

Original Research

## Outcome in Pediatric Population of Traumatic Brain Injury Based on Rotterdam Score

Nadia Banaras<sup>1</sup>, Aneeta Gazal<sup>2</sup>, Rabail Zamir<sup>3</sup>, Sumayya Gilani<sup>4</sup>

<sup>1</sup>Department of Neurosurgery, Trauma Center, Civil Hospital, Quetta

<sup>2</sup>Department of Neurosurgery, Fouji Foundation Hospital, Rawalpindi

<sup>3</sup>Department of Neurosurgery, Indus Medical College, Tando Muhammad Khan

<sup>4</sup>Department of Neurosurgery, Pakistan Air Force (PAF) Hospital, Islamabad – Pakistan

### ABSTRACT

**Objective:** To evaluate the predictive value of the Rotterdam CT score for in-hospital mortality in pediatric TBI.

**Materials & Methods:** This prospective observational study was performed in the Emergency Department, Section of Neurosurgery, Trauma Center, Civil Hospital. CT brain imaging was performed at admission, and outcomes were assessed over two weeks.

**Results:** The patients had a mean age of  $10.18 \pm 4.74$  years; 96 (66.7%) were boys, and 48 (33.3%) were girls. Road traffic accidents were recorded in 64 (44.45%) cases. Nineteen patients died, giving an overall mortality of 13.1%. Mortality rose as the Rotterdam score increased and was greatest at score 6. The association between Rotterdam score and mortality was statistically significant (Chi-square = 15.043;  $p < 0.001$ ).

**Conclusion:** In this pediatric cohort, the Rotterdam score was useful for estimating the risk of mortality after TBI.

**Keywords:** Traumatic brain injury, pediatric population, computed tomography, Rotterdam score.

**Corresponding Author:** Nadia Banaras

Senior Registrar, Neurosurgery

Trauma Center Civil Hospital, Quetta

Email: nadiabanaras94@gmail.com

Date of Submission: 22-01-2026

Date of Revision: 15-08-2026

Date of Acceptance: 20-09-2026

Date of Online Publishing: 30-9-2026

Date of Print: 30-9-2026

DOI: 10.36552/pjns.v30i3.1301

### INTRODUCTION

Traumatic brain injury (TBI) refers to impaired brain function caused by an external force or to structural brain injury demonstrated on CT imaging. It is an important contributor to childhood death and disability. Pediatric TBI may involve the scalp, skull, or brain, and presentation can range from headache and nausea to loss of consciousness.<sup>1-3</sup>

Published estimates of pediatric TBI range from 47 to 280 cases per 100,000 children and vary by region. Boys become more frequently affected

after three years of age. In younger children, falls predominate, whereas in adolescents, road traffic and sports-related injuries are seen more often.<sup>4,5</sup>

In children, to assess consciousness and grade head injury severity, the Glasgow Coma Scale (GCS) is routinely used. A less favorable prognosis and more severe injury are generally associated with lower scores. As GCS does not describe intracranial abnormalities on CT, imaging-based scores may add more prognostic information.<sup>6-9</sup>

A key early investigation in acute TBI is a non-contrast CT scan, because it can reveal lesions requiring urgent treatment. The Marshall Classification System and Rotterdam Scoring System are commonly used CT-based approaches. The Rotterdam score considers basal cisterns, midline shift, epidural mass lesion, and intraventricular blood or traumatic subarachnoid hemorrhage, and produces a total score from 1 to 6; increasing scores indicate increasing mortality risk.<sup>10-14</sup>

Although the Rotterdam score has been widely validated in adults, evidence in pediatric TBI remains limited. The present study therefore examined its relationship with mortality among children treated for traumatic brain injury at Civil Hospital, Quetta.

## MATERIALS AND METHODS

### Study Design & Setting

A prospective observational study was conducted in the neurotrauma care unit of Civil Hospital Trauma Center, Quetta, from January 1, 2024 to December 31, 2024. Non-probability consecutive sampling was used. Ethical approval was granted by the Ethical Review Committee and Clinical Study Unit, Civil Hospital Trauma Center, Quetta (Ethical Approval/Registration No. PG135).

### Inclusion and Exclusion Criteria

Children aged one to eighteen years who fulfilled the study criteria were enrolled. Patients were

excluded if surgery had been performed before the initial non-contrast CT scan, if they had a previous neurological disorder or neurosurgical procedure, or if they had multiple trauma. Written informed consent was obtained from the parent or legal guardian before inclusion.

### Data Collection

Age, sex, medical record number, date of presentation, mechanism of injury, post-resuscitation GCS, CT findings, neurological intervention, and hospital outcome (alive or dead) were recorded on a structured proforma. CT scans were reviewed by a radiologist who was unaware of the clinical outcome. Rotterdam scores were assigned from the CT findings by a radiologist, and operative treatment was undertaken when clinically indicated.

### Data Analysis

The primary outcome was in-hospital mortality during the two-week observation period. Data were analyzed in SPSS version 23. Continuous variables were summarized as mean and standard deviation, whereas categorical variables were reported as frequencies and percentages. Associations between categorical variables were tested with the chi-square test, and  $p < 0.05$  was regarded as statistically significant.

## RESULTS

### Demographic Characteristic

The analysis included 144 children with significant head trauma. Ten (6.9%) were aged 1-2 years, 28 (19.4%) were aged 3-5 years, 29 (20%) were aged 6-9 years, 26 (18%) were aged 10-12 years, 22 (15%) were aged 13-15 years, and 22 (15%) were aged 16-18 years. There were 96 boys (66.7%) and 48 girls (33.3%). Road traffic accidents accounted for 64 (44.45%) injuries, while falls accounted for 18 (12.5%).

## Distribution of Rotterdam CT Scores

The mean Rotterdam score was  $2.1 \pm 1$ . Score 2 was the most frequent category and occurred in 62 patients (43.05%). Score 1 was recorded in 10 patients (6.9%), score 3 in 38 (27.08%), score 4 in 22 (15.27%), score 5 in 8 (5.5%), and score 6 in 3 (2.08%).

## Clinical Outcomes and Mortality

Nineteen children died in hospital (13.1%), while 125 survived (86.8%). Mortality increased across Rotterdam categories: there were no deaths at Score 1: 5 deaths (7.9%); score 2: 5 (12.8%); score 3: 4 (18.1%); score 4: 3 (37.5%); score 5; and 2 (66.6%) at score 6.

## Factors Associated with Outcome

Rotterdam score, age group, and sex were tested for association with mortality. Tables 2 and 3 show that mortality was significantly related to a higher Rotterdam score and greater TBI severity. Sex, mechanism of injury, and age were not statistically significant predictors.

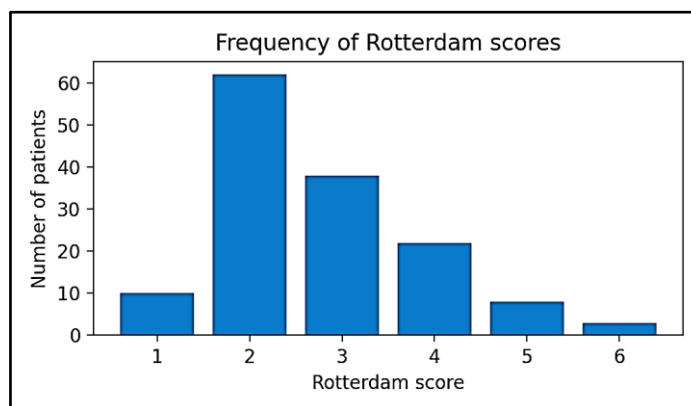
## DISCUSSION

Traumatic brain injury may follow either closed or open cranial trauma and remains a major source of childhood morbidity and mortality. Children with head injury form a substantial proportion of emergency visits and hospital admissions. It can be seen clearly that with age, injury patterns change: in younger children, falls are more frequent, while in older children and adolescents, road traffic injuries become increasingly important. The mean age in this series was  $10.18 \pm 4.18$  years, which is in keeping with reports showing that school-aged children and adolescents are particularly vulnerable.<sup>21-25</sup>

Haque et al. reported road traffic accidents as the principal cause of pediatric TBI, with falls

**Table 1:** Rotterdam Score [14].

| Serial | Parameter                               | Score                   |
|--------|-----------------------------------------|-------------------------|
| 1      | Basal cistern                           | 0 = normal              |
|        |                                         | 1 = compressed          |
|        |                                         | 2 = absent              |
| 2      | Midline shift                           | 0 = none or $\leq 5$ mm |
|        |                                         | 1 = $> 5$ mm            |
| 3      | Epidural mass lesion                    | 0 = present             |
|        |                                         | 1 = absent              |
| 4      | Intraventricular blood or traumatic SAH | 0 = absent              |
|        |                                         | 1 = present             |
| Sum    |                                         | Range: 1-6              |



**Figure 1:** Descriptive statistics of frequency and Rotterdam score of patients.

**Table 2:** Descriptive Statistics of Rotterdam Score and Patient Outcome.

| Rotterdam Score | Alive (%)  | Death (%) | P-Value | Chi-Square |
|-----------------|------------|-----------|---------|------------|
| 1               | 9 (100%)   | 0 (0%)    | 0.001   | 15.043     |
| 2               | 58 (92%)   | 5 (7.9%)  |         |            |
| 3               | 34 (87.1%) | 5 (12.8%) |         |            |
| 4               | 18 (81.8%) | 4 (18.1%) |         |            |
| 5               | 5 (62.5%)  | 3 (37.5%) |         |            |
| 6               | 1 (33.3%)  | 2 (66.6%) |         |            |

**Table 3:** Descriptive Statistics of Severity of TBI and Patient Outcome

| Severity of Traumatic Brain Injury | Alive       | Death      | P-Value |
|------------------------------------|-------------|------------|---------|
| Severe                             | 4 (2.7%)    | 14 (9.72%) | 0.00    |
| Moderate                           | 46 (31.9%)  | 5 (3.47%)  |         |
| Mild                               | 75 (52.08%) | 0 (0%)     |         |
| Total                              | 125         | 19         |         |

ranking next in several series. Among all injuries in our cohort, 44.45% were road traffic accidents, emphasizing the predominance of road traffic accidents among children presenting to tertiary trauma centers in Pakistan.<sup>20,26,27</sup>

In our study, the pediatric TBI mortality rate was 13.1%, while Kate et al, reported a corresponding rate of 16%. This was a little lower than what Kate et al, found; however, it was still within the range of 5% to 53% reported in other published studies. The reason why the mortality rate differs among studies is because of a few factors, such as how severe the injuries are, which patients are chosen for the study, when the patients are sent to the hospital, whether there are doctors who can perform brain surgery, and whether there are resources to take care of the patients in the intensive care unit.<sup>28-31</sup>

The most frequent category in this cohort was Rotterdam score 2. It was observed that, as the score rose, mortality progressively increased, and two of the three patients with a score of 6 did not survive. Liesemer et al, and Haque et al, have reported similar trends, observing that higher Rotterdam Scores were associated with increasing mortality. Therefore, our findings are consistent with these pediatric studies, supporting the value of the Rotterdam score as a useful CT-based prognostic tool associated with poorer outcomes at higher scores.<sup>10-12,20,29,32</sup>

Although available studies support its prognostic value, evidence on Rotterdam scoring in pediatric TBI is less extensive than in adults. Liesemer et al, studied more than 600 children with moderate-to-severe TBI and found an association between Rotterdam score and mortality. The score may therefore assist clinical assessment and prioritization of resources in pediatric neurotrauma.<sup>11,20,29</sup>

The study was limited by its modest sample size, single-center setting, and brief follow-up. Confirmation of the predictive performance of the Rotterdam score will require larger multicenter pediatric studies with longer outcome assessment.

## CONCLUSION

The findings indicate that the Rotterdam score can help predict mortality in children with traumatic brain injury. Road traffic accidents were the leading mechanism, followed by falls from height. Age, sex, and mechanism of injury were not significant predictors, whereas Rotterdam score and TBI severity showed strong relationships with mortality. Combining standardized neurological assessment with CT findings may improve early estimation of prognosis in pediatric head injury.

## REFERENCES

1. Brain Injury Association Of America. BIAA adopts new TBI definition. [online] 2011 [cited 2020 Mar 4]. Available from: <https://www.biausa.org/public-affairs/public-awareness/news/biaa-adopts-new-tbi-definition>.
2. Araki T, Yokota H, Morita A. Pediatric traumatic brain injury: characteristic features, diagnosis, and management. *Neurol Med Chir*. 2017;57:82-93. Doi: <https://doi.org/10.2176/nmc.ra.2016-0191>.
3. Dang B, Chen W, He W, Chen G. Rehabilitation treatment and progress of traumatic brain injury dysfunction. *Neural Plast*. 2017;2017:1582182. Doi: <https://doi.org/10.1155/2017/1582182>.
4. Dewan MC, Mummareddy N, Wellons III JC, Bonfield CM. Epidemiology of global pediatric traumatic brain injury: qualitative review. *World Neurosurg*. 2016;91:497-509. Doi: <https://doi.org/10.1016/j.wneu.2016.03.045>.
5. Centers for Disease Control and Prevention. Injury prevention and control: traumatic brain injury. *Natl Vital Stat Rep*. 2014;6. DOI: Not available.
6. Kochanek PM, Carney N, Adelson PD, Ashwal S, Bell MJ, Bratton S, et al. Guidelines for the acute medical management of severe traumatic brain injury in infants, children, and adolescents. *Pediatr Crit Care Med*. 2012;13(2):252-8. Doi: <https://doi.org/10.1097/PCC.0b013e31823f435c>.
7. Campbell CGN, Kuehn SM, Richards PMP, Ventureyra E, Hutchison JS. Medical and cognitive outcome in children with traumatic brain injury. *Can J Neurol Sci*. 2004;31(2):213-9. Doi: <https://doi.org/10.1017/S0317167100003403>.

8. Chung CY, Chen CL, Cheng PT, See LC, Tang SF, Wong AM. Critical score of Glasgow Coma Scale for pediatric traumatic brain injury. *Pediatr Neurol*. 2006;34(5):379-87.  
Doi: <https://doi.org/10.1016/j.pediatrneurol.2005.10.012>.
9. Ghaffarpasand F, Razmkon A, Dehghankhalili M. Glasgow Coma Scale score in pediatric patients with traumatic brain injury: limitations and reliability. *Bull Emerg Trauma*. 2013;1(4):135-6. Doi: Not available.
10. Huang YH, Deng YH, Lee TC, Chen WF. Rotterdam computed tomography score as a prognosticator in head-injured patients undergoing decompressive craniectomy. *Neurosurgery*. 2012;71(1):80-5.  
Doi: <https://doi.org/10.1227/NEU.0b013e318258a0d0>.
11. Liesemer K, Riva-Cambrin J, Bennett KS, Bratton SL, Tran H, Metzger RR, et al. Use of Rotterdam CT scores for mortality risk stratification in children with traumatic brain injury. *Pediatr Crit Care Med*. 2014;15(6):554-62.  
Doi: <https://doi.org/10.1097/PCC.000000000000177>.
12. Charry J, Falla J, Ochoa J, Pinzon M, Tejada JH, Henriquez MJ, et al. External validation of the Rotterdam computed tomography score in the prediction of mortality in severe traumatic brain injury. *J Neurosurg Rural Pract*. 2017;8(Suppl 1):S23-S26.  
Doi: <https://doi.org/10.4103/0976-3147.196466>.
13. Waqas M, Shamim MS, Enam SF, Qadeer M, Bakhshi SK, Patoli I, et al. Predicting outcomes of decompressive craniectomy: use of Rotterdam CT classification and Marshall classification. *Br J Neurosurg*. 2016;30(2):258-63.  
Doi: <https://doi.org/10.3109/02688697.2015.1119249>.
14. The Brain Trauma Foundation. Guidelines: computed tomography scan features. *J Neurotrauma*. 2000;17(6-7):597-627.  
Doi: Not available.
15. Anderson T, Heitger M, Macleod AD. Concussion and mild head injury. *Pract Neurol*. 2006;6:342-7.  
Doi: <https://doi.org/10.1136/jnnp.2006.106583>.
16. Adirim TA, Wright JL, Lee E, Lomax TA, Chamberlain JM. Injury surveillance in a pediatric emergency department. *Am J Emerg Med*. 1999;17:499-503.  
Doi: [https://doi.org/10.1016/S0735-6757\(99\)90129-7](https://doi.org/10.1016/S0735-6757(99)90129-7).
17. Ashaleye CM, Famurewa OC, Komolafe EO, Komolafe MA, Amusa YB. The pattern of computerized tomographic findings in moderate and severe head injuries in Ile-Ife, Nigeria. *West Afr J Radiol*. 2005;12:8-13. Doi: Not available.
18. Ogunseyinde AO, Obajimi MO, Ogundare SM. Radiological evaluation of head trauma by computed tomography in Ibadan, Nigeria. *West Afr J Med*. 1999;18:33-8. Doi: Not available.
19. Akang EE, Kuti MA, Ogunkoya AO, Komolafe EO, Malomo AO, Shokunbi MT, et al. Pattern of fatal head injuries in Ibadan: a 10-year review. *Med Sci Law*. 2002;42:160-6.  
Doi: <https://doi.org/10.1258/rsmmsl.42.2.160>.
20. Haque A, Dhanani Z, Ali A, Salam B, Abbas Q, Javed G, Jurair H. Outcome of traumatic brain injury in children by using Rotterdam score on computed tomography. *J Ayub Med Coll Abbottabad*. 2018;30(1):140-5. Doi: Not available.
21. Emejulu JK, Shokunbi MT. Aetiological patterns and management outcomes of pediatric head trauma: one year prospective study. *Niger J Clin Pract*. 2010;13:276-9. Doi: Not available.
22. Pathak A, Desania NL, Verma R. Profile of road traffic accidents and head injury in Jaipur. *J Indian Acad Forensic Med*. 2008;30:6-9. Doi: Not available.
23. Ghebrehiwet M, Quan LH, Andebirhan T. The profile of CT scan findings in acute head trauma in Orotta Hospital, Asmara, Eritrea. *J Eritrean Med Assoc*. 2008;3:58. Doi: Not available.
24. Ohaegbulam SC, Mezue WC, Ndubuisi CA, Erechukwu UA, Ani CO. Cranial computed tomography scan findings in head trauma patients in Enugu, Nigeria. *Surg Neurol Int*. 2011;2:136.  
Doi: <https://doi.org/10.4103/2152-7806.85638>.
25. Nelson DW, Nystrom H, MacCallum RM, Thornquist B, Lilja A, Bellander BM, et al. Extended analysis of early computed tomography scans of traumatic brain injured patients and relations to outcome. *J Neurotrauma*. 2010;27(1):51-64.  
Doi: <https://doi.org/10.1089/neu.2009.0955>.
26. Mata-Mbemba D, Mugikura S, Nakagawa A, Murata T, Ishii K, Li L, et al. Early CT findings to predict early death in patients with traumatic brain injury: Marshall and Rotterdam CT scoring systems compared in a major academic tertiary care hospital in northeastern Japan. *Acad Radiol*. 2014;21(5):605-11. Doi: <https://doi.org/10.1016/j.acra.2014.01.009>.
27. Maas AI, Hukkelhoven CW, Marshall LF, Steyerberg EW. Prediction of outcome in traumatic brain injury with computed tomographic characteristics: a comparison between the computed tomographic classification and combinations of computed

- tomographic predictors. Neurosurgery. 2005;57(6):1173-82.  
Doi: <https://doi.org/10.1227/01.NEU.0000186013.63046.6B>.
28. Talari HR, Fakharian E, Mousavi N, Abedzadeh-Kalahroudi M, Akbari H, Zoghi S. The Rotterdam scoring system can be used as an independent factor for predicting traumatic brain injury outcomes. *World Neurosurg.* 2016;87:195-9.  
Doi: <https://doi.org/10.1016/j.wneu.2015.10.035>.
  29. Liesemer K, Riva-Cambrin J, Bennett KS, Bratton SL, Tran H, Metzger RR, et al. Use of Rotterdam CT scores for mortality risk stratification in children with traumatic brain injury. *Pediatr Crit Care Med.* 2014;15(6):554-62.  
Doi: <https://doi.org/10.1097/PCC.0000000000000177>.
  30. Hirsch W, Schobess A, Eichler G, et al. Severe head trauma in children: cranial computer tomography and clinical consequences. *Paediatr Anaesth.* 2002;12(4):337-44.  
Doi: <https://doi.org/10.1046/j.1460-9592.2002.00846.x>.
  31. Tasker RC, Fleming TJ, Young AE, et al. Severe head injury in children: intensive care unit activity and mortality in England and Wales. *Br J Neurosurg.* 2011;25(1):68-77.  
Doi: <https://doi.org/10.3109/02688697.2010.548882>.
  32. Haque A, Dhanani Z, Ali A, Salam B, Abbas Q, Javed G, Jurair H. Outcome of traumatic brain injury in children by using Rotterdam score on computed tomography. *J Ayub Med Coll Abbottabad.* 2018;30(1):140-5. Doi: Not available.

## Additional Information

**Disclosures:** The authors report no conflict of interest.

**Ethical Review Board Approval:** Approval was obtained from the Ethical Review Committee and Clinical Study Unit, Civil Hospital Trauma Center, Quetta (Ethical Approval/Registration No. PG135).

**Human Subjects:** Written informed consent was obtained from the parent or legal guardian of every enrolled patient.

**Conflicts of Interest:** All authors declare that they have no conflicts of interest related to this work.

**Financial Relationships:** The authors declare no financial relationship with any organization that could have influenced the submitted work.

**Other Relationships:** The authors declare no other relationship or activity that could reasonably be perceived to have influenced this manuscript.

**Data Availability Statement:** De-identified study data may be made available by the corresponding author upon reasonable request and subject to institutional approval.

**Artificial Intelligence (AI) Statement:** No artificial intelligence (AI) tool was used to compile this research.

**Funding:** None.

## AUTHORS CONTRIBUTIONS

| Role              | Contributing Author(s)             | Role                                        | Contributing Author(s)             |
|-------------------|------------------------------------|---------------------------------------------|------------------------------------|
| Conceptualization | Nadia Banaras                      | Data Curation.                              | Aneeta Ghazal, Rabail Zamir        |
| Methodology       | Nadia Banaras, Rabail Zamir        | Writing – Original Draft/Literature Review. | Nadia Banaras                      |
| Software          | none                               | Writing – Review & Editing.                 | Nadia Banaras, Syeda Sumaya Gilani |
| Validation        | Aneeta Ghazal, Syeda Sumaya Gilani | Visualization.                              | Rabail Zamir                       |
| Formal analysis   | Rabail Zamir                       | Supervision.                                | Syeda Sumaya Gilani                |
| Investigation     | Nadia Banaras, Dr. Aneeta Ghazal   | Project administration.                     | Nadia Banaras                      |
| Resources         | Nadia Banaras                      |                                             |                                    |