# Applicability of the Revised Trauma Score in Paediatric Patients Admitted to a South African Intensive Care Unit: A Retrospective Cohort Study

**Cameron Kuronen-Stewart, Nirav Patel, Tarryn Gabler, Isabel Khofi-Phiri[1], Gladness Dakalo Nethathe[1], Jerome Loveland**

Department of Paediatric Surgery, Faculty of Health Sciences, University of the Witwatersrand, [1]Division of Critical Care, Intensive Care Unit, Faculty of Health Sciences, University of the Witwatersrand, Chris Hani Baragwanath Academic Hospital, Johannesburg, South Africa

## Abstract

**Context:** Revised Trauma Score (RTS) is a validated tool in assessing patients in a pre-hospital setting. There are limited data describing its potential use in guiding referral to intensive care. **Aims:** Trauma scoring systems require appropriate validation in a local setting before effective application. This work examines the applicability of RTS to a paediatric intensive care trauma population. **Settings and Design:** A retrospective record review of trauma patients admitted to the paediatric intensive care unit at Chris Hani Baragwanath Academic Hospital between 2011 and 2013 was performed. **Subjects and Methods:** The cohort was arbitrarily split into three subgroups based on RTS using the 33rd and 66th percentile values and groups compared. Outcome measures examined included mortality, age, gender, length of stay (LoS), duration of ventilation (DoV) and change in Glasgow Coma Scale (GCS) from admission to discharge. **Statistical Analysis Used:** Categorical values examined with Fisher's exact test. Non-categorical values examined with the Kruskal–Wallis and Dunn's multiple comparisons tests. **Results:** Of 919 children admitted, 165 admissions were secondary to trauma. Data necessary for calculation of RTS were available in 91 patients. The mean RTS was 5.3, 33rd percentile was 4.7 and 66th was 5.9. DoV ($P = 0.0104$) and LoS ($P = 0.0395$) were significantly different between intermediate- and low-risk groups as was change in GCS between low-risk and both other groups ($P < 0.0001$). **Conclusions:** RTS is not predictive of mortality between high-risk (RTS < 4.09) and low-risk patients (RTS > 5.67) in this population. It may be useful in predicting other outcomes such as DoV and LoS.

**Keywords:** Paediatric surgery, paediatric trauma, Revised Trauma Score, South Africa

## Introduction

The foremost cause of morbidity and mortality amongst children across the globe is trauma, which accounts for 40% of all childhood deaths.[1] Mortality from childhood trauma is disproportionately and unacceptably high in low- and middle-income countries (LMICs). In children under the age of 15, approximately 95% of the one million annual trauma-related mortalities occur in LMICs.[1,2] Non-fatal injuries add to the burden of trauma, with 390,000 disability-adjusted life years (DALY) lost globally every year in children under 15.[1,3] Again, the burden of morbidity is disproportionately high in LMICs, which account for 90% of all DALYs.[1] The most common mechanisms of paediatric trauma in South Africa are Road traffic accidents (RTA), burns, falls and assault.[4]

The consequences of childhood injury can impact other key aspects of childhood health such as educational, social, psychological and economic well-being.[5] Paediatric trauma cannot be underestimated and is a significant public health problem requiring appropriate recognition and intervention. However, the lack of appropriate data describing the burden of paediatric trauma in an intensive care setting represents a significant obstacle in enhancing strategies for injury prevention in South Africa.[1]

A variety of different scoring systems have been widely used to assess and guide the treatment of trauma patients. Triage

**Received:** 04-05-2020 **Revised:** 21-06-2020 **Accepted:** 13-07-2020 **Available Online:** 20-07-2021

| Access this article online | |
|---|---|
| Quick Response Code: | **Website:** www.afrjpaedsurg.org |
| | **DOI:** 10.4103/ajps.AJPS_33_20 |

**Address for correspondence:** Dr. Cameron Kuronen-Stewart,
34 Alnwickhill Road, Edinburgh, EH16 6LN, UK.
E-mail: c.kuronen.stewart@gmail.com



**How to cite this article:** Kuronen-Stewart C, Patel N, Gabler T, Khofi-Phiri I, Nethathe GD, Loveland J. Applicability of the revised trauma score in paediatric patients admitted to a South African intensive care unit: A retrospective cohort study. Afr J Paediatr Surg 2021;18:150-4.

scores such as the Trauma Score (TS) and RTS are typically used to determine physiological risk, guide referral patterns in a pre-hospital setting and as prognostic tools.[6] The RTS requires few data to calculate and has been previously validated in both adult and paediatric populations.[6-9] Although it was originally developed as a triage tool, its use has since been expanded to allow prognostication and prediction of outcomes in trauma patients.[10] The RTS may be calculated using the formula shown in Figure 1.[8]

Before effective application of a clinical score to any specific population, there must be objective validation of the tool within that population. Whilst the validity of RTS in predicting outcome in an adult intensive care unit (ICU) population has been examined,[11] the authors are not aware of any previous validation data in a paediatric ICU setting. As such, we set out to examine the validity of RTS as a predictive tool for clinical outcome in a paediatric trauma ICU population.

## Subjects and Methods

A retrospective record review of all trauma patients admitted to the paediatric ICU (PICU) at the Chris Hani Baragwanath Academic Hospital (CHBAH) between 1 January 2011 and 31 January 2013 was performed. Data on patient demographics, injury pattern, treatment interventions and patient outcomes were collected and RTS was calculated. The cohort was arbitrarily split into three subgroups based on RTS. The group above the 66th percentile was classified as low risk, between the 33rd and 66th as intermediate risk and below the 33rd as high risk. No burns patients were included as these patients are admitted to a separate ICU facility at CHBAH.

Outcome measures that were compared between groups were mortality, age, gender, length of stay (LoS), duration of ventilation (DoV) and change in Glasgow Coma Scale (GCS). Change in GCS was calculated by subtracting GCS on admission from GCS at discharge after excluding all mortalities. For continuous variables such as age, change in GCS, LoS and DoV, the non-parametric Kruskal–Wallis test followed by Dunn's multiple comparisons test was used for analysis. Categorical variables such as mortality and gender were analysed using Fisher's exact test. All descriptive statistics were generated with Microsoft Excel™ (Redmond, Washington). Statistical significance was defined as $P \leq 0.05$.

$$RTS = (0.9368 \times GCS\ coded\ value) + (0.7326 \times SBP\ coded\ value) + (0.2908 \times RR\ coded\ value$$

| Glasgow Coma Scale (GCS) | Systolic blood pressure (SBP) | Respiratory rate (RR) | Coded value |
|---|---|---|---|
| 13-15 | >89 | 10-29 | 4 |
| 9-12 | 76-89 | >29 | 3 |
| 6-8 | 50-75 | 6-9 | 2 |
| 4-5 | 1-49 | <6 | 1 |
| 2T-3 | 0 | 0 | 0 |

**Figure 1:** (a and b) Equation used to calculate the Revised Trauma Score (above) and clinical parameters and assigned coded values used (below)

Statistical tests were run using GraphPad Prism version 7 software (GraphPad software Inc, US). Ethics clearance was obtained from the University of the Witwatersrand Human Research Ethics Committee. All data collected remained anonymous.

## Results

The mean RTS across all patients was 5.3, with the 33rd and 66th percentile values being 4.7 and 5.9, respectively. Thus, the cohort was divided into a high-risk group (RTS <4.7), an intermediate-risk group (≥4.7 and <5.9) and a low-risk group (RTS ≥5.9). This is summarised in Figure 2.

Table 1 compares the demographic and outcome variables between the whole study cohort and each of the groups. The mean age of the high-risk (6.3) and the intermediate-risk groups (6.0) was higher than the total cohort (5.9) and the low-risk groups (5.4). There was a male preponderance throughout the entire cohort (58%:42%) and all risk groups.

Although mortality rate was higher in high-risk (16%) and intermediate-risk groups (9.6%) compared to the total cohort (8.8%) and the low-risk group (2.9%), no statistical significance was observed when comparing the groups to one another.

DoV and LoS were significantly different when compared between intermediate- and low-risk groups ($P = 0.0104$ and $P = 0.0395$, respectively) but not between other groups. Change in GCS was strongly significant when compared between intermediate and low risk ($P < 0.0001$), as well as between high and low risk ($P < 0.0001$) but not between high and intermediate risk ($P = 0.0803$). These data are presented in Table 2.

Data describing mechanism of injury by risk group are presented in Table 3. The most common mechanism of injury in all groups was RTA, with a higher proportion of pedestrian-vehicle accident (PVA) than motor vehicle

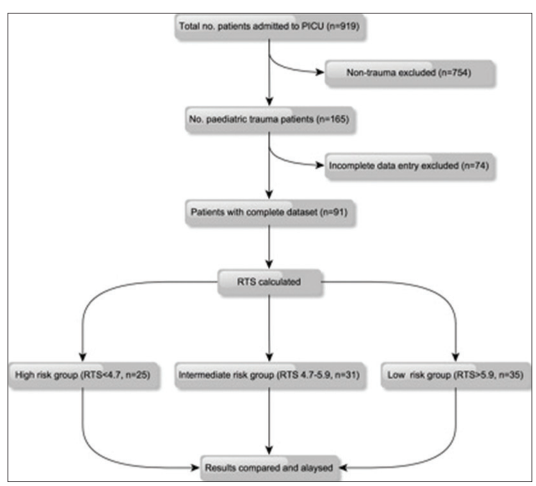


**Figure 2:** Breakdown of patients included and excluded from the final analysis

**Table 1: Comparison of variables between groups**

| | Total | High risk | Intermediate risk | Low risk |
|---|---|---|---|---|
| No. of patients | 91 | 25 | 31 | 35 |
| Age (yrs) | | | | |
| Mean | 5.9 | 6.3 | 6.0 | 5.4 |
| Median (IQR) | 5.8 (3.1-8.0) | 5.8 (3.1-8.4) | 6.3 (2.9-8.9) | 4.8 (3.4-7.3) |
| Gender (M: F) | 53:38 (58%:42%) | 13:12 (52%:48%) | 19:12 (61%:39%) | 21:14 (60%:40%) |
| No. Mortalities (%) | 8 (8.8%) | 4 (16.0%) | 3 (9.6%) | 1 (2.9%) |
| Length of Stay (Days) | | | | |
| Mean | 7.5 | 6.6 | 9.4 | 6.5 |
| Median (IQR) | 5 (4-9) | 5 (4-7) | 6 (4.5-12) | 4 (2-7.5) |
| Duration of Ventilation (days) | | | | |
| Mean | 5.4 | 5.2 | 7.2 | 3.9 |
| Median (IQR) | 4 (2-5) | 4 (3-8) | 4 (3-7.5) | 3 (1-4) |
| Change in GCS | | | | |
| Mean | 7.2 | 10.5 | 8.6 | 4.0 |
| Median (IQR) | 7 (4.5-11) | 11 (10-12) | 9 (7-11) | 4 (2-6) |

**Table 2: Comparison of statistically significant variables and mortality between RTS groups**

| Group | Mean | Comparison | *P* |
|---|---|---|---|
| Duration of Ventilation | | | |
| High risk | 6.6 | HR vs. IR | >0.9999 |
| Intermediate risk | 9.4 | IR vs. LR | 0.0104* |
| Low risk | 6.5 | HR vs. LR | 0.1335 |
| Length of Stay | | | |
| High risk | 5.2 | HR vs. IR | 0.8922 |
| Intermediate risk | 7.2 | IR vs. LR | 0.0395* |
| Low risk | 3.9 | HR vs. LR | 0.6175 |
| Change in GCS | | | |
| High risk | 10.5 | HR vs. IR | 0.0803 |
| Intermediate risk | 8.6 | IR vs. LR | <0.0001* |
| Low risk | 4 | HR vs. LR | <0.0001* |
| Mortality | | | |
| High risk | - | HR vs. IR | 0.6880 |
| Intermediate risk | - | IR vs. LR | 0.3346 |
| Low risk | - | HR vs. LR | 0.1502 |

HR=High risk, IR=Intermediate risk and LR=Low risk

accident (MVA) throughout. Other injuries included fall from height, near drowning, foreign body aspiration, dog bite, assault, blunt force injury and railway associated injury.

The most common site of injury throughout the cohort was head injury (43.2%), followed by long bone injury (17.1%), thoracic injury (14.4%) and intra-abdominal injury (13.7%). There were a higher proportion of head injury and long bone injury in the high- and intermediate-risk groups as compared to the low-risk group. These data are summarised in Table 4.

## Discussion

CHBAH is one of the highest volume trauma centres in the world and only has 8 PICU beds available to trauma patients that must be shared with all other medical and surgical patients.[12] More than one in six patients admitted to PICU at CHBAH are trauma patients. Within this setting, a validated severity assessment tool for trauma would be useful in making referral decisions by prognosticating and identifying candidates for referral who would be particularly likely to benefit from PICU admission. It may also help in decisions about resource allocation in tertiary centres with relatively low PICU capacity such as CHBAH.

The RTS has been successfully validated as a triage tool in both adult and paediatric populations and is the most widely used TS in the literature.[6-9] Its advantages compared to other TSs are that it relies purely on objective parameters, thus improving inter-rater reliability.[6] The parameters used in the RTS form part of the basic assessment of any patient in the hospital or pre-hospital environment, making its use more feasible and acceptable.

Limitations of the RTS include that is was originally validated in an adult American trauma population[8] and its applicability to other settings has not been specifically proven. RTS is a versatile tool but has classically been reported to weight certain injuries (for instance, head injury) proportionately higher than others.[10,13] Further, the RTS relies on purely physiological parameters, and clinicians must use it in conjunction with clinical details such as mechanism of injury and anatomical site of injury.[14,15]

Within hospital, TSs may be used in mobilisation of specific trauma teams and senior staff, as a predictor of outcomes and in evaluating the quality of care and benchmarking.[10,16] Classically, RTS has been shown to be a robust tool in predicting mortality but less so in predicting other outcomes.[6,10,13,17-19] It has not yet been evaluated to be able to predict Intesive Therapy Unit (ITU) admission or to aid in decisions regarding ITU referral.

In our cohort, RTS was unable to predict mortality with any statistical significance. This is contrary to the experience

**Table 3: Comparison of number and proportion of different mechanism of injury between RTS risk groups**

| Mechanism of Injury | High risk (*n*) | Intermediate risk (*n*) | Low risk (*n*) | Total |
|---|---|---|---|---|
| Road Traffic Injuries | 20 (80.0%) | 27 (87.0%) | 25 (71.4%) | 72 (79.1%) |
| Pedestrian Vehicle accidents | 15 (60.0%) | 21 (67.7%) | 15 (42.9%) | 51 (56.0%) |
| Motor vehicle accidents | 5 (20.0%) | 6 (19.4%) | 10 (28.6%) | 21 (23.1%) |
| Fall from Height | 1 (4.0%) | 2 (6.5%) | 1 (2.9%) | 4 (4.4%) |
| Near Drowning | 1 (4.0%) | 1 (3.2%) | 1 (2.9%) | 3 (3.3%) |
| Foreign Body Aspiration | 0 | 0 | 2 (5.7%) | 2 (2.2%) |
| Dog bite | 1 (4.0%) | 0 | 1 (2.9%) | 2 (2.2%) |
| Assault | 0 | 0 | 2 (5.7%) | 2 (2.2%) |
| Blunt force injury/heavy object | 1 (4.0%) | 1 (3.2%) | 3 (8.6%) | 5 (5.5%) |
| Railway associated injury | 1 (4.0%) | 0 | 0 | 1 (1.1%) |
| Total (*n*) | 25 | 31 | 35 | 91 |

**Table 4: Comparison of site of injury between groups**

| Site of injury | High risk (*n*) | Intermediate risk (*n*) | Low risk (*n*) | Total |
|---|---|---|---|---|
| Head | 20 (47.6%) | 24 (49.0%) | 19 (34.5%) | 63 (43.2%) |
| Long bone | 9 (21.4%) | 10 (20.4%) | 6 (10.9%) | 25 (17.1%) |
| Thoracic | 4 (9.5%) | 6 (12.2%) | 11 (20.0%) | 21 (14.4%) |
| Intra-abdominal | 5 (11.9%) | 6 (12.2%) | 9 (16.4%) | 20 (13.7%) |
| Pelvis | 2 (4.8%) | 2 (4.1%) | 3 (5.9%) | 7 (4.8%) |
| Cervical spine | 0 | 0 | 1 (1.8%) | 1 (0.7%) |
| Other | 2 (4.8%) | 1 (2.0%) | 6 (10.9%) | 9 (6.2%) |
| Total (*n*) | 42 | 49 | 55 | 146 |

of many other series examining the predictive applicability of the RTS.[6,10,13,17-19] Although not significantly different, there was a definite observable trend between groups with mortality rate reducing from the high-risk group (16%) to the intermediate-risk (9.6%) and low-risk groups (2.9%). Inability to show a significant reduction in mortality with increasing RTS may be due to the small sample size of the cohort. As such, evaluation of larger cohorts is warranted in order to interpret the prognostic ability of the RTS with respect to mortality in the PICU setting.

Change in GCS from admission to discharge in patients who survived was also significantly different between the high- and low-risk groups and the intermediate-risk and low-risk groups. This was not the case when comparing the high- and intermediate-risk groups. This variable has not been examined in the literature before, but the authors suggest that it can be interpreted as a relative proxy of neurological improvement. These results show that patients in intermediate and low RTS scores show greater neurological improvement than those with high RTS scores providing useful information for prognostication.

The most common mechanism of injury was road traffic injury (RTI), which conforms with both local and international data.[20-23] PVAs were more common than MVAs. This is contrary to data from developed countries where MVA is much more common than PVA in all age groups.[24] In our series, patients in the high- and intermediate-risk groups had a higher proportion of RTIs as compared to those in the low-risk group. This reflects a higher severity of injury from RTIs as compared to other injuries.[24,25] Proportions of other mechanisms of injury were broadly similar between groups with no trends identified.

The most common anatomical site of injury was head injury, followed by long bone injury and thoracic injury. This propensity for head trauma conforms to international literature, which suggests a high burden of head injury in the global paediatric population.[26,27] Our high- and intermediate-risk groups had a higher proportion of head injury as compared to those in the low-risk group scores. It therefore appropriately triages head injury with reduced GCS as high risk. The undertriage of isolated head injury was a classic limitation of the TS before its revision.[6,17]

RTS is a purely physiological score, with no component for assessment of anatomical site of injury. Therefore, care must be taken in both pre-hospital and hospital settings to correlate the RTS with mechanism and site of injury.[6,10,17] To overcome this problem, other scores such as Injury Severity Score that use the anatomical site of injury to predict outcome can be combined with RTS into scores that take both of these approaches into account. Examples of these scores include the Trauma and Injury Severity Score, which is shown to be an effective mortality prediction model that performs well in both adult and paediatric populations. However, it is more tedious to compute as compared to RTS and uses many different clinical parameters that may be difficult to collect and use in the clinical setting. Therefore, its feasibility and acceptability as a triage score and TS is variable, especially in a pre-hospital setting.[6,17] Balance must be struck between feasibility of use and effective clinical predictions when using TSs.

## Conclusions

RTS is not predictive of mortality between high-risk (RTS <4.09) and low-risk patients (RTS >5.67) in a South African Paediatric Intensive Care trauma population. RTS may be of value in prognostication and predication of other outcomes such as DoV, LoS and change in GCS from admission to discharge. Further work, ideally in a prospective study, is required before recommendations can be made regarding the role of RTS in aiding prognostication or referral decisions in a paediatric trauma setting.

## Financial support and sponsorship

Nil.

## Conflicts of interest

There are no conflicts of interest.

## References

1. Herbert HK, van As AB, Bachani AM, Mtambeka P, Stevens KA, Millar AJ, *et al*. Patterns of pediatric injury in South Africa: An analysis of hospital data between 1997 and 2006. J Trauma Acute Care Surg 2012;73:168-74.
2. Van As AB. Global factors affecting child trauma and the need for ongoing child advocacy. Vulnerable Child Youth Stud 2011;6:277-83.
3. Haagsma JA, Graetz N, Bolliger I, Naghavi M, Higashi H, Mullany EC, *et al*. The global burden of injury: Incidence, mortality, disability-adjusted life years and time trends from the global burden of disease study 2013. Inj Prev 2016;22:3-18.
4. Van As AB, Millar AJ. From the pursuit of excellence to the quest for significance: Promotion of a Childsafe South Africa. S Afr Med J 2012;102:427-8.
5. Van As A. Physical and sexual violence against children. S Afr Med J 2016;106:1075-8.
6. Furnival RA, Schunk JE. ABCs of scoring systems for pediatric trauma. Pediatr Emerg Care 1999;15:215-23.
7. Eichelberger MR, Bowman LM, Sacco WJ, Mangubat EA, Lowenstein AD, Gotschall CS. Trauma score versus revised trauma score in TRISS to predict outcome in children with blunt trauma. Ann Emerg Med 1989;18:939-42.
8. Champion HR, Sacco WJ, Copes WS, Gann DS, Gennarelli TA, Flanagan ME. A revision of the Trauma Score. J Trauma 1989;29:623-9.
9. Champion HR, Copes WS, Sacco WJ, Lawnick MM, Keast SL, Bain LW Jr., *et al*. The major trauma outcome study: Establishing national norms for trauma care. J Trauma 1990;30:1356-65.
10. Gabbe BJ, Cameron PA, Finch CF. Is the revised trauma score still useful? ANZ J Surg 2003;73:944-8.
11. Llompart-Pou JA, Chico-Fernández M, Sánchez-Casado M, Salaberria-Udabe R, Carbayo-Górriz C, Guerrero-López F, *et al*. Scoring severity in trauma: Comparison of prehospital scoring systems in trauma ICU patients. Eur J Trauma Emerg Surg 2017;43:351-7.
12. Pillay J, Ramokgopa M. The spectrum of orthopaedics at Chris Hani Baragwanath Academic Hospital. SA Orthop J 2013;12:28-31.
13. Alvarez BD, Razente DM, Lacerda DA, Lother NS, VON-Bahten LC, Stahlschmidt CM. Analysis of the revised trauma score (RTS) in 200 victims of different trauma mechanisms. Rev Col Bras Cir 2016;43:334-40.
14. Ornato J, Mlinek EJ Jr, Craren EJ, Nelson N. Ineffectiveness of the trauma score and the CRAMS scale for accurately triaging patients to trauma centers. Ann Emerg Med 1985;14:1061-4.
15. Baxt WG, Berry CC, Epperson MD, Scalzitti V. The failure of prehospital trauma prediction rules to classify trauma patients accurately. Ann Emerg Med 1989;18:1-8.
16. Lee YT, Feng XY, Lin YC, Chiang LW. Pediatric trauma team activation: are we making the right call?. Eur J Pediatr Surg. 2014;24:46-50. doi:10.1055/s-0033-1349717.
17. Abantanga EA, Nwomeh BC. Paediatric Injury Scoring and Trauma Registry. In: Ameh E, editor. Paediatric Surgery: A Comprehensive Text for Africa. Vol. 1. Seattle, USA: GlobalHELP Organisation; 2011. p. 165-71.
18. Jones JM, Maryosh J, Johnstone S, Templeton J. A multivariate analysis of factors related to the mortality of blunt trauma admissions to the North Staffordshire Hospital Centre. J Trauma 1995;38:118-22.
19. Brennan PW, Everest ER, Griggs WM, Slater A, Carter L, Lee C, *et al.* Risk of death among cases attending South Australian major trauma services after severe trauma: The first 4 years of operation of a state trauma system. J Trauma 2002;53:333-9.
20. Roberts I. Trauma Africa. BMJ 2005;331:114.
21. Bass D, Albertyn R, Melis J. Child pedestrian injuries in the Cape metropolitan area--final results of a hospital-based study. S Afr Med J 1995;85:96-9.
22. Norman R, Matzopoulos R, Groenewald P, Bradshaw D. The high burden of injuries in South Africa. Bull World Health Organ 2007;85:695-702.
23. Schrieff LE, Thomas KG, Dollman AK, Rohlwink UK, Figaji AA. Demographic profile of severe traumatic brain injury admissions to Red Cross War Memorial Children's Hospital, 2006-2011. S Afr Med J 2013;103:616-20.
24. Tracy ET, Englum BR, Barbas AS, Foley C, Rice HE, Shapiro ML. Pediatric injury patterns by year of age. J Pediatr Surg 2013;48:1384-8.
25. Saggie J. Trauma: South Africa's other epidemic. S Afr Med J 2013;103:589-90.
26. Couch L, Yates K, Aickin R, Pena A. Investigating moderate to severe paediatric trauma in the Auckland region. Emerg Med Australas 2010;22:171-9.
27. Ament JD, Greenan KN, Tertulien P, Galante JM, Nishijima DK, Zwienenberg M. Medical necessity of routine admission of children with mild traumatic brain injury to the intensive care unit. J Neurosurg Pediatr 2017;19:668-74.