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Original Research Article

Comparison of Outcomes Following Severe TBI Between Pediatric and Adult Patients With Similar GCS and Pupil Parameters

Ramsha Nasir Obaid[*1], Atiq Ahmad Khan[1], Irfan Ali Shah[1], Shiraz Ahmed[1], Shahida Shahnawaz[1], Syed Muhammad Moaaz Bin Sultan[2]

[1]Department Of Neurosurgery, Dow University of Health Sciences, Karachi, Pakistan
2Department of Otorhinolaryngology, Aga University of Health Sciences, Karachi, Pakistan
**Corresponding author`s email address: ramshanasir@live.com*

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Abstract: *Severe traumatic brain injury (TBI) remains a leading cause of mortality and long-term disability across all age groups. Pediatric patients are often thought to have superior neuroplasticity, potentially yielding better outcomes compared to adults. However, limited data exist directly comparing age-stratified outcomes when initial injury severity is matched.* ***Objective:*** *To evaluate and compare outcomes following severe TBI between pediatric and adult patients with similar initial neurological severity, as defined by Glasgow Coma Scale (GCS) scores and pupil reactivity.* ***Methods:*** *This cross-sectional study was conducted at the Shaheed Mohtarma Benazir Bhutto Institute of Trauma, Karachi, from February 2025 to May 2025 after receiving ethical approval from the institutional review board. A total of 300 patients aged 0 to 55 years with severe TBI (GCS score 3–8 and Abbreviated Injury Scale [AIS] head score >3) were enrolled using consecutive non-probability sampling. Participants were stratified into pediatric (0–17 years) and adult (18–55 years) groups. Outcome categories included good recovery, moderate disability, severe disability, vegetative state, and death. Comparative analysis was performed using the chi-square test, with $p<0.05$ considered statistically significant.* ***Results:*** *Outcome distributions did not significantly differ between groups ($p = 0.527$). Among adults, 20% had good recovery, 23% moderate disability, 18% severe disability, 17% were vegetative, and 23% died. In the pediatric group, 24% achieved good recovery, 13% had moderate disability, 24% severe disability, 22% were vegetative, and 17% died. Imaging and recovery pattern variations were observed but did not affect overall outcome parity.* ***Conclusion:*** *When initial injury severity is controlled, pediatric and adult patients with severe TBI exhibit comparable short-term outcomes. These findings emphasize the need for standardized, age-inclusive neurocritical care protocols and challenge assumptions of age-dependent prognostication.*

Keywords: Adults, peads, traumatic brain injury, outcomes

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Introduction

Traumatic brain injury (TBI) is a leading cause of morbidity and mortality worldwide, affecting individuals across all age groups. Severe TBI, characterized by a Glasgow Coma Scale (GCS) score of ≤8, often results in significant long-term disabilities or death (1). The GCS, combined with pupil reactivity assessments, serves as a critical prognostic tool in evaluating TBI severity and predicting patient outcomes (2).

Pediatric and adult populations exhibit distinct physiological responses to TBI. Children's brains, due to their developmental plasticity, may have different recovery trajectories compared to adults (3). However, this plasticity also renders them susceptible to unique complications, such as diffuse cerebral swelling and second impact syndrome. Recent studies have highlighted these differences, emphasizing the need for age-specific management strategies (4).

A study analyzing data from 10,105 patients across 512 trauma centers found that mortality rates for children with TBI were higher when treated at adult trauma centers compared to pediatric or mixed centers. Specifically, crude mortality rates were 25.2% at pediatric centers, 36.2% at adult centers, and 28.9% at mixed centers. After adjusting for confounding factors, the odds of mortality remained significantly higher for children managed at adult trauma centers (odds ratio, 1.67; 95% confidence interval, 1.30-2.13) (5).

Further research indicates that the GCS-Pupil (GCS-P) score, which integrates GCS and pupil reactivity, provides a more accurate prediction of mortality and functional outcomes than GCS alone. In pediatric severe TBI cases, a GCS-P score of ≤2 was associated with a higher likelihood of poor outcomes, underscoring the importance of comprehensive neurological assessments (6, 7).

Despite the higher resilience often attributed to pediatric patients, severe TBI in children remains a significant public health concern. Mortality rates from severe pediatric TBI worldwide range from 1% to 7%, translating to approximately 2.8 to 3.8 deaths per 100,000 children under 18 annually (8). These statistics highlight the critical need for targeted prevention strategies and specialized care protocols for pediatric populations. In conclusion, while both pediatric and adult patients with severe TBI present with similar initial clinical parameters, their outcomes can differ markedly. Understanding these differences is essential for developing age-appropriate treatment strategies and improving overall patient prognoses. The aim of the present study was to evaluate and compare outcomes following severe traumatic brain injury (TBI) between pediatric and adult patients with similar initial neurological severity, defined by Glasgow Coma Scale (GCS) scores and pupil reactivity.

Methodology

After the ethical approval from the institutional review board, this cross-sectional study was conducted at Shaheed Mohtarma Benazir Bhutto Institute of Trauma, Karachi. Through consecutive non-probability sampling technique, A total sample size of 300 patients was selected, including individuals aged 0 to 55 years who presented with severe TBI, operationally defined as a GCS score of 3 to 8 and an Abbreviated Injury Scale (AIS) head score greater than 3. The population was further stratified into two groups based on age: pediatric patients (0–17 years) and adult patients (18–55 years). Exclusion criteria included patients older than 55 years, those with major extracranial injuries requiring hospitalization, individuals with a prior history of non-traumatic

neurosurgical conditions, and those who had undergone major non-neurological surgery in the past.

After obtaining informed consent from the patients or their attendants, data collection commenced post-resuscitation. A standardized questionnaire created using Google Forms was utilized for real-time data entry by the principal investigator via a mobile device. The data collection tool captured demographic details (age, gender), mode of injury (e.g., road traffic accident, fall, assault), and clinical findings, including initial GCS score and pupil reactivity. Further clinical information, such as neuroimaging findings (e.g., extradural hematoma [EDH], subdural hematoma [SDH], subarachnoid hemorrhage [SAH], diffuse axonal injury [DAI], or mixed injury patterns), was recorded once imaging results were available.

Each patient was monitored throughout their hospital stay, and functional outcomes were recorded at discharge using standard outcome measure is GCS score. Data were subsequently exported and analyzed using IBM SPSS version 23. Descriptive statistics, such as mean and standard deviation, were calculated for continuous variables like age, while frequencies and percentages were used for categorical variables such as gender, mode of injury, and outcome. Comparative analyses between pediatric and adult groups were conducted using chi-square tests for categorical variables and t-tests for continuous variables, with a significance threshold set at $p < 0.05$.

Results

A total of 300 patients were included in the study, comprising 203 adults and 97 pediatric patients with severe traumatic brain injury (TBI). The mean age in the adult group was 35.9 ± 10.6 years, while the pediatric group had a significantly lower mean age of 7.74 ± 5.3 years ($p < 0.0001$). In terms of gender distribution, both groups showed identical proportions, with 46% females and 54% males in each category, and no statistically significant difference ($p = 0.779$).

Regarding the mode of injury, road traffic accidents (RTA) were the most common cause among adults (26%) and pediatric patients (29%), followed by falls (23% adults vs. 25% pediatric), assaults (28% vs. 26%), and other causes (24% vs. 21%). These distributions did not show a significant difference between the two groups ($p = 0.582$).

When comparing clinical parameters, the mean Glasgow Coma Scale (GCS) score in adults was 5.50 ± 1.69, while the pediatric group had a mean GCS of 5.37 ± 1.65, with no statistically significant difference ($p = 0.751$). Analysis of pupil reactivity revealed that in adults, 37% had one reactive pupil, 32% had both reactive pupils, and 31% had non-reactive pupils. In pediatric patients, 31% had one reactive pupil, 36% had both reactive, and 33% had non-reactive pupils, with no significant intergroup variation ($p = 0.646$).

A significant difference was observed in neuroimaging findings between the two groups ($p = 0.024$). In adults, the most frequent findings were diffuse axonal injury (DAI) (18.2%) and subdural hematoma (SDH) (18%), followed by epidural hematoma (EDH) (17%), mixed lesions (17%), subarachnoid hemorrhage (SAH) (16%), and contusions (13%). In contrast, pediatric patients showed a higher proportion of SDH (26%), followed by SAH (18%), contusions (15%), and DAI, EDH, and mixed injuries (each around 14%).

The outcome profiles were similar between groups ($p = 0.527$). In the adult group, 20% had good recovery, 23% had moderate disability, 18% severe disability, 17% were in a vegetative state, and 23% died. In the pediatric group, 24% achieved good recovery, 13% had moderate disability, 24% experienced severe disability, 22% were vegetative, and 17% died. These findings suggest broadly comparable outcomes between adults and children with severe TBI, despite slight differences in imaging and recovery patterns.

Table 1: Demographic variables

Variables	Adults group (n=203)	Pediatric (n=97)	P value
Age (years)	35.9±10.6	7.74±5.3	<0.0001
Gender			0.779
Female	93 (46%)	45 (46%)	
Male	110 (54%)	53 (54%)	
Mood of Injury			0.582
RTA	52 (26%)	28 (29%)	
Fall	47 (23%)	24 (25%)	
Assault	56 (28%)	25 (26%)	
Other	48 (24%)	20 (21%)	

Table 2: Clinical parameters in both groups

Variables	Adults group (n=203)	Pediatric (n=97)	P Value
GCS score	5.50±1.69	5.37±1.65	0.751
Pupil status			0.646
One reactive	76 (37%)	30 (31%)	
both reactive	64 (32%)	35 (36%)	
both non-reactive	63 (31%)	32 (33%)	
Imaging Findings			0.024
DAI	37(18.2%)	14 (14%)	
Mixed	34 (17%)	14 (14%)	
Contusion	27 (13%)	15 (15%)	
EDH	35 (17%)	11 (11%)	
SDH	36 (18%)	25 (26%)	
SAH	34(16%)	18 (18%)	
Outcomes			0.527
Good recovery	40 (20%)	23 (24%)	
Moderate disability	46 (23%)	13 (135)	
Severe disability	36 (18%)	23 (24%)	
Vegetative state	35 (17%)	21 (22%)	
Death	46 (23%)	17 (17%)	

Discussion

The present study demonstrates that once initial neurological severity is equalised, adults and children with severe TBI experience broadly

comparable in-hospital outcomes. Our mortality (23 % in adults vs 17 % in children, p = 0.527) and functional end-points mirror the multicentre cohort of Emami et al., who found that after adjusting for Glasgow Coma Scale (GCS) and pupil status, paediatric mortality was only marginally lower and long-term disability rates were equivalent to those of adults (9). This convergence contrasts with older work suggesting a distinct survival advantage in younger brains, and probably reflects contemporary improvements in adult neurocritical care as well as the inclusion of older adolescents at the upper end of the paediatric band. Mechanistically, our cohort replicates global epidemiological trends: road-traffic collisions accounted for roughly one-quarter of injuries in both age groups, consistent with the World Health Organization estimate that road traffic injuries cause 1.35 million deaths annually and remain the dominant precipitant of TBI worldwide (10). The matched exposure profile strengthens the internal validity of our age comparisons.

Initial clinical indices were also evenly balanced (mean GCS ≈ 5.4 and indistinguishable patterns of pupil reactivity). Large validation studies show that integrating pupillary response with the GCS (the GCS-P score) improves prognostic accuracy across the age spectrum, outperforming GCS alone in predicting early mortality (11). The absence of a difference in these parameters in our sample therefore supports the premise that any divergence in outcome would truly be age-related rather than severity-driven—yet no such divergence was identified.

Neuro-imaging, however, revealed age-specific injury morphologies. Adults exhibited more diffuse axonal injury (18 %) and epidural haematoma (17 %), whereas children showed a higher burden of subdural (26 %) and subarachnoid haemorrhage (18 %). These patterns accord with biomechanical and anatomical distinctions: the compliant paediatric skull and relatively fragile bridging veins predispose to subdural bleeding, while higher myelination and greater rotational inertia in adults favour axonal shearing and extradural arterial tears (12). A comprehensive review in Frontiers in Neurology likewise notes that diffuse and venous injuries predominate in children, whereas focal contusions and EDH are characteristic of adults. Despite these radiological contrasts, functional trajectories converged. One explanation is that the neuroplasticity that aids paediatric recovery is counter-balanced by the higher vulnerability of developing brains to secondary insults, yielding a net result similar to adult outcomes. Moreover, contemporary systems-of-care may attenuate historic paediatric advantages: a 2023 registry analysis showed that when children are managed at adult trauma centres their mortality rises by 67 % compared with paediatric or mixed units, a finding that may explain the parity observed in our mixed-centre setting (5).

Conclusion

Pregabalin is an effective option for controlling hemodynamic stress response observed after the creation of pneumoperitoneum.

Declarations

Data Availability statement
All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate
Approved by the department concerned. (IRBEC-DUHS-24)

Consent for publication
Approved

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Conflict of interest

The authors declared the absence of a conflict of interest.

Author Contribution

RNO (Postgraduate Trainee)
Manuscript drafting, Study Design,
AAK (Professor)
Review of Literature, Data entry, Data analysis, and drafting article.
IAS (Associate Professor)
Conception of Study, Development of Research Methodology Design,
SA (Associate Professor)
Study Design, manuscript review, critical input.
SS (Consultant)
Manuscript drafting, Study Design,
SMMBS (Associate Professor)
Review of Literature, Data entry, Data analysis, and drafting article.

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

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