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Original Article

Evaluating the Rotterdam Score as a Prognostic tool for Traumatic Brain Injury Outcomes

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ABSTRACT

Background: Traumatic brain injury (TBI) is a major cause of mortality and long-term disability worldwide. Early prognostication is essential for guiding clinical management. The Rotterdam CT Score is a validated imaging-based tool designed to predict outcomes following TBI. This study evaluates the prognostic accuracy of the Rotterdam Score in patients presenting with TBI at a tertiary care centre.

Materials and Methods: A retrospective observational study was conducted in the Department of Radiodiagnosis at Vydehi Institute of Medical Sciences and Research Centre from January 2024 to June 2025. A total of 200 TBI patients aged ≥18 years with complete clinical and radiological records were included. Initial CT scans were assessed using the Rotterdam CT Score. Outcomes were evaluated at 6 months using the Glasgow Outcome Scale (GOS). Sensitivity, specificity, and predictive values were calculated to determine prognostic performance.

Results: Of the 200 patients, 152 (76%) were males and 48 (24%) were females, with a mean age of 37 years. Rotterdam Scores were distributed as follows: Score 1 (42%), Score 2 (36%), Score 3 (14%), and Score 4 (8%). At 6-month follow-up, 38% achieved good recovery (GOS 5), while 2% died (GOS 1). The Rotterdam Score demonstrated a sensitivity of 80%, specificity of 76%, positive predictive value of 91.35%, and negative predictive value of 54.55% for predicting adverse outcomes.

Conclusion: The Rotterdam CT Score is a valuable and reliable prognostic tool for predicting functional outcomes in TBI patients. Higher scores are significantly associated with poor prognosis and increased mortality. Its ease of application and strong predictive performance support its continued use in emergency neurotrauma evaluation.

Keywords*: Traumatic brain injury, Rotterdam CT Score, prognosis, computed tomography, Glasgow Outcome Scale.*

INTRODUCTION

Traumatic brain injury (TBI) is a major global health concern and remains one of the leading causes of mortality and long-term disability worldwide. It affects individuals of all age groups but is particularly prevalent among young adults involved in road traffic accidents (RTAs) [1]. According to recent estimates, TBI contributes to substantial socioeconomic burden due to prolonged hospitalization, rehabilitation needs, and loss of productivity [2].

Early identification of life-threatening intracranial injuries plays a crucial role in guiding clinical decision-making and improving patient outcomes. Computed tomography (CT) of the brain is the initial imaging modality of choice for evaluating acute TBI because of its rapid availability, sensitivity to intracranial hemorrhage, and ability to detect mass effect or herniation [3]. However, CT findings alone may not fully predict patient prognosis unless interpreted using a validated scoring system.

The Rotterdam CT Score, introduced by Maas et al., is a widely accepted imaging-based prognostic system that refines the earlier Marshall classification. It incorporates key radiological parameters such as basal cistern status, degree of midline shift, presence of epidural hematomas, and traumatic subarachnoid or intraventricular haemorrhage [4]. This scoring system has shown significant correlation with mortality and functional outcomes in TBI patients and is increasingly being used in both clinical and research settings [5].

Predicting outcomes following TBI is essential for triage, family counselling, and resource allocation. The Glasgow Outcome Scale (GOS) remains the standard functional outcome measure for assessing recovery following brain injury [6]. Studies have demonstrated that higher Rotterdam scores are associated with poorer outcomes and increased mortality, while lower scores correlate with better recovery [7].

Despite its widespread use, there is limited region-specific evidence evaluating the prognostic accuracy of the Rotterdam Score in diverse patient populations. Therefore, the present study aims to assess the predictive value of the Rotterdam CT Score for TBI outcomes in patients presenting to a tertiary care centre. This evaluation will enhance understanding of its utility in routine clinical practice and support more informed prognosis estimation.

MATERIALS AND METHODS

Study Design and Setting

A retrospective observational study was conducted to evaluate the prognostic utility of the Rotterdam CT Score in patients diagnosed with traumatic brain injury (TBI). The study was carried out in the Department of Radiodiagnosis at Vydehi Institute of Medical Sciences and Research Centre (VIMS & RC). It included all eligible cases from January 2024 to June 2025.

Ethical Considerations

The study protocol received approval from the Institutional Ethics Committee of VIMS & RC. All procedures adhered to institutional and national ethical guidelines. Patient confidentiality was ensured by anonymising all identifiable information before data extraction and analysis.

Study Population

A total of 200 patients who presented with TBI during the study period were included. The cohort consisted of 152 males and 48 females.

Inclusion Criteria

- Adults aged 18 years and above.
- Patients diagnosed with TBI on admission.
- Availability of initial CT imaging scored using the Rotterdam Score.

Exclusion Criteria

- Incomplete or missing clinical or radiological records.
- Non-traumatic brain injuries (e.g., stroke, neoplasm, infections).
- Patients not assessed using the Rotterdam CT Score at initial evaluation.

Data Collection

Data were extracted from electronic medical records and radiology archives. The following variables were collected:

1. **Demographic Data:** age, sex, and relevant comorbidities.

2. **Clinical Variables:**
    a. Glasgow Coma Scale (GCS) score on admission
    b. Pupil reactivity
    c. Mechanism of injury (road traffic accident, blunt trauma, penetrating injury)

3. **Radiological Assessment:**
    Initial CT scans were evaluated according to the Rotterdam CT Score, incorporating:
    a. Status of basal cisterns
    b. Degree of midline shift
    c. Traumatic subarachnoid/intraventricular hemorrhage

d. Presence of epidural mass lesion

4. **Outcome Assessment**
Patient outcomes were assessed using the Glasgow Outcome Scale (GOS) at 6-month follow-up and categorised as:
1 – Death
2 – Persistent vegetative state
3 – Severe disability
4 – Moderate disability
5 – Good recovery

Statistical Analysis
Descriptive statistics (mean, standard deviation, frequencies, and percentages) were used to summarise demographic and clinical characteristics. The predictive validity of the Rotterdam CT Score for clinical outcomes was evaluated by calculating sensitivity and specificity. Data analysis was performed using standard statistical software.

RESULTS AND OBSERVATIONS

Table 1: Demographic Characteristics of the Study Population (n = 200)

Variable	Value
➢ **Mean Age (years)**	37
➢ **Sex Distribution**	
Male	152 (76%)
Female	48 (24%)

Table 2: Distribution of Rotterdam CT Scores

Rotterdam Score	Number of Patients (%)
Score 1	84 (42%)
Score 2	72 (36%)
Score 3	28 (14%)
Score 4	16 (8%)

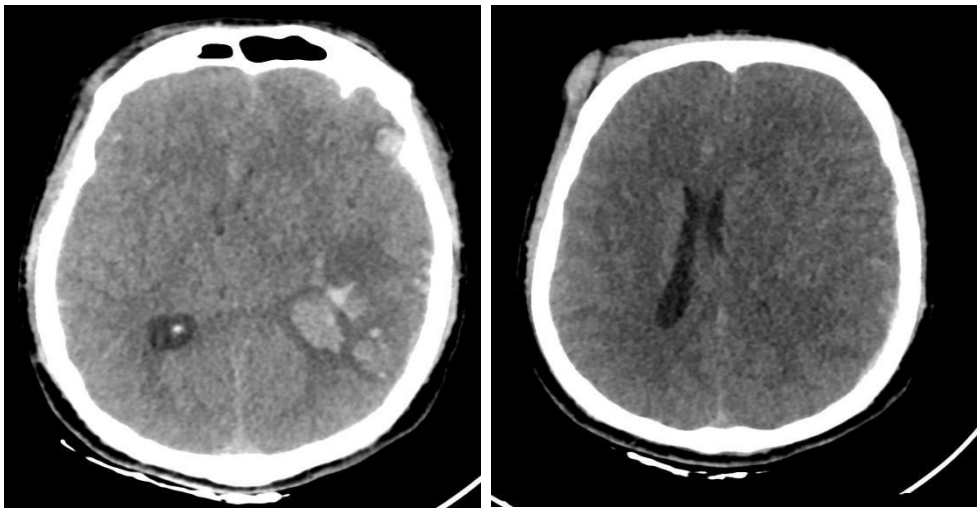
Table 3: Glasgow Outcome Scale (GOS) at 6-Month Follow-Up

GOS Category	Outcome Description	Number of Patients (%)
GOS 1	Death	4 (2%)
GOS 2	Persistent vegetative state	16 (8%)
GOS 3	Severe disability	32 (16%)
GOS 4	Moderate disability	72 (36%)
GOS 5	Good recovery	76 (38%)

Table 4: Predictive Validity of the Rotterdam CT Score

Parameter	Value
Sensitivity	80%
Specificity	76%
Positive Predictive Value (PPV)	91.35%
Negative Predictive Value (NPV)	54.55%
Positive Likelihood Ratio (LR+)	3.33
Negative Likelihood Ratio (LR–)	0.26

Case 1:
35 year old female patient presented with loss of counsciousness following road traffic accident



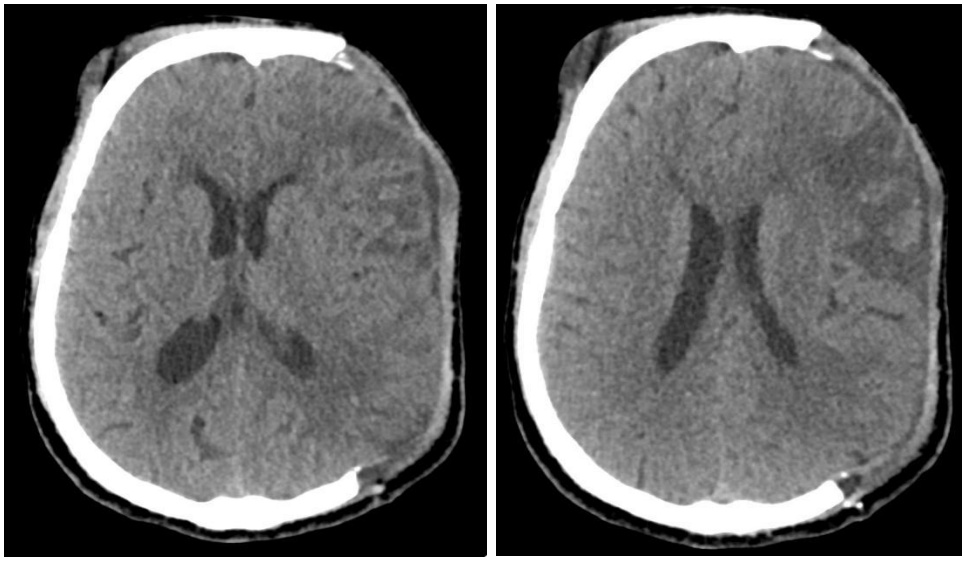
CT scan dated 11-06-2024

Imaging Findings:

- Extradural haemorrhage in the left parietal region.
- Intraparenchymal haemorrhage in the left temporal and occipital regions with a midline shift of 8 mm.
- Multiple intraparenchymal contusions in the left frontal, temporal, and parietal lobes.

Rotterdam Score: 2

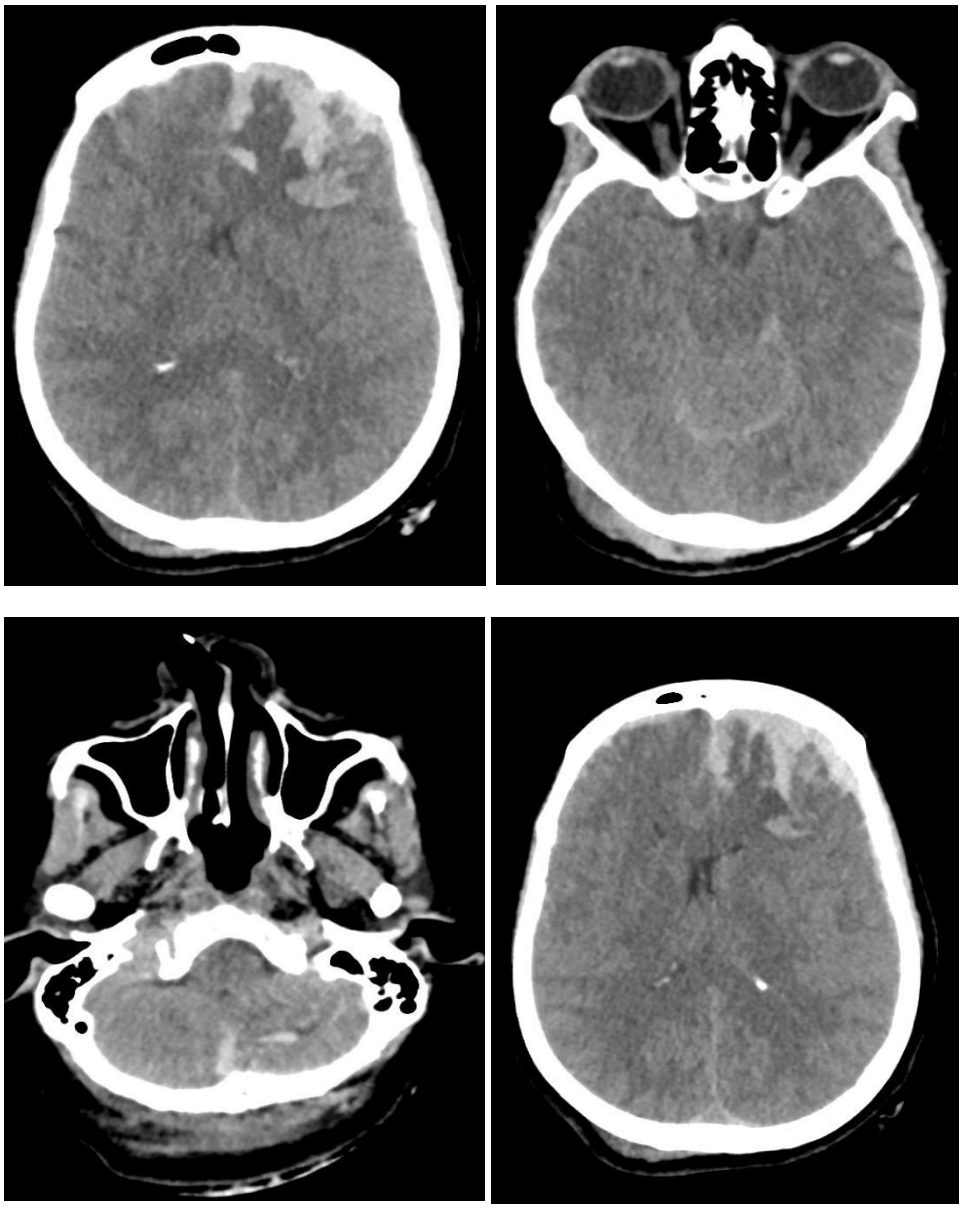
- **Follow-up CT of the same patient done on 15-12-2024. Status post left decompressive craniotomy.**



- Glasgow Outcome Scale (GOS) score: 5
- The patient was doing well on follow-up

Case 2:

24 year old patient presented with history of unresponsiveness and injury to head following road traffic accident



CT scan dated 24-04-2024

Imaging Findings:

- Extradural hemorrhage in the left frontal region.
- Intraparenchymal hemorrhage in the left basifrontal region with a midline shift of 6 mm.
- Subarachnoid hemorrhage in the left temporal region and cerebellar hemisphere.
- Effacement of the basal cisterns.

Rotterdam Score: 5

- **The patient deteriorated rapidly and died within 4 hours of admission**

DISCUSSION

Traumatic brain injury (TBI) continues to be a major global health burden with significant morbidity and mortality, especially in low- and middle-income countries. Accurate early prognostication is essential to guide clinical decision-

making, allocate resources appropriately, and provide realistic expectations to families. In this study, the Rotterdam CT Score showed strong predictive value for 6-month outcomes, consistent with previously published literature. Similar to earlier studies, lower Rotterdam Scores were more prevalent among survivors, whereas higher scores correlated with severe disability and mortality (1,2).

The study demonstrated a clear association between increasing Rotterdam Score and poorer Glasgow Outcome Scale (GOS) categories. This finding aligns with the original work by Maas et al., who reported a stepwise increase in mortality risk with each incremental rise in Rotterdam Score (3). Previous multicentre analyses have similarly shown that CT variables such as basal cistern compression, midline shift, and traumatic subarachnoid haemorrhage are strong indicators of unfavourable prognosis (4,5).

The sensitivity (80%) and specificity (76%) observed in the present analysis fall within the range reported in earlier validation studies, reinforcing the robustness of this scoring system (6,7). The high positive predictive value (91.35%) supports its effectiveness in identifying patients at high risk of adverse outcomes. Additionally, features such as effacement of basal cisterns, significant midline shift, and extensive intraparenchymal haemorrhage were associated with poor prognosis, a pattern similarly described in previous literature (8,9).

Despite its strengths, the Rotterdam Score evaluates only structural CT parameters and does not incorporate key physiological indicators such as hypoxia, hypotension, metabolic abnormalities, or secondary brain injury mechanisms. These factors play an important role in determining outcomes and may limit the standalone predictive power of CT-based scoring (10). Emerging research suggests that integration of biomarkers, magnetic resonance imaging (MRI), and machine-learning–based predictive models may further enhance prognostication accuracy (11,12).

Nevertheless, the Rotterdam CT Score remains a practical, rapid, and validated prognostic tool suitable for routine emergency care, especially in resource-limited settings. Its strong performance in this study supports its continued use as an effective method for early risk stratification in TBI patients.

CONCLUSION

The Rotterdam CT Score proved to be a reliable and efficient prognostic tool for evaluating outcomes in patients with traumatic brain injury. In this study, higher Rotterdam Scores were significantly associated with increased mortality and poorer functional outcomes at 6 months, while lower scores correlated with favourable recovery. The scoring system demonstrated good sensitivity and specificity, reaffirming its clinical utility in early risk stratification. Despite its limitations in excluding physiological and biochemical parameters, the Rotterdam Score remains a valuable component of initial TBI assessment, particularly in emergency and resource-limited settings. Integrating CT-based scoring with emerging biomarkers and advanced predictive models may further enhance prognostic accuracy in the future.

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