zimmerman A, et al. *reprot 78.4% mild TBI [18],* Yaqoob U, et al. *reprot 72.8% mild TBI [25] and* Umar A, et al. *reprot 65.0% mild TBI [26].* According to all comparative studies, most TBI patients present in the emergency setting with mild TBI.

In this study, the six-month predicted mortality rate based on the RCT score was 27.8% and the six-month mortality was 15.4%. A similar study by Charry JD, et al. reports that the six-month predicted mortality rate based on the RCT score was 26.0% and the six-month mortality was 29.13% [16]. Another similar study by Talari HR, et al. also reports the higher sensitivity and specificity (84.2% and 96.2%) of the RCT score in predicting mortality in TBI patients [27]. Various other studies also report favorable prognostic results in patients with TBI using the RCS score. A higher RCS score is significantly associated with both predicted and actual mortality [28-31]. This study also reports the significant association of higher RCS score with mortality risk. In this study, none of the

TBI patients died with a mortality risk between 5% and 7%, whereas 3, 5, and 17 TBI patients died with a mortality risk of 16%, 26%, and 53%, respectively. The main cause of disparities in outcomes for serious head injuries, is believed to be a lack of health care facilities, skilled medical personnel and financial resources in developing countries like Pakistan. In this study; the RCT grading system was found to be a reliable independent factor for predicting six-month mortality in patients presented with TBI.

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