Rotterdam Computed Tomography Score to Predict Outcome in Traumatic Brain Injury Patients

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Abstract

Introduction In this article, we describe our experience of using Rotterdam computed tomography (CT) score at index admission to predict the outcome in traumatic brain injury (TBI) patients.

Materials and Methods A total of 370 TBI patients admitted to the Neurosurgery Intensive Care Unit, Narayana Medical College and Hospital, Andhra Pradesh, between January 2014 and December 2014 were evaluated. Based on availability of emergency CT scan, these patients' charts were reviewed prospectively. CT scan findings were quantified using Rotterdam CT classification (basal cistern, midline shift, and intraventricular blood/subarachnoid blood). Patient characteristic, Glasgow Coma Scale (GCS) score, Rotterdam CT classification, and outcome were analyzed. Correlation between Rotterdam CT classification at index admission and outcome at discharge from the hospital, alive or dead, was assessed.

Results The mean age of patients was 39.19 $\pm$ 15.18 years. Rotterdam CT score was significant ($p < 0.001$) with age, GCS score, and outcome but not significant with gender ($p = 0.618$). The outcome and individual components of Rotterdam CT classification were statistically significant.

Conclusion Increase in Rotterdam CT score was significantly associated with mortality at discharge. We suggest that it is possible to predict the outcome based on CT scan findings. However, the findings can have shortcomings, due to obvious reasons.

Keywords
- Rotterdam score
- computed tomography
- traumatic brain injury
- prognosis
- outcome

Introduction

With the advent of computed tomography (CT) scan, radiological evaluation of traumatic brain injury (TBI) has undergone major changes not only in terms of identifying and localizing intracranial lesions but also for predicting outcome of these patients based on the imaging findings.[1–11] In this article, we describe our experience of using Rotterdam score to predict the outcome in TBI patients.

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Material and Methods

From January 2014 to December 2014, a total of 370 TBI patients admitted to the Neurosurgery Intensive Care Unit, Narayana Medical College and Hospital, Andhra Pradesh, were evaluated. Based on availability of emergency CT scan, 370 patients' charts were prospectively reviewed after consent was obtained from our institutional review board. The data collected include demographic information, Glasgow Coma Scale (GCS) score, and CT image details. All TBI patients with lower or worsening GCS score, acute onset of focal neurological deficits, progressively disturbed consciousness, or absence of neurological signs underwent brain CT scans soon after arrival at the emergency department. Rotterdam CT classification was used to categorize the CT scan findings.[12,13] The individual CT image findings were interpreted and scored according to the Rotterdam CT classification 7 as follows: (a) status of basal cisterns subdivided into normal (0), compressed (1), or absent (2); (b) midline shift subdivided into 0 to 5 mm (0) or more than 5 mm (1); (c) epidural hematoma subdivided into present (0) or absent (1); and (d) traumatic subarachnoid hemorrhage or/and intraventricular hemorrhage subdivided into absent (0) or present (1). Adding plus 1 to the sum score made the grading numerically consistent with the grading of the motor score of the GCS. Outcome assessment was based on patient status at the time of discharge from the hospital, either alive or dead.

Statistical Analysis

A common analysis and reporting plan was prepared and analysis of data was done using StatsDirect version 3.0.150 (StatsDirect statistical software, StatsDirect Ltd.: http://www.statsdirect.com). The strength of the association between the Rotterdam CT score and outcome for TBI was examined by a univariate analysis using binary logistic regression models. Results are expressed as frequency for categorical and descriptive for continuous variables and for univariate analysis odds ratios with 95% confidence intervals.

Results

The details of 370 patient characteristic, GCS score, Rotterdam CT classification, and outcome are given in ►**Table 1**. The patient's ages were subclassified into decade wise. Most of the patients were managed conservatively, and in 145 cases neurosurgical intervention was performed. The details of Rotterdam CT classification in each decade is shown in ►**Table 2**. Distribution of Rotterdam CT classification in mild, moderate, and severe category is shown in ►**Table 3**. During the study period, 57 (15.4%) patients expired. Rotterdam CT score was significant ($p < 0.001$) with age, GCS score, and outcome but not significant with gender ($p = 0.618$). The outcome and individual components of Rotterdam CT classification (basal cistern, midline shift, and intraventricular blood/subarachnoid blood) were statistically significant (►**Table 3**). Univariate analysis revealed that the Rotterdam CT score was significantly associated with mortality (odds ratio: 2.783, 95% confidence interval: 2.011–3.852; $p < 0.001$). The details of 370 patient characteristics, GCS score, and outcome are given in ►**Table 1**. During study period, 53 (14.3%) patients expired. The outcome and individual components on CT score (subdural blood, intracerebral blood, epidural blood, intraventricular blood/subarachnoid blood, and suprasellar blood) were tested for statistical significant (►**Table 3**).

Table 1 Clinical characteristics of 370 patients

Variables	
Age (y)	39.19 ± 15.18
Gender	
Male	280 (75.7%)
Female	90 (24.3%)
Glasgow Coma Scale	
Mild (13–15)	215 (58.1%)
Moderate (9–12)	91 (24.6%)
Severe (3–8)	64 (17.3%)
Rotterdam CT score	
1	29 (7.8%)
2	177 (47.8%)
3	116 (31.4%)
4	34 (9.2%)
5	14 (3.8%)
Outcome	
Alive	313 (84.6%)
Dead	57 (15.4%)

Discussion

Several studies have reported different grading systems and have correlated the imaging findings to predict outcome in cases with TBI.[2,7–10,14–16] Few studies have raised the issue related to the differences between the prognostic models for low-middle and high-income countries and found that only few prognostic models for TBI were developed in low-middle–income countries.[17,18]

Because of its widespread availability and ability to precisely detect and locate intracranial hematomas, contusions, edema, and other mass lesions, the CT scan has become the investigation of choice in TBI patients.[1] Apart from the clinical characteristics, several studies have demonstrated the role of abnormal and positive CT scan to predict the outcome in patients with TBI.[1,2,6,12,13,19,20] As far as the demographic details are concerned, this study is in agreement with many other studies that the TBI involves young adult males.[21,22]

Table 2 Rotterdam CT score versus clinical parameters

Rotterdam CT score	1	2	3	4	5
Age groups (y)					
< 10	0	1	0	0	0
10–20	3	24	10	1	0
21–30	10	46	13	9	4
31–40	5	41	32	6	0
41–50	8	35	35	8	2
51–60	2	21	13	4	4
61–70	1	6	6	3	3
71–80	0	3	6	3	1
> 80	0	0	1	0	0
Head injury according to GCS					
Mild	23	122	62	8	0
Moderate	2	39	35	11	4
Severe	4	16	19	15	10
Mortality					
Patients	29 (7.8%)	177 (47.8%)	116 (31.4%)	34 (9.2%)	14 (3.8%)
Mortality	1 (1.75%)	16 (28.05%)	17 (29.85%)	12 (21.05%)	11 (19.3%)

Many authors have studied the abnormal CT characteristics and suggested different classification and scoring systems to grade the severity of TBI and, based on these abnormal characteristics, to predict the outcome.[2,10,13,20,23–28] It has been found that in moderate and severe TBI, the volume of the intracranial lesions and extent of midline shift are powerful outcome predictors and can be used to predict the outcome of these patients.[29] In the Rotterdam CT score, the authors included individual CT characteristics (i.e., the status of basal cisterns, midline shift, and types of mass lesions or intracranial hemorrhage) and combined them to develop a model to predict the outcome in patients with moderate to severe TBI who underwent decompressive craniectomy.[2,28,30,31] A study involving pediatric patients (<17 years) reports that children with lower scores have better survival outcome as compared with adults with same scoring, but children with higher Rotterdam CT scores have worst survival as compared with adults.[28] The authors concluded that the Rotterdam CT scoring system can be a relatively objective, simple, and practical tool to prognosticate the outcome in both adults and pediatric patients with TBI.[2,28,30,31] In our study, we found that easy-to-use model and result showed that the higher the Rotterdam CT score, the poorer the outcome (it is in agreement with published literature).[2,28,30,31]

Table 3 Outcome and predictor in Rotterdam CT score classification

Rotterdam CT score	Outcome		*p*-Value
	Dead	Alive	
Basal cisterns			
Normal	37	282	<0.001
Compressed	20	31	
Midline shift			
< 5 mm	30	295	<0.001
> 5 mm	27	18	
Epidural mass lesion			
Present	8	56	0.479
Absent	49	257	
Intraventricular hemorrhage or subarachnoid hemorrhage			
Present	35	132	0.007
Absent	22	181	

Conclusion

CT is widely used in emergency as the standard investigation tool for the evaluation of structural injuries and to plan the management of TBI patients. Although it is possible to predict the outcome just based on CT scan findings, because of obvious reasons predicting outcome that is solely based on CT scan findings can have significant shortcomings. To further verify these differences, there is a need for more research with more reliable data from low- and middle-income countries to help improve our understanding regarding the differences (if any) relating to prediction models.

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