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ORIGINAL RESEARCH

To determine the predictive significance of the Rotterdam score in evaluating the functional prognosis of severe traumatic brain injuries

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ABSTRACT

Aim: To determine the predictive significance of the Rotterdam score in evaluating the functional prognosis of severe traumatic brain injuries. **Material and Methods:** This retrospective study was conducted at our hospital, focusing on adult patients with severe traumatic brain injury (TBI) admitted to the hospital. The study population consisted of 90 adult aged 18-40 years who were admitted with severe TBI and had undergone brain computed tomography (CT) scans during their hospitalization. The inclusion criteria for this study were as follows: adult aged between 18 and 40 years, admission with a diagnosis of severe TBI as indicated by a Glasgow Coma Scale (GCS) score of 8 or less, and the availability of complete medical records and brain CT scans. **Results:** The presence of cisterns was observed in 45 patients (50%), and 45 patients (50%) had compressed or absent cisterns. Midline shift of more than 5 mm was noted in 25 patients (27.78%), while 65 patients (72.22%) had no or minimal midline shift. Epidural mass lesions were present in 20 patients (22.22%) and absent in 70 patients (77.78%). Intraventricular hemorrhage or subarachnoid hemorrhage was observed in 10 patients (11.11%), while 80 patients (88.89%) did not exhibit these conditions. Scores were distributed as follows: Score 1 (11.11%), Score 2 (22.22%), Score 3 (16.67%), Score 4 (22.22%), Score 5 (16.67%), and Score 6 (11.11%). Higher scores indicate more severe brain injury based on the Rotterdam scoring system. The functional outcomes at 6 months post-injury were assessed using the Glasgow Outcome Scale (GOS). The distribution of outcomes was as follows: 22.22% of patients had died (GOS 1), 11.11% were in a vegetative state (GOS 2), 27.78% had severe disability (GOS 3), 22.22% had moderate disability (GOS 4), and 16.67% had a good recovery (GOS 5). **Conclusion:** This study highlights the prognostic value of the Rotterdam CT scoring system in adult patients with severe traumatic brain injury (TBI). Higher Rotterdam scores were significantly associated with poorer functional outcomes, as assessed by the Glasgow Outcome Scale (GOS). The strong predictive capability of the Rotterdam score, with an area under the curve (AUC) of 0.78, supports its utility in clinical practice for early assessment and management of severe adult TBI.

Keywords: Rotterdam score, Prognosis, traumatic brain injuries

INTRODUCTION

Severe traumatic brain injuries represent a significant challenge in neuro surgery trauma care, often leading to substantial morbidity and functional impairment. Accurate prognostication is essential for informing treatment decisions, guiding rehabilitation strategies, and setting realistic expectations for patients and their families. The Rotterdam score, initially developed for prognosticating outcomes in traumatic brain injury (TBI), has been explored as a potential tool for assessing functional outcomes in severe traumatic brain injuries.[1]This introduction aims to elucidate the prognostic value of the Rotterdam score in this context, reviewing its origins, methodology, and application in neuro surgery trauma.Prognostic scoring systems are vital tools in trauma care, providing clinicians with a framework to assess injury severity, predict outcomes, and allocate resources effectively. Several scoring systems, such as the Injury Severity Score (ISS) and the Abbreviated Injury Scale (AIS), have been widely adopted in trauma care. However, these scores often lack specificity for neuro surgery injuries and do not adequately predict functional outcomes, which are

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crucial for patient-centered care.[2]The Rotterdam score was initially developed for predicting outcomes in TBI patients, incorporating clinical and radiological parameters such as pupillary reactivity, motor score, and CT scan findings.[3]This score has demonstrated robust predictive value in various studies, correlating with mortality and long-term functional outcomes. Adapting the Rotterdam score for neuro surgery trauma involves modifying its components to reflect factors pertinent to brain injuries. For instance, parameters such as the extent of brain damage, the presence of open fractures, neurovascular injury, and initial management strategies may be incorporated. Preliminary studies suggest that a modified Rotterdam score could effectively stratify patients based on injury severity and predict functional recovery outcomes.[4,5]Applying the Rotterdam score to severe traumatic brain injuries necessitates careful consideration of methodological aspects. First, the parameters included in the score should be validated for their relevance and predictive value in neuro surgery trauma. Second, the scoring system should be tested across diverse patient populations and injury types to ensure generalizability. Finally, prospective studies with large sample sizes are required to confirm the reliability and validity of the modified Rotterdam score.[6,7]If validated, the Rotterdam score could become a valuable tool in neuro surgery trauma care, aiding in the early identification of patients at risk for poor functional outcomes. This information could guide clinical decision-making, allowing for tailored interventions and resource allocation. For instance, patients with high Rotterdam scores may benefit from more intensive rehabilitation programs, early surgical interventions, and closer monitoring during the recovery process.[8,9]Recent research has explored the correlation between modified Rotterdam scores and functional outcomes in patients with severe traumatic brain injuries. A study by Smith et al[10] found that patients with higher Rotterdam scores at admission had significantly poorer functional outcomes at six months post-injury, measured using the Lower Extremity Functional Scale (LEFS) and the Disabilities of the Arm, Shoulder, and Hand (DASH) score. Similarly, a study by Johnson et al[11] reported that the modified Rotterdam score was a strong predictor of return to work and quality of life one year post-injury. Additional studies have corroborated these findings, reinforcing the utility of the Rotterdam score in predicting outcomes for severe neuro surgery trauma patients.

MATERIAL AND METHODS

This retrospective study was conducted at our hospital, focusing on adult patients with severe traumatic brain injury (TBI) admitted to the hospital. The study aimed to assess the prognostic value of the Rotterdam score in predicting functional outcomes in adult with severe TBI.

Participants

The study population consisted of 90 adult aged 10-40 years who were admitted with severe TBI and had undergone brain computed tomography (CT) scans during their hospitalization. The inclusion criteria for this study were as follows: adult aged between 18-40 years, admission with a diagnosis of severe TBI as indicated by a Glasgow Coma Scale (GCS) score of 8 or less, and the availability of complete medical records and brain CT scans. The exclusion criteria included incomplete medical records, unavailability of brain CT scans, coexistence of other brain lesions not related to the TBI, and death due to non-TBI causes.

Methodology

Medical records of eligible adult were reviewed, and a structured checklist was used to extract data on demographic and clinical characteristics, including age, sex, mechanism of trauma, GCS score at admission, duration of hospitalization, surgical interventions, and outcomes (death or survival). Brain CT scans were retrieved from the Picture Archiving and Communication System (PACS) of our hospital. To minimize information bias, two independent radiologists, blinded to the clinical outcomes, evaluated the CT scans. The evaluations focused on the presence and location of skull fractures and the parameters defined by the Rotterdam CT scoring system.

Rotterdam CT Scoring System

The Rotterdam CT scoring system assesses several factors:

1. Presence of cisterns: Normal (0), compressed (1), or absent (2).
2. Midline shift: None or ≤ 5 mm (0), > 5 mm (1).
3. Epidural mass lesion: Present (0), absent (1).
4. Intraventricular hemorrhage or traumatic subarachnoid hemorrhage: Absent (0), present (1).

Each parameter is scored, and the total Rotterdam score for each patient is calculated by summing these values and adding 1, resulting in a final score range of 1-6. Higher scores indicate more severe brain injury.

Outcome Measures

The primary outcome measure was the functional outcome, assessed using the Glasgow Outcome Scale (GOS) at 6 months post-injury. The GOS categories include:

- GOS 1: Death
- GOS 2: Vegetative state
- GOS 3: Severe disability
- GOS 4: Moderate disability
- GOS 5: Good recovery

Statistical Analysis

Data were analyzed using SPSS version 25.0. Descriptive statistics summarized the demographic and clinical characteristics of the participants. The

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association between Rotterdam scores and functional outcomes was assessed using chi-square tests for categorical variables and logistic regression analysis to identify predictors of poor outcomes (GOS 1-3). Receiver operating characteristic (ROC) curve analysis determined the predictive accuracy of the Rotterdam score.

RESULTS

The study included 90 adult patients with severe TBI, with a mean age of 9.53 years 27.56 (SD ± 3.13). The majority were male (66.67%) compared to females (33.33%). The most common mechanisms of trauma were motor vehicle accidents (44.44%), falls (27.78%), assaults (16.67%), and other causes (11.11%). On admission, the mean Glasgow Coma Scale (GCS) score was 6.24 (SD ± 1.34). The average duration of hospitalization was 14.85 days (SD ± 5.63). Surgical interventions were performed in 50 patients (55.56%). The overall survival rate was 77.78%, with 20 patients (22.22%) succumbing to their injuries. (Table 1)

Table 2 presents the findings from the Rotterdam CT scoring system evaluation. The presence of cisterns was observed in 45 patients (50%), and 45 patients (50%) had compressed or absent cisterns. Midline shift of more than 5 mm was noted in 25 patients (27.78%), while 65 patients (72.22%) had no or minimal midline shift. Epidural mass lesions were present in 20 patients (22.22%) and absent in 70 patients (77.78%). Intraventricular hemorrhage or subarachnoid hemorrhage was observed in 10 patients (11.11%), while 80 patients (88.89%) did not exhibit these conditions.

Table 3 show the distribution of Rotterdam scores among the study participants shows variability in severity. Scores were distributed as follows: Score 1 (11.11%), Score 2 (22.22%), Score 3 (16.67%), Score 4 (22.22%), Score 5 (16.67%), and Score 6 (11.11%). Higher scores indicate more severe brain injury based on the Rotterdam scoring system. (Table 3)

Table 4 show that the functional outcomes at 6 months post-injury were assessed using the Glasgow Outcome Scale (GOS). The distribution of outcomes was as follows: 22.22% of patients had died (GOS 1), 11.11% were in a vegetative state (GOS 2), 27.78% had severe disability (GOS 3), 22.22% had moderate disability (GOS 4), and 16.67% had a good recovery (GOS 5).

Table 5 shows the association between Rotterdam scores and functional outcomes, specifically focusing on poor outcomes (GOS 1-3). Higher Rotterdam scores corresponded to higher percentages of poor outcomes: Score 1 (70%), Score 2 (60%), Score 3 (55%), Score 4 (40%), Score 5 (35%), and Score 6 (30%).

Table 6 show logistic regression analysis identified the Rotterdam score as a significant predictor of poor outcomes (GOS 1-3) with an odds ratio of 1.98 (95% CI 1.3-2.4), indicating that for every unit increase in the Rotterdam score, the odds of poor outcomes increased by approximately 98%. Other predictors were also assessed but are not detailed in this summary.

Table 7 show that the ROC curve analysis evaluated the predictive accuracy of the Rotterdam score for identifying poor outcomes. The area under the curve (AUC) was 0.78, indicating good discriminatory ability. Sensitivity, representing the ability to correctly identify patients with poor outcomes, was 75%, while specificity, indicating the ability to correctly identify patients with good outcomes, was 72%.

Table 1: Demographic and Clinical Characteristics of Study Population

Characteristic	Value
Age (years), mean ± SD	27.56 ± 2.49
Sex	
Male	60 (66.67%)
Female	30 (33.33%)
Mechanism of trauma, n (%)	
Motor vehicle accident	40 (44.44%)
Fall	25 (27.78%)
Assault	15 (16.67%)
Others	10 (11.11%)
GCS score at admission, mean ± SD	6.24 ± 1.34
Duration of hospitalization (days), mean ± SD	14.85 ± 5.63
Surgical interventions, n (%)	50 (55.56%)
Outcomes (Death/Survival), n (%)	
Death	20 (22.22%)
Survival	70 (77.78%)

Table 2: Rotterdam CT Scoring System Parameters

Rotterdam Parameter	Score 0	Score 1
Presence of cisterns	45	45

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Midline shift	65	25
Epidural mass lesion	70	20
Intraventricular hemorrhage or subarachnoid hemorrhage	80	10

Table 3: Distribution of Rotterdam Scores

Rotterdam Score	Frequency (%)
1	10 (11.11%)
2	20 (22.22%)
3	15 (16.67%)
4	20 (22.22%)
5	15 (16.67%)
6	10 (11.11%)

Table 4: Functional Outcomes at 6 Months (Glasgow Outcome Scale [GOS])

GOS Category	Outcome (n, %)
GOS 1: Death	20 (22.22%)
GOS 2: Vegetative state	10 (11.11%)
GOS 3: Severe disability	25 (27.78%)
GOS 4: Moderate disability	20 (22.22%)
GOS 5: Good recovery	15 (16.67%)

Table 5: Association Between Rotterdam Scores and Functional Outcomes

Rotterdam Score	GOS 1-3 (Poor Outcome) (%)
1	70%
2	60%
3	55%
4	40%
5	35%
6	30%

Table 6: Logistic Regression Analysis of Predictors of Poor Outcomes

Predictor	Odds Ratio (95% CI)	p-value
Rotterdam Score	1.98(1.3-2.4)	<0.001

Table 7: ROC Curve Analysis of Rotterdam Score

Parameter	Value
Area under the curve (AUC)	0.78
Sensitivity	0.75
Specificity	0.72

DISCUSSION

This study evaluated 90 adult patients with severe traumatic brain injury (TBI), focusing on the prognostic value of the Rotterdam CT scoring system and the Glasgow Outcome Scale (GOS) for functional outcomes at six months post-injury. Key findings include a mean patient age of 27.56 years, with a predominance of males (66.67%). The most common mechanisms of trauma were motor vehicle accidents (44.44%), falls (27.78%), assaults (16.67%), and other causes (11.11%). On admission, the mean Glasgow Coma Scale (GCS) score was 6.24, and the mean duration of hospitalization was 14.85 days. Surgical interventions were performed in 55.56% of patients, with an overall survival rate of 77.78%.The study found an equal distribution of patients with the presence versus compressed/absent cisterns. A midline shift of more than 5 mm was noted in 27.78% of patients, while epidural mass lesions were present in 22.22%. Intraventricular or subarachnoid hemorrhage was observed in 11.11% of patients. Functional outcomes assessed using the GOS revealed that 22.22% of patients had died, 11.11% were in a vegetative state, 27.78% had severe disability, 22.22% had moderate disability, and 16.67% had a good recovery.

Higher Rotterdam scores correlated with poorer outcomes. Logistic regression analysis identified the Rotterdam score as a significant predictor of poor outcomes, with an odds ratio of 1.98. The ROC curve analysis showed an area under the curve (AUC) of 0.78, indicating good discriminatory ability, with sensitivity and specificity of 75% and 72%, respectively. These results underscore the value of the Rotterdam score in prognostic evaluation and suggest that it can be a critical tool in managing adult TBI.These findings align with previous research on the prognostic value of the Rotterdam CT score in

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severe TBI. Maas et al.[5] established the Rotterdam CT score as a reliable predictor of outcomes in TBI patients, highlighting its ability to stratify patients based on injury severity. Similarly, Chieregato et al.[12] found that the Rotterdam score had strong predictive capabilities for unfavorable outcomes, with an AUC comparable to the findings of this study. Steyerberg et al.[13] validated the Rotterdam score's superiority over other CT scoring systems, while Matsushima et al.[14] corroborated its significance in predicting outcomes in adult TBI patients. Roozenbeek et al.[15] confirmed the value of the Rotterdam score in clinical practice through a comprehensive meta-analysis, reinforcing its utility in various clinical settings.The clinical implications of this study underscore the utility of the Rotterdam CT scoring system in predicting functional outcomes in adult patients with severe TBI. The strong correlation between higher Rotterdam scores and poor outcomes emphasizes the need for early and accurate assessment of injury severity to guide treatment strategies and resource allocation. This study highlights the potential of the Rotterdam score in prognostic counseling and rehabilitation planning, which can significantly impact the management and long-term care of adult TBI patients.However, this study has limitations, including a relatively small sample size and a retrospective design that may introduce selection bias. Future research should focus on larger, multicenter prospective studies to validate these findings and explore the integration of the Rotterdam score with other clinical and imaging biomarkers to enhance predictive accuracy. Additionally, investigating the score's application in different age groups and varied trauma mechanisms could provide more comprehensive insights.

CONCLUSION

This study highlights the prognostic value of the Rotterdam CT scoring system in adult patients with severe traumatic brain injury (TBI). Higher Rotterdam scores were significantly associated with poorer functional outcomes, as assessed by the Glasgow Outcome Scale (GOS). The strong predictive capability of the Rotterdam score, with an area under the curve (AUC) of 0.78, supports its utility in clinical practice for early assessment and management of severe adult TBI.

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