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Research Article

Role of the Rotterdam CT Score in Predicting Surgical Requirement in Traumatic Intracranial Hemorrhage

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Abstract: ***Introduction:*** Computerized tomography (CT) scanning plays a vital role in the emergency evaluation of head injury patients and remains the primary imaging modality in acute trauma settings. CT imaging is widely available, rapid, and highly effective in detecting acute intracranial abnormalities. To improve prognostic assessment in traumatic brain injury, several CT-based scoring systems have been developed, among which the Rotterdam CT score is widely utilized. **Methods:** A retrospective study was conducted at the Department of General Surgery and Neurosurgery, SSIMS&RC, Davangere, Karnataka, between January 2024 and January 2026. A total of 40 adult patients, who presented traumatic brain injury and had intracranial hemorrhage on NCCT Brain, were enrolled in the study. Data collection included demographic details such as age and sex, GCS on admission, initial CT brain findings and Rotterdam CT scores, neurosurgical intervention and repeat CT scans done during the patients' hospital stay and overall clinical outcomes.**Results:** The admission Glasgow Coma Scale findings in the present study showed a broad range of neurological severity. However, based on the grading of head injury based on the Glasgow Coma Scale, there were equal number of patients with moderate and severe head injury (45%) and the remaining 10% had mild head injury. Based on the Rotterdam CT scoring system, majority of the patients had a score of 2 (40%) on the initial NCCT- Brain. Total number of patients with lower Rotterdam CT scores (1-3) were 27 (67.5%) and the remaining (32.5%) had higher Rotterdam CT score (4-5). Total number of patients that required a neurosurgical intervention were 15 (37.5%). Most of the patients with higher Rotterdam CT scores required surgery while majority of the patients with lower GCS scores were managed conservatively.**Conclusion:** the Rotterdam CT score is a valuable prognostic tool in traumatic brain injury and has significant utility in predicting the need for neurosurgical intervention. Its simplicity, reproducibility, and strong association with outcome make it an effective aid in clinical decision-making, helping improve early management and optimize patient outcomes in head injury care.

Keywords: Traumatic brain injury, intracranial hemorrhage, Computed tomography, Rotterdam CT score, Glasgow Coma Scale, neurosurgical intervention

INTRODUCTION

Traumatic brain injury (TBI) is a major cause of morbidity and mortality worldwide, especially in developing countries like India and represents a significant public health concern.(1) It occurs when an external mechanical force causes disruption of normal brain function or structural damage to the brain.(2) The injury may result from road traffic accidents, falls, assaults, sports injuries, or occupational trauma.(3)

Clinical manifestations vary widely depending on the severity and location of injury and may include transient confusion, loss of consciousness, post-traumatic amnesia, focal neurological deficits, or severe coma.(4) Importantly, traumatic brain injury is not merely an isolated event occurring at the moment of impact. Instead, it initiates a complex cascade of biochemical and cellular processes that continue to evolve over time, contributing to secondary brain injury and influencing long-term neurological outcome.(5) Because of the heterogeneous nature of TBI, patients may demonstrate considerable variation in symptoms, radiological findings, and prognosis.(6)

Traumatic brain injury is commonly classified according to clinical severity into mild, moderate, and severe categories. This classification is primarily based on the level of consciousness and neurological impairment at presentation. Mild injuries may involve brief alteration of mental status or short-term memory disturbance, whereas moderate and severe injuries are associated with prolonged impairment of consciousness and greater risk of intracranial pathology.(7)

Structural classification further categorizes injuries into focal lesions, such as hematomas and contusions, and diffuse injuries, including diffuse axonal injury and cerebral edema.(8) Among the most important pathological consequences of TBI are intracranial hemorrhages, which include epidural hematoma, subdural hematoma, traumatic subarachnoid

hemorrhage, intraparenchymal hemorrhage, and intraventricular hemorrhage. These hemorrhagic lesions can rapidly worsen neurological status and therefore require prompt diagnosis and management.(9)

Computed tomography (CT) plays a vital role in the emergency evaluation of head injury patients and remains the primary imaging modality in acute trauma settings.(10) CT imaging is widely available, rapid, and highly effective in detecting acute intracranial abnormalities.(11) In emergency departments, early identification of life-threatening lesions is essential for timely clinical decision-making and neurosurgical intervention.(12) CT enables visualization of intracranial hemorrhage, skull fractures, cerebral edema, mass effect, midline shift, and compression of basal cisterns.(13) These findings assist clinicians in determining the severity of injury, monitoring progression, and identifying patients at risk of neurological deterioration.(14) CT is particularly valuable in unstable or unconscious patients where clinical examination may be limited or unreliable.(10) Additionally, it provides objective documentation of injury severity, facilitates communication among healthcare teams, and serves as a baseline for follow-up imaging.(15)

To improve prognostic assessment in traumatic brain injury, several CT-based scoring systems have been developed, among which the Rotterdam CT score is widely utilized. This scoring system evaluates specific radiological parameters including the status of basal cisterns, degree of midline shift, presence or absence of epidural hematoma, and the existence of traumatic subarachnoid or intraventricular hemorrhage.(13) Each parameter contributes to an overall numerical score that reflects the severity of intracranial injury.(16) Higher Rotterdam scores are associated with increased mortality and poorer neurological outcomes.(17) The system offers improved prognostic accuracy compared with earlier classification methods because it incorporates multiple independent predictors of outcome.(13) Owing to its simplicity, reproducibility, and strong predictive value, the Rotterdam CT score has become an important tool in clinical practice and research for assessing patients with traumatic brain injury.(18)

Aim:

Use of Rotterdam CT score as a predictor for need of neurosurgical intervention.

Objective:

To evaluate the effectiveness of the Rotterdam CT scoring system in predicting the need for neurosurgical intervention in patients with traumatic brain injury.

MATERIALS AND METHODS

A retrospective study was conducted at the Department of General Surgery and Neurosurgery, SSIMS&RC, Davangere, Karnataka, between January 2024 and January 2026. The study aimed to evaluate the effectiveness of the Rotterdam CT scoring system in predicting the need for neurosurgical intervention in patients with traumatic brain injury.

The sample size was calculated using the formula $n = (Z^2 \times p \times q) / d^2$. Where Zα was 1.96 for a significance level of 0.05, p was the incidence of head injury cases taken as 0.15%, q was calculated as 99.85%, and d was taken as 1% absolute precision.

The calculated sample size was 40.

Patients meeting the inclusion criteria were selected for the study. The inclusion criteria were as follows:

- Patients above the age of 18 years
- Patients with intracranial hemorrhage as seen of NCCT Brain

Exclusion criteria included

- Patients with injuries to chest, abdominal organs or long bones severe enough to effect the overall outcome of the patient were excluded**.**

Data collection included demographic details such as age and sex, along with GCS on admission, initial CT brain findings and Rotterdam CT scores, neurosurgical intervention and repeat CT scans done during the patients' hospital stay. Additionally, the study monitored the number of patients who completed the study and those who were deceased during the study period.

Statistical analysis:

The data were systematically recorded and entered into a spreadsheet for analysis. Statistical analysis was performed using appropriate software, with continuous variables, such as neurosurgical intervention. A p-value of <0.05 was considered statistically significant, indicating a meaningful difference between the groups undergoing neurosurgical intervention and patients who were managed conservatively.

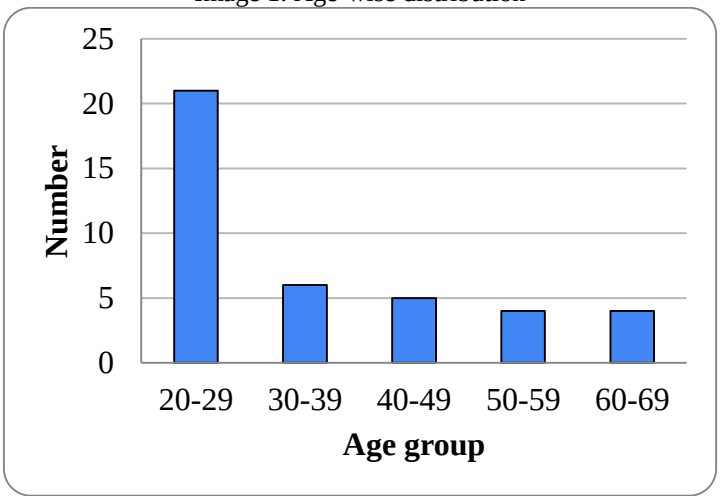
RESULTS

Table 1. Age-wise distribution of participants

Age group	Number	Percentage
20-29	21	52.50%
30-39	6	15%
40-49	5	12.50%

50-59	4	10%
60-69	4	10%

Image 1. Age-wise distribution

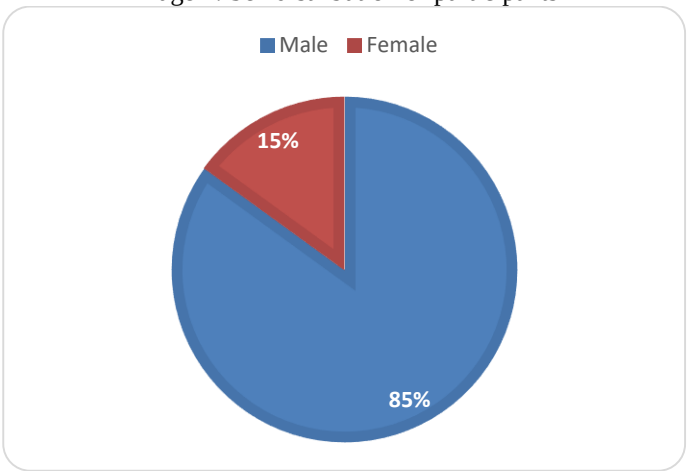


Majority of the patients were within the age of 20-29 years (52.50%) followed by older age groups showing traumatic brain injury being more common in young adults compared to other age groups.

Table 2. Sex distribution of participants

Sex	Number	Percentage
Male	34	75%
Female	6	15%

Image 2. Sex distribution of participants

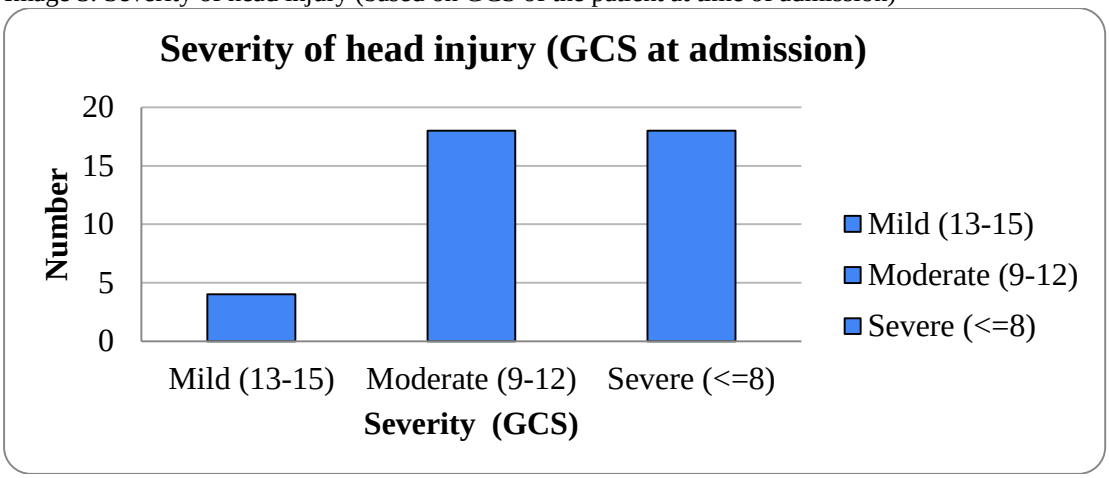


There is a marked male predominance seen (75%) indicating that intracranial hemorrhage following traumatic brain injury occurred far more commonly in males.

Table 3. Severity of head injury (based on GCS of the patient at time of admission)

Severity (GCS)	Number	Percentage
Mild (13-15)	4	10%
Moderate (9-12)	18	45%
Severe (<=8)	18	45%

Image 3. Severity of head injury (based on GCS of the patient at time of admission)

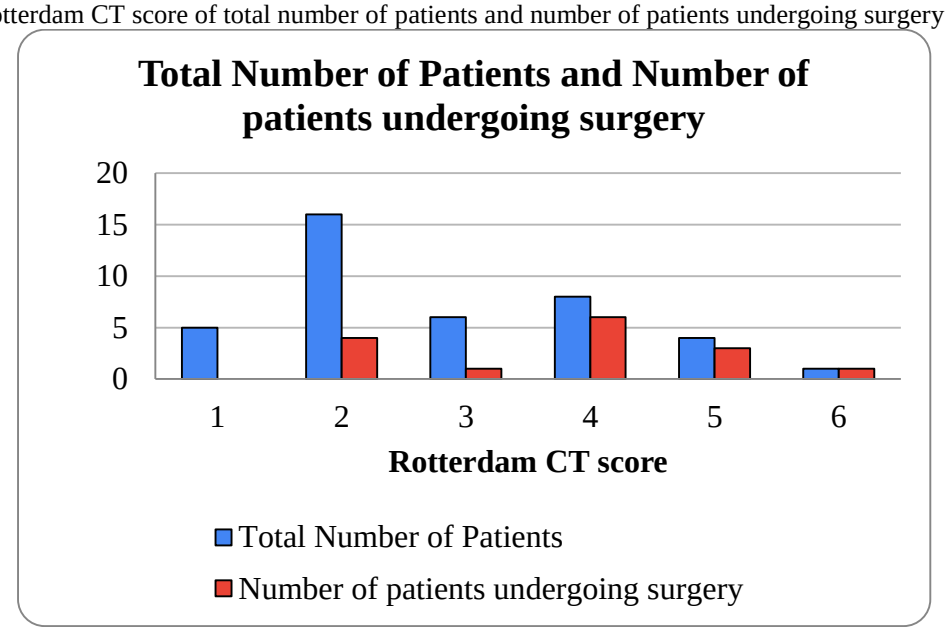


The admission Glasgow Coma Scale findings in the present study showed a broad range of neurological severity. However, based on the grading of head injury based on the Glasgow Coma Scale, there were equal number of patients with moderate and severe head injury (45%).

Table 4. Number of patients with each Rotterdam CT score and number of patients undergoing surgery

Rotterdam CT score	Total Number of Patients	Number of patients undergoing surgery
1	5	0
2	16	4
3	6	1
4	8	6
5	4	3
6	1	1
Total	40	15

Image 4. Rotterdam CT score of total number of patients and number of patients undergoing surgery



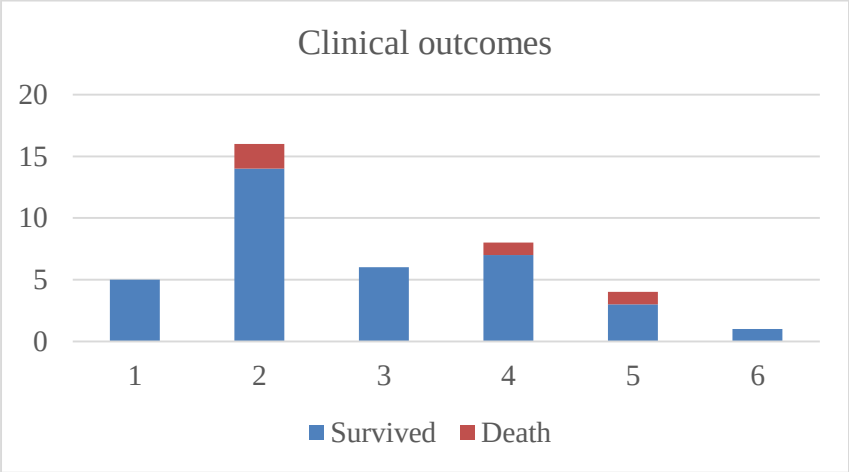
Based on the Rotterdam CT scoring system, majority of the patients had a score of 2 (40%) on the initial NCCT-Brain. Total number of patients with lower Rotterdam CT scores (1-3) were 27 (67.5%) and the remaining (32.5%) had higher Rotterdam CT score (4-5).

However, total number of patients that required a neurosurgical intervention were 15 (37.5%). Most of the patients with higher Rotterdam CT scores required surgery while majority of the patients with lower GCS scores were managed conservatively.

Table 5. Clinical outcomes

Rotterdam CT score	Clinical outcome		
	Survived	Death	Total
1	5	0	5
2	14	2	16
3	6	0	6
4	7	1	8
5	3	1	4
6	1	0	6
	36	4	40

Image 5. Clinical outcomes



Majority of the patients (90%) survived while mortality was observed in 10% of the patients.

DISCUSSION

Early identification, diagnosis, regular monitoring and timely intervention are essential in management of intracranial hemorrhage to obtain a better outcome. The study helps to evaluate if the Rotterdam CT score is a reliable tool to predict the need for surgical intervention.

Sociodemographic comparison

The present study demonstrated a clear predominance of younger patients, with 21 of 40 cases (52.50%) occurring in the 20–30 years age group, followed by older age groups. This indicates that traumatic intracranial hemorrhage in the current cohort largely affected young adults, who are generally more exposed to road traffic trauma, occupational injury, and high-impact physical activity.

The relatively young age structure may partly explain the overall favourable outcome, with 36 patients (90.0%) surviving.

A marked male predominance was observed in the present study, with 34 of 40 patients (75.0%) being male and only 6 patients (15.0%) female. This pattern indicates that traumatic intracranial hemorrhage following traumatic brain injury occurred far more commonly in males, likely due to greater exposure to high-risk environments and mechanisms of injury.

However, despite the higher number of male patients, their study found no statistically significant independent influence of gender on hospital mortality or unfavourable outcome.

Comparison of Rotterdam CT score with surgical intervention and outcomes of the patient

The admission Glasgow Coma Scale findings in the present study showed a broad range of neurological severity. However, based on grading of severity of head injury based on GCS, number of patients with moderate and severe head injury were 45.0% each and patients with mild head injury were the remaining 10%.

Admission GCS remains a crucial severity marker, although it should be interpreted together with CT findings and possible confounding factors such as intoxication.

The CT sum score distribution in the present study showed that score 2 was the most frequent category, seen in 16 patients (40.0%), followed by score 4 in 8 patients (20%), score 3 in 6 patients (15%), score 1 in 5 patients (12.5%), score 5 in 4 patients (10%), and score 6 in 1 patient (2.5%). This indicates that most patients were concentrated in the lower scores of Rotterdam severity, while only a small subset had a high radiological severity.

The present study showed that conservative management was sufficient in 25 of 40 patients (62.5%), indicating that most traumatic intracranial hemorrhages did not require operative treatment and that conservative management was sufficient in all cases with CT scores of 1 and most of cases with CT score of 2 and 3. Majority of the patients with CT scores of 4, 5 and 6 underwent surgery- either craniotomy, decompressive craniectomy or in some cases bilateral frontal craniotomy.

Among the patients that underwent surgery in lower CT scores, 3 patients in CT score 2 and 1 patient with CT score of 3 had severe head injury as per GCS on admission and other 1 patient with CT score of 2 underwent surgery after a repeat CT which showed progressive worsening of head injury.

The patients that did not undergo surgery even with higher CT scores (4,5) had late presentation to the hospital with severe head injury and neurosurgical intervention could not be done as the patients died before the intervention could be planned and performed.

Two patients with initial CT score of 4 and 6 required a second surgery after a repeat CT scan done after the first surgery.

The final clinical outcome in the present study was favourable in the majority of cases, with 36 of 60 patients (90.0%) surviving and mortality observed in 4 patients (10.0%).

This mortality rate indicates that although traumatic intracranial hemorrhage following traumatic brain injury is potentially life-threatening, most patients in the current cohort had outcomes compatible with survival. The relatively low mortality may be related to several favourable baseline features, including the younger age distribution, earlier time of presentation to the hospital, predominance of lower CT scores, early diagnosis and intervention.

Limitations and future directions

Our study's limitations include the relatively small sample size, which may limit the generalizability of the results. Additionally, the study was retrospective, it was not blinded, which could introduce bias in selection of patients. Future research with larger, multicenter trials and blinded assessments would be valuable in further validating these findings. Moreover, exploring the long-term clinical outcomes of patients receiving conservative and surgical interventions could provide further insights into the optimal management for traumatic brain injury and prediction of outcomes from initial CT brain Rotterdam score.

CONCLUSION

Overall, the Rotterdam CT score is a valuable prognostic tool in traumatic brain injury and has significant utility in predicting the need for neurosurgical intervention. Its simplicity, reproducibility, and strong association with outcome make it an effective aid in clinical decision-making, helping improve early management and optimize patient outcomes in head injury care.

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