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Hemoglobin, Hematocrit, and Glucose Levels in Patients Aged 0-2 Years with Head Trauma Assessed in the Emergency Department

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Abstract

Aim: Head injuries are common in the pediatric population, with traumatic brain injury being a significant cause of morbidity and mortality. Assessing the clinical condition of children aged 0-2 years with head injuries is particularly challenging due to non-specific symptoms and limited communication abilities. This study aimed to investigate changes in post-traumatic levels of hemoglobin (HGB), hematocrit (HCT), and glucose, and to evaluate their potential as prognostic indicators for clinical outcomes and mortality.

Materials and Methods: This retrospective study was conducted with the approval of the Çukurova University Non-Interventional Clinical Research Ethics Committee. A total of 342 pediatric patients diagnosed with isolated moderate to severe head trauma were included. These patients were admitted to the Emergency Department of Niğde Ömer Halisdemir Training and Research Hospital between January 1, 2019, and January 1, 2022. Data were reviewed retrospectively. HGB, HCT, and glucose levels were compared based on trauma type and lesion characteristics using one ANOVA followed by Duncan's test. An independent t-test was used to compare laboratory values between patients who survived and those who did not. Statistical significance was set at $p<0.05$. All analyses were performed using SPSS version 26.0 (IBM Corp.).

Results: Falls were the most common mechanism of injury, accounting for 161 cases (47%). Linear skull fractures were observed in 86 cases (25%). Of the total cases, 270 patients (79%) were admitted to the general ward, and 72 (21%) were admitted to the intensive care unit (ICU). A significant decrease in HGB and HCT levels, along with an increase in glucose levels, was observed in patients who died ($p<0.001$). Similarly, these changes were significant among patients requiring ICU admission ($p<0.001$).

Conclusion: Increased severity of head trauma was associated with greater reductions in HGB and HCT levels and elevated glucose levels. These laboratory parameters may serve as useful indicators of prognosis and mortality risk in pediatric patients with moderate to severe head trauma.

Keywords: Head trauma, hemoglobin, hematocrit, glucose, traumatic brain injury

Introduction

Head injuries are commonly encountered in pediatric emergency departments and can result in serious short- and long-term consequences. Due to their high prevalence and potentially severe outcomes, the Centers for Disease Control and Prevention have characterized traumatic brain injuries as a "silent epidemic" (1). Although trauma-related risks and complications affect all pediatric age groups, clinical assessment is particularly challenging in children aged 0-2 years. In this age group, head injuries can range from minor trauma to skull fractures (2). Difficulties in obtaining an accurate history, limited cooperation during physical examination, and challenges in assessing the Glasgow Coma scale (GCS) complicate the evaluation process. Additionally, the risk of multiple organ injury and shock further hinders accurate clinical assessment in this vulnerable population (3).

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Computed tomography (CT) of the brain is considered the gold standard for diagnosing pediatric head trauma. However, its use involves exposure to ionizing radiation, which poses a significant concern in young children due to the associated increased lifetime risk of malignancies, including brain tumors and leukemia. This has led to diagnostic uncertainty, particularly in asymptomatic or minimally symptomatic cases, and raises concerns about overuse of imaging (4). In response, several clinical decision-making algorithms have been developed to guide CT use, including the Canadian CT Head Rule, New Orleans Criteria, NEXUS-II, National Institute for Health and Care Excellence guidelines, the Children's Head Injury Algorithm for the Prediction of Important Clinical Events, the Canadian Assessment of Tomography for Childhood Head Injury, and the Pediatric Emergency Care Applied Research Network (PECARN) criteria (5).

Among these, the PECARN criteria have shown the highest specificity for children under two years of age, with a reported sensitivity of 100% and specificity of 53%. The PECARN algorithm for this age group includes the following risk indicators: GCS ≤14, altered mental status, presence of scalp hematoma in the occipital, parietal, or temporal regions, history of loss of consciousness ≥5 seconds, abnormal behavior as reported by a caregiver, and mechanisms of severe trauma (e.g., ejection from a motor vehicle, fatal motor vehicle collision, vehicle rollover, fall from a height greater than 3 feet (90 cm), or bicycle/motorcycle accidents without helmet use) (6). Despite the utility of PECARN and similar algorithms, they may not adequately capture early or asymptomatic presentations in young children, particularly when radiologic signs such as intracranial hemorrhage have not yet manifested (5,6).

This diagnostic limitation highlights the need for alternative, accessible, and objective biomarkers to support prognosis and clinical decision-making in this age group. Therefore, the present study investigates the relationship between hemoglobin (HGB), hematocrit (HCT), and glucose levels, which are commonly measured in emergency departments, inpatient units, and intensive care settings, and the severity of head trauma. The study also aims to evaluate the potential of these biomarkers as predictors of prognosis and mortality in children under the age of two with head injuries.

Materials and Methods

This retrospective study was conducted following the approval of the Çukurova University Non-Interventional Clinical Research Ethics Committee (desicion number: 59, date: 07.04.2023). A total of 342 pediatric patients who presented to the emergency department of Niğde Ömer Halisdemir Training and Research Hospital between January 1, 2019, and January 1, 2022, and were diagnosed with moderate to severe head trauma during their initial evaluation, were included in the review.

Exclusion criteria were as follows: the presence of additional trauma apart from head trauma, bleeding diathesis or any other bleeding disorder, acute or chronic anemia, congenital anomalies, diabetes mellitus, or hemolyzed blood samples obtained for biochemical and/or hematological analysis.

Inclusion criteria included isolated head trauma cases in children aged 0-2 years who were asymptomatic at the time of presentation to the emergency department and showed no evidence of bleeding on the initial brain CT scan.

The patients were stratified into two age groups: 0-12 months and 12-24 months. The aim was to evaluate potential differences in HGB, HCT, and glucose values across these age groups.

Falls from a height of 3 feet (90 cm) or more were classified as high falls, while those from lower heights were categorized as

Table 1. Frequencies of the parameters and data used in the study categorized by groups

		Number (n)	Percentage (%)
Trauma type	Fall	161	47
	Traffic accident	141	41
	Fall from height	40	12
Hospitalization	Intensive care	72	21
	Neurosurgery ward	270	79
Sex	Male	164	48
	Female	178	52
Age	0-12 months	209	61
	12-24 months	133	39
Lesion	Epidural hemorrhage	65	19
	Contusion	77	23
	Subdural hemorrhage	60	18
	Subarachnoid hemorrhage	54	16
	Linear skull bone fractures (total)	86	25
	Temporal skull bone fractures	35	10.2
	Frontal skull bone fractures	27	7.8
	Parietal skull bone fractures	15	4.3
	Occipital skull fractures	9	2.6

low falls, in accordance with the PECARN criteria for children under 2 years of age.

To minimize confusion related to timing and to allow for a more accurate analysis of case distribution throughout the day, the 24-hour period was divided into three equal 8-hour intervals over the study's 3-year duration.

In the emergency department of our hospital, 2 mL of venous blood was collected for complete blood count analysis and transferred immediately into purple-capped tubes containing K2 or K3 ethylenediaminetetraacetic acid (EDTA). The tubes were gently inverted several times to ensure proper mixing of EDTA with the blood to prevent clotting. The samples were promptly sent to the hospital laboratory and analyzed using the Sysmex XN-1000 SA-01 hematology analyzer. Reference ranges in our laboratory for HGB and HCT values in children aged 0-2 years are as follows: male patients: HGB 10.1-12.5 g/dL; HCT 30.8-37.8%; female patients: HGB 10.2-12.7 g/dL; HCT 30.9-37.9%. For glucose analysis, 1 mL of venous blood was collected into a 13×10 mm serum tube specifically designed for glucose testing. The samples were analyzed in the hospital's biochemistry laboratory using a Roche Cobas C501 autoanalyzer. The reference range for glucose in both male and female patients under 2 years of age was 74-106 mg/dL.

Statistical Analysis

Normality of the HCT, HGB, and glucose data was assessed using the Shapiro-Wilk test, along with evaluations of skewness and kurtosis. The data were found to follow a normal distribution ($p>0.05$). Therefore, one-way ANOVA was employed to compare HCT, HGB, and glucose levels based on trauma type and lesion characteristics. When significant differences were detected, the Duncan post-hoc test was used to identify group-specific differences. An independent samples t-test was applied to compare laboratory values between deceased and surviving patients.

All statistical analyses were performed using IBM SPSS Statistics version 26 (SPSS Inc., Chicago, IL, USA), and a p value of <0.05 was considered statistically significant.

Results

The most common mechanism of head trauma was falls, accounting for 161 cases (47%), while falls from a height represented the least common cause, with 40 cases (12%). Of the 342 cases, 164 (48%) were male and 178 (52%) were female. Regarding age distribution, 209 patients (61%) were in the 0-12 month group, and 133 patients (39%) were in the 12-24 month group.

The most frequently observed injury was linear skull fracture, reported in 86 cases (25%), whereas the least frequent injury was subarachnoid hemorrhage, identified in 54 cases (16%), (Table 1).

One-way ANOVA and Duncan's post-hoc test were performed, based on the evaluated parameters, to assess whether there were statistically significant differences in HGB, HCT, and glucose levels among the groups. The results indicated significant differences in HGB and HCT values according to both the type of trauma and the type of lesion.

Although glucose levels did not significantly differ based on trauma type, a statistically significant increase in glucose values was observed when grouped by lesion type. Specifically, among trauma types, the lowest HGB and HCT values were recorded in

Table 2. Mean values of hemoglobin, hematocrit, and glucose levels according to trauma type and lesion type, including groupings based on Duncan's test results

Parameter	**Trauma type**					
	Fall	**Traffic accident**		**Fall from height**		**p value**
	Mean ± SD	**Mean ± SD**		**Mean ± SD**		
Hemoglobin	11.75±0.10c	10.43±0.11b		9.74±0.17a		**0.01**
Hematocrit	34.88±0.26c	31.52±0.29b		29.5±0.5a		**0.01**
Glucose	102.91±1.09	108.28±1.51		103.3±3.03		>0.05
Parameter	Lesion					
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	**p value**
Group	Epidural hemorrhage	Contusion	Linear skull fractures	Subarachnoid hemorrhage	Subdural hemorrhage	
Hemoglobin	10.04±0.15ab	11.95±0.13c	12.04±0.14c	9.69±0.14a	10.34±0.11b	**0.01**
Hematocrit	30.78±0.36b	35.41±0.32c	35.61±0.32c	29.45±0.48a	31.01±0.26b	**0.01**
Glucose	107.86±2.47bc	102.16±1.6ab	101.78±1.63a	109.56±2.75c	107.05±1.45abc	**0.01**

*Values expressed with different letters are in different groups. Letters a, b and c represent different groups

cases involving falls from height. When categorized by lesion type, cases of SAH exhibited the lowest HGB and HCT values, as well as the highest glucose levels.

HGB, HCT, and glucose values were analyzed using one-way ANOVA and Duncan's post-hoc test to evaluate potential differences based on age group, sex, and hospital ward. No statistically significant differences were found in HGB, HCT, or glucose levels when grouped by age or gender. However, when grouped according to the ward of admission, the lowest HGB and HCT values and the highest glucose levels were observed in patients admitted to the ICU. An independent samples t-test was conducted to compare HGB, HCT, and glucose levels between patients who died and those who survived. The analysis revealed statistically significant differences in all three parameters between the deceased and surviving patients. Specifically, HGB and HCT levels were significantly lower, while glucose levels were significantly higher in the exitus group.

The distribution of cases was analyzed across three eight-hour intervals within a 24-hour period. The highest number of cases, 150 (44%), occurred between 08:00 and 15:59, while the lowest, totaling 68 cases (20%), was recorded between 00:01 and 07:59.

Discussion

Head injuries represent the most common type of pediatric trauma. Despite the implementation of preventive strategies, morbidity and mortality rates remain notably high among children. It has been reported that approximately 80% of pediatric deaths due to multiple trauma involve head injuries (7). Several studies have demonstrated that the severity of head trauma correlates with changes in specific laboratory parameters, such as HGB, HCT, and glucose levels. In cases of severe head trauma, HGB and HCT levels tend to decrease, while glucose levels often increase (1,8).

Torabi et al. (9) reported that in a study involving 157 patients, 19.2% exhibited brain damage on CT scans, and glucose levels were significantly higher in those with such findings. Another study suggested that elevated blood glucose and reduced HGB and HCT levels in pediatric patients with isolated head trauma may be associated with a poorer prognosis (10). A statistically significant association has also been noted between clinical symptoms such as recurrent vomiting, decreased consciousness, and headache and abnormal brain CT findings. It was further reported that only 3.5% of asymptomatic cases demonstrated positive CT findings (11). In some cases, it may take up to 48 hours for CT abnormalities to become apparent (12).

Table 3. Mean values of hemoglobin, hematocrit, and glucose levels based on gender, age group, and ward of admission, with groupings determined by Duncan's test

Sex				
Parameter		**Male**	**Female**	**p value**
		Mean ± SD	**Mean ± SD**	
	Hemoglobin	11.09±0.1	10.86±0.11	0.67
	Hematocrit	32.9±0.29	32.83±0.30	0.86
	Glucose	102.83±1.16	107.33±1.31	0.71
Age group				
Parameter		**0-12 months**	**12-24 months**	**p value**
		Mean ± SD	**Mean ± SD**	
	Hemoglobin	11±0.11	10.93±0.12	0.68
	Hematocrit	32.85±0.28	32.89±0.30	0.94
	Glucose	106.08±1.25	103.75±1.17	0.62
Service**				
Parameter		**İntensive care hospitalization**	**Service hospitalization**	**p value**
		Mean ± SD	**Mean ± SD**	
	Hemoglobin	9.98±0.14	11.24±0.09	**<0.001**
	Hematocrit	29.89±0.40	33.66±0.22	**<0.001**
	Glucose	105.58±2.02	105.56±1.99	**<0.001**

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Table 4. Comparison of mean glucose, hemoglobin, and hematocrit values between deceased and surviving patients

Parametre	Group		p value
	Dead patients	Surviving patients	
Hemoglobin	8.01±0.14	10.97±0.08	**<0.001**
Hematocrit	27.25±0.38	32.87±0.20	**<0.001**
Glucose	159.24±3.98	105.17±0.88	**<0.001**

Table 5. Distribution of cases by time of occurrence within 24-hour intervals

	Time	Number (n)	Percentage (%)
Time period of the event	08:00-16:00	150	44.01
	16:01-24:00	124	36.25
	24:01-07:59	68	20.04

Given the potential long-term risks of ionizing radiation, especially the increased risk of malignancy in pediatric populations, cautious use of CT imaging is advised in this age group (13). Several studies have indicated that repeated cranial CT scans in hospitalized children may contribute to mortality rates of up to 15% annually, and result in substantial healthcare costs due to radiation-induced malignancies (14).

Consistent with findings in the literature, this study observed that decreasing HGB and HCT levels and increasing glucose levels were associated with increasing trauma severity. In fatal cases (exitus), these changes were particularly pronounced. Cases involving high-energy trauma, such as traffic accidents or falls from heights, were associated with lower initial GCS scores and more severe clinical presentations. These patients were more likely to be admitted to the ICU. Among ICU admissions, patients who were later found to have subarachnoid hemorrhage (SAH) on follow-up CT scans exhibited more pronounced reductions in HGB and HCT, and elevated glucose levels.

These findings suggest that reductions in HGB and HCT, and elevations in glucose may be indicative of poor prognosis, increased morbidity, and higher mortality risk. Therefore, such laboratory parameters could serve as useful adjuncts in clinical decision-making and management. Furthermore, in asymptomatic pediatric patients, particularly those under 2 years of age, monitoring these parameters may reduce the need for unnecessary or repeated CT scans between the time of trauma and symptom onset potentially minimizing radiation exposure, reducing the risk of long-term complications such as malignancy, and decreasing healthcare costs.

Head trauma can lead to a variety of intracranial lesions, with traumatic SAH associated with higher morbidity and mortality rates compared to other intracranial hemorrhages. The reported mortality rate for traumatic SAH ranges from 50% to 60% (15). In line with this, our study found that patients with SAH particularly those resulting from high-energy trauma per PECARN criteria presented with more severe clinical findings, lower GCS scores, and were more frequently admitted to the ICU. In these cases, laboratory data showed greater declines in HGB and HCT and higher glucose values.

Moreover, existing studies have identified linear skull fractures as the most common lesion in pediatric head trauma (16), with the temporal and frontal bones being the most frequently affected sites (17). Our study similarly found linear skull fractures to be the most prevalent injury pattern.

Similarly, in this study, linear skull fractures were identified as the most common cranial injury, observed in 86 cases (25%). Among these, 35 cases (10.2%) involved the temporal bone, 27 cases (7.8%) involved the frontal bone, 15 cases (4.3%) involved the parietal bone, and 9 cases (2.6%) involved the occipital bone. Other documented lesions included cerebral contusions in 77 cases (23%), epidural hemorrhage in 65 cases (19%), subdural hemorrhage in 60 cases (18%), and SAH in 54 cases (16%).

Previous studies have shown gender-related differences in the incidence of pediatric head trauma, with most reporting a higher prevalence among males (18). However, in this study, females accounted for 178 cases (52%) and males for 164 cases (48%). This reversal may reflect demographic or social factors influencing healthcare-seeking behavior during the study period, such as a higher likelihood of female children being brought to the emergency department.

Research has also indicated that head trauma in children below one year of age most frequently occurs between 0 and 12 months and is primarily caused by falls (19,20). In line with this, our study found that 209 cases (61%) occurred in the 0-12 month age group, compared to 133 cases (39%) in the 12-24 month group. Falls were the leading cause of injury (161 cases, 47%), followed by traffic accidents (141 cases, 41%) and falls from height (40 cases, 12%). The high frequency of falls in this age group may be attributed to underdeveloped motor skills, increased susceptibility to environmental obstacles, and insufficient supervision by caregivers.

Several studies have explored the timing of pediatric head trauma. Some have reported peak incidence between 06:01 am and 12:00 pm (1), while others noted increased frequency between 3:00 pm and 7:00 pm (21). AlSowailmi et al. (22)

similarly reported that most cases occurred in the afternoon. Consistent with these findings, this study found that 150 cases (44.01%) occurred between 8:00 am and 4:01 pm., 124 cases (36.25%) between 4:01 pm and midnight, and 68 cases (20.04%) between midnight and 7:59 am. The higher number of daytime cases may be related to increased physical activity during waking hours, whereas lower case counts at night may correspond to longer sleep durations.

Study Limitations

It is important to note that this study is limited by its retrospective design and single-center data collection from a hospital in Niğde, which may affect the generalizability of the findings. Further multicenter studies with larger and more diverse populations are necessary to validate these results and improve clinical guidelines.

Conclusion

This study demonstrated that in children under two years of age, increasing trauma severity was associated with greater reductions in HGB and HCT levels, and elevations in glucose levels. These changes were more pronounced in patients with fatal outcomes (exitus) or those requiring ICU admission. A statistically significant association was observed between HGB, HCT, and glucose values, and poor prognosis, including increased morbidity and mortality. The majority of head trauma cases occurred between 8:00 am and 4:00 pm and were primarily caused by falls. No significant differences in HGB, HCT, or glucose levels were found when analyzed by age or gender. Further research is essential to develop predictive models, improve early diagnosis and treatment strategies, and establish standardized clinical criteria. The present study aims to contribute to the existing body of literature and serve as a reference point for future investigations.

Ethics

Ethics Committee Approval: The approval of the Çukurova University Non-Interventional Clinical Research Ethics Committee (desicion number: 59, date: 07.04.2023).

Informed Consent: This retrospective study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: Ö.Y., Concept: Ö.Y., Design: Ö.Y., Data Collection or Processing: Ö.Y., M.G., Analysis or Interpretation: Ö.Y., Literature Search: Ö.Y., M.G., Writing: Ö.Y.

Conflict of Interest: The authors declare that they have no conflicts of interest.

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