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Pediatric Trauma Support System (PTSS) as a Tool for Automated Assessment of Trauma in Children

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Abstract

Background: Early and accurate assessment of traumatic injuries in pediatric patients is critical for timely diagnosis and prevention of missed associated injuries. The Pediatric Trauma Support System (PTSS) is a digital clinical decision support tool designed to integrate physiological parameters, trauma mechanism, and demographic characteristics to provide automated trauma risk assessment in children. Aim: To evaluate the clinical applicability of the Pediatric Trauma Support System (PTSS) in the primary assessment of pediatric patients with blunt trauma and to analyze the sensitivity of the Pediatric Trauma Score (PTS), particularly in children under one year of age. Materials and Methods: A prospective observational study was conducted in the Emergency Department and the Department of Pediatric Surgery at the University Hospital "St. George", Plovdiv, Bulgaria. The study included 100 pediatric patients aged 0-18 years presenting with blunt traumatic injuries. Standard clinical evaluation was performed for all patients, including assessment of vital signs and neurological status using the Glasgow Coma Scale (GCS). PTSS was used to automatically calculate the Pediatric Trauma Score (PTS) and generate recommendations for imaging diagnostics. Twenty-five patients were under two years of age, including nine infants younger than one year (6 boys and 3 girls). Demographic and clinical variables were analyzed descriptively. Results: Among the nine patients under one year of age, all had PTS values below the normal age-adjusted threshold. In cases of mild trauma the PTS was 9/12, while in moderate trauma it was 8/12. The PTSS algorithm generated recommendations for head computed tomography (CT) and abdominal ultrasound in all infants. Head imaging was performed in all nine patients, revealing a parietal bone fracture in one 27-day-old infant. Abdominal ultrasound was not performed in clinical practice despite the algorithmic recommendation. In patients older than one year with similar trauma severity, PTS values were higher (11/12), and PTSS recommended only head CT without additional abdominal imaging. Conclusion: PTSS provides a structured and automated approach to pediatric trauma assessment by integrating PTS with clinical and demographic parameters. The system demonstrates increased sensitivity in infants under one year of age, where physiological characteristics may mask significant associated injuries. Automated recommendations for additional imaging may contribute to earlier detection of occult injuries and improved patient safety in pediatric trauma care.

Keywords: pediatric trauma score; clinical decision support system; trauma assessment; pediatric emergency medicine; trauma scoring systems; automated risk assessment; pediatric imaging recommendations

Introduction

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Traumatic injuries represent a leading cause of morbidity and mortality in the pediatric population worldwide, with falls, domestic accidents, and blunt trauma contributing to a significant proportion of hospitalizations in emergency departments [1,2]. The pediatric organism has a considerable compensatory capacity, which often leads to minimal clinical findings despite the presence of significant internal injuries, especially in the youngest patients [3]. Therefore, the assessment of trauma severity in children requires standardized tools that allow early and accurate risk evaluation, with the potential to distinguish high-risk cases from low-risk ones.

One of the traditional and widely used scores is the Revised Trauma Score (RTS), based on the level of consciousness according to the Glasgow Coma Scale, systolic arterial blood pressure values, and respiratory rate, with proven prognostic value for physiological stability in trauma [4,5]. However, RTS does not directly include an assessment of anatomical injuries and may be insufficiently sensitive for detecting isolated organ damage when physiological parameters are within normal ranges.

In response to this need, the Pediatric Trauma Score (PTS) was developed-an assessment tool specifically adapted for children, which includes parameters such as weight, maintenance of airway patency, arterial blood pressure values, level of consciousness, and the presence of injuries and fractures [6,7]. PTS ranges from - 6 to +12 points, with lower values being associated with an increased risk of mortality and the occurrence of complications [8]. Early studies indicate that PTS may be useful in structuring trauma severity and prognosis in pediatric patients, although its sensitivity in different contexts varies [9].

In addition to PTS, the clinical assessment of trauma also requires integration of the mechanism of injury and data from performed imaging studies. The development of digital solutions enables automated integration of multiple parameters within a unified platform for clinical decision support. Pediatric Trauma Support System (PTSS) represents such a system, combining physiological indicators, data on the mechanism of trauma, and age characteristics for automated calculation of PTS and other risk indicators in order to generate recommendations for diagnostic strategies. PTSS uses international algorithms and clinical protocols developed in pediatric trauma centers, including Oxford Children's Hospital-UK, Bambino Gesù Children's Hospital-Rome, Italy, and Johns Hopkins University-USA.

Particularly important in the triage of trauma patients is determining risk in the youngest patients under one year of age. This age group is characterized by unique physiological features, including a higher respiratory rate and lower normal arterial blood pressure values, which may lead to lower PTS values under equivalent mechanical loads [8,10]. A study by Kim et al. demonstrates that PTS is a significant preliminary indicator for the presence of internal complications in pediatric patients with traumatic brain injury and has high sensitivity for identifying patients with severe injuries, emphasizing the role of this score in clinical decision-making and in the optimization of diagnostic algorithms [11].

In addition to physiological and anatomical parameters, ultrasound examination of the abdominal organs has proven useful in assessing internal traumatic injuries in childhood, as ultrasound shows good diagnostic performance for detecting free fluid in the abdominal cavity, which is a determining factor in the decision to perform more invasive investigations [12,13].

The present article aims to place the role of PTSS and PTS in context, as well as their significance in patients under one year of age, in whom minimal clinical manifestations often complicate the early diagnosis of trauma that may have serious consequences.

Materials and Methods

The present study represents a prospective observational study conducted in the Emergency Department and the Clinic of Pediatric Surgery at University Hospital St. George, aimed at evaluating the clinical application of the Pediatric Trauma Support System (PTSS) in the primary assessment of pediatric patients with blunt trauma [1,2]. The study population included 100 patients aged 0 to 18 years who sought medical care due to traumatic injury. All patients underwent a standard initial

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examination, including assessment of vital signs and level of consciousness using the Glasgow Coma Scale (GCS) [4,5]. Of the total population, 25 patients were under two years of age, of whom 9 were under one year of age, respectively 6 boys and 3 girls, allowing a separate analysis of this high-risk age group in which physiological characteristics may significantly influence the value of the Pediatric Trauma Score (PTS) [6,7].

The inclusion criteria comprised all patients with a blunt mechanism of trauma and available clinical data sufficient for calculation of PTS and entry into PTSS [6,7].

In all patients, the digital platform Pediatric Trauma Support System (PTSS) was used, enabling automated calculation of PTS and generation of recommendations for imaging diagnostics and therapy. The system integrates international protocols from Oxford Children's Hospital, Bambino Gesù Children's Hospital, and Johns Hopkins University, combining physiological parameters, mechanism of trauma, age characteristics, and clinical data in order to assess risk and identify potential associated injuries [1,10,12].

PTS is calculated based on the level of consciousness according to GCS, systolic arterial blood pressure values, and respiratory rate, with the algorithm adapted to the age of the patient. In the youngest patients, particularly those under one year of age, PTS is a sensitive indicator for potential associated trauma, as compensatory mechanisms may mask early signs of internal injuries [6,7,10]. In addition to physiological parameters, additional data are entered into PTSS, including age, weight, mechanism of trauma, approximate height of fall, localization of the primary trauma, and the presence of clinical symptoms. Based on these parameters, the system generates recommendations for performing abdominal ultrasound and/or computed tomography of the head according to the severity of the trauma and the value of PTS [11,12].

The collected clinical and demographic data included age, sex, weight, mechanism of trauma, localization of the primary trauma, PTS values, and PTSS recommendations for imaging diagnostics. Particular attention was paid to children under one year of age (n = 9, 6 boys and 3 girls), in whom PTS values were lower, reflecting the physiological characteristics of early age and the higher risk of additional injuries [10,11].

For statistical processing, the data were analyzed descriptively using means, standard deviations, and ranges for quantitative variables, and frequencies and percentages for qualitative indicators. Differences between age groups were assessed using non-parametric tests, with the critical level of statistical significance set at $p < 0.05$ [9,10].

Results

In the studied cohort of 100 patients aged 0 to 18 years examined for trauma, 25 patients were up to two years of age, of whom 9 were under one year of age (6 boys and 3 girls). The main mechanism of trauma in this age group was falling from a low height, and the most common localization of the primary injury was the head.

In all nine patients under one year of age, the calculated Pediatric Trauma Score (PTS) was below the normal limit for age. In cases of mild trauma severity, the score value was 9 out of a maximum of 12 points, while in cases of moderate trauma severity it was 8 out of 12 points. In all these patients, PTSS generated a recommendation to perform computed tomography of the head and an ultrasound examination of the abdominal organs with the aim of detecting free fluid in the peritoneal cavity.

In practice, imaging of the head was performed in all nine children, and in one child, aged 27 days, a fracture of the parietal bone was identified. Ultrasound examination of the abdominal organs was not performed in real clinical practice, despite the algorithmic recommendation generated by PTSS.

In patients older than one year with analogous trauma and equivalent clinical severity, PTS values were higher-11 out of 12 points. In these cases, PTSS recommended imaging diagnostics only of the head by CT, without an automatic recommendation for abdominal ultrasound examination.

These results emphasize the age-dependent sensitivity of PTS, in which children under one year of age, even with minimal and moderate head trauma, receive a lower score, leading to algorithmic

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recommendation for additional imaging diagnostics of the abdominal organs. In older children with normal PTS and similar trauma severity, the risk of occult intra-abdominal injuries is considered lower, which is also reflected in the absence of a recommendation for abdominal ultrasound [1–15].

Discussion

The results of the present study demonstrate that the Pediatric Trauma Support System (PTSS) provides a structured and standardized assessment of traumatic risk in children by integrating automated calculation of the Pediatric Trauma Score (PTS) with multiple clinical and demographic parameters [1–3]. PTS appears to be particularly important in patients under one year of age, in whom physiological compensatory mechanisms may mask serious associated injuries, while traditional clinical assessment based on vital signs and the Glasgow Coma Scale (GCS) may not reflect the actual risk [6,7,10]. In our cohort, all nine children under one year of age had PTS values below the normal range, with the score reaching 9 out of 12 even in cases of mild trauma and 8 out of 12 in cases of moderate trauma. This finding highlights the high sensitivity of PTS in early infancy and its role as a reliable indicator of potentially occult injuries [6,7,11].

PTSS proposes a new approach to the primary assessment of pediatric trauma by automating the calculation of PTS and combining it with the mechanism of trauma, age, body weight, and localization of the primary injury. This approach provides a rapid and standardized risk assessment, enabling clinicians to identify patients in whom potentially high-risk injuries may remain undetected [2,10,12]. This capability is particularly critical in the youngest patients, in whom early signs of internal injury may be subtle or delayed [6,7].

One of the key aspects highlighted by the system is the recommendation to perform abdominal ultrasound in children under one year of age, even when the primary trauma is limited to the head and the GCS score is maximal. This recommendation is based on international protocols developed in pediatric trauma centers such as Oxford Children's Hospital, Bambino Gesù Children's Hospital, and Johns Hopkins University, where early detection of intra-abdominal injuries is considered a key component of patient safety in infants [1,4,10]. Without ultrasound examination, there is a real risk of missing the presence of free fluid in the abdominal cavity, hematomas, or other intra-abdominal injuries that may not be evident through standard clinical parameters [3,7,11].

Failure to perform abdominal ultrasound in children with PTS values below the normal range may lead to delayed detection of potentially dangerous injuries, thereby increasing the risk of complications, additional interventions, or even severe clinical outcomes [2,6,10]. At the same time, the recommendation for ultrasound in older children with normal PTS is not applied, as the algorithm takes into account their greater physiological resilience and lower risk of injury. This demonstrates the adaptability of the system to age-related physiological differences [6,11,12].

The system also presents significant potential for continuous learning and optimization. PTSS is designed as an adaptive platform that can be improved based on the clinical data entered and the results of performed imaging studies. Over time, by integrating real clinical cases, the system can refine its algorithms, reduce the risk of overdiagnosis, and increase the accuracy of its recommendations while maintaining high sensitivity for the detection of associated injuries [2,10,12–15].

PTSS also demonstrates potential for integration into clinical practice as a training tool for medical personnel. By visualizing risk and providing recommendations, the system supports physicians in clinical decision-making while simultaneously creating a database for future analyses and protocol improvements [1,2,12]. This approach not only enhances patient safety but also offers opportunities for scientific research and for the standardization of pediatric trauma assessment at both national and international levels [3,6,10,14].

In summary, PTSS provides an integrated approach in which PTS represents a key, but not the only, factor in identifying high-risk patients. The system automatically combines PTS, mechanism of trauma, age, and body weight to generate recommendations for additional imaging studies, including abdominal ultrasound in the youngest children. This highlights the role of PTS as a

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sensitive and critically important tool in the evaluation of young children with trauma and demonstrates the potential of PTSS to improve and adapt in real time based on accumulated clinical data [1–15].

Conclusion

The present study demonstrates that the Pediatric Trauma Support System (PTSS) represents an effective tool for the standardized and automated assessment of traumatic injuries in pediatric patients aged 0-18 years. The system integrates the calculation of Pediatric Trauma Score (PTS), Revised Trauma Score (RTS), Shock Index (SI), and Glasgow Coma Scale (GCS), providing clinicians with structured real-time information regarding physiological stability and trauma severity [1–3].

PTS proved to be particularly sensitive and informative in patients under one year of age, in whom conventional clinical assessment may mask the presence of associated injuries. In our cohort, all nine infants under one year of age had PTS values below the normal range, with scores of 9/12 in cases of mild trauma and 8/12 in cases of moderate trauma. Based on these values, the system automatically generated recommendations for cranial computed tomography and abdominal ultrasound, reflecting the preventive logic of the algorithms, particularly for early detection of potential intra-abdominal injuries that may remain clinically silent during the initial examination [6,7,10].

PTSS provides a comprehensive automated assessment by integrating physiological parameters (RR, SpO_2, HR, SBP), trauma mechanism, and demographic characteristics (age, sex, body weight). This approach allows more precise triage categorization and reduces the risk of overlooking high-risk patients [1–3,12]. In patients older than one year with comparable trauma severity, PTS values were higher (11/12), and the system did not recommend abdominal ultrasound, demonstrating an age-adapted approach and increased algorithm sensitivity for the youngest patients [6,11].

Furthermore, PTSS offers potential for future development through continuous adaptive learning. The algorithms can be refined using accumulated clinical data, imaging results, and patient outcomes. Such adaptive capability allows the system to optimize its recommendations over time, potentially reducing overdiagnosis while improving patient safety and resource efficiency in pediatric trauma care [1,2,12–15].

In conclusion, PTSS functions as an integrated platform for early risk stratification by combining PTS, RTS, SI, and GCS with clinical and demographic parameters to generate preventive recommendations for imaging and triage decisions. The system appears particularly valuable in patients under one year of age, where early identification of associated injuries is critical and clinical signs may be subtle or delayed. PTSS therefore represents a promising tool for improving the safety, efficiency, and standardization of pediatric trauma assessment in clinical practice [1–5].

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Data Availability Statement: The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author(s).

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List of Abbreviations

- PTSS - Pediatric Trauma Support System
- PTS - Pediatric Trauma Score
- RTS - Revised Trauma Score
- SI - Shock Index
- GCS - Glasgow Coma Scale
- CDSS - Clinical Decision Support System
- RR - Respiratory Rate
- HR - Heart Rate
- SBP - Systolic Blood Pressure
- SpO_2 - Peripheral Oxygen Saturation
- CT - Computed Tomography
- US - Ultrasound

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