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The Effect of Corticosteroids on the Progression and Outcomes of Polytrauma in Children

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Summary

Polytrauma in children is among the most common causes of death in the pediatric intensive care unit (ICU).

The aim of this study was to evaluate the effect of systemic corticosteroids (SCS) on the progression, laboratory parameters, and outcomes of severe multiple injuries in children requiring ICU.

Materials and methods. A retrospective, observational, multicenter (case-control and cross-sectional) study included 203 patients from pediatric ICUs across the Russian Federation. The Abbreviated Injury Scale (AIS) score was 36.81 (25–48), and the Pediatric Trauma Score (PTS) was 5.2 (2–8). SCS were administered to 113 (55.7%) children, 19 (9.36%) of whom died.

Results. The most severe changes in laboratory parameters, such as an increase in amylase (35.3 vs. 18.3; $P<0.001$) and activated partial thromboplastin time (APTT) (28.9 vs. 25.8; $P<0.001$), were documented upon admission of children with multiple traumatic injuries to the hospital compared with subsequent days of treatment in the ICU. The average fluid volume (as a percentage of age-related fluid requirements) on the first day of treatment in the ICU was 118.53% and did not exceed 84.42% on subsequent days ($P<0.001$). Higher systolic blood pressure (SBP) during the first three days of ICU treatment was observed in children treated without SCS. SBP tended to decrease by day 5, and then a tendency toward arterial hypertension emerged on days 6–7. In children treated with SCS, blood pressure remained stable during the first seven days in the ICU, contributing to a favorable outcome.

Conclusion. The use of SCS in children with severe polytrauma from the first day of ICU treatment contributed to the stabilization of hemodynamic parameters and improved control of shock signs. A positive response to SCS in these patients can be considered a marker for a favorable disease course during ICU treatment.

Keywords: corticosteroids; multiple injuries in children; intensive care unit; outcome

Conflict of interest. The authors declare no conflict of interest.

Introduction

Severe polytrauma is one of the leading causes of death in children, and the younger the child, the higher the likelihood of an adverse outcome [1, 2]. It often results in irreversible brain damage and brain death due to underlying systemic hypoxia. Although there are many guidelines for the treatment of both adults and children with polytrauma, most provide only basic principles of intensive care and do not adequately address the subtleties and details of individual therapeutic strategies that significantly affect outcome [3–13].

Currently, international guidelines for hemodynamic and respiratory support in pediatric polytrauma are lacking, highlighting the need to find optimal solutions to this problem.

One therapeutic strategy widely used in clinical practice for patients with polytrauma and shock of various etiologies is the use of systemic corticosteroids (CS). However, the efficacy of their use raises many questions and requires multicenter randomized trials. This is particularly true for severe combined spinal trauma, where methylprednisolone is commonly used, but the need for and timing of its administration remains controversial.

In 2017, clinical guidelines for the use of methylprednisolone in adult patients with spinal cord injury were published, noting that methylprednisolone had no significant beneficial effect on motor recovery; however, patients prescribed it within the first 8 hours of injury had better motor recovery at 6 and 12 months. The authors do not recommend administering high-dose methylprednisolone to adults after 8 hours of injury, but continuous infusion of high-dose methylprednisolone for 24 hours is warranted in patients hospitalized within the first 8 hours of injury. Continuous infusion for 48 hours is not recommended. Similar results have been reported in pediatric practice [14]. Caruso M. C. et al (2017) found that the use of high doses of methylprednisolone is associated with a high probability of complications, indicating the need to abandon this therapeutic strategy, especially in the absence of convincing evidence of severe spinal injury and late hospitalization of the child [15].

Nonetheless, in the presence of refractory septic shock-often a result of severe polytrauma in children-the use of systemic corticosteroids is one

of the life-saving techniques since patients have critical acute adrenal insufficiency [16–18].

Based on the above, it can be concluded that the use of systemic glucocorticoids in children with polytrauma requires further study.

The aim of this study was to evaluate the effects of systemic corticosteroids on clinical and laboratory parameters and outcomes of polytrauma in children requiring intensive care.

Patients and Methods

We performed a retrospective observational multicenter study (case-control and cross-sectional type) based on the pediatric intensive care units of the Northwest Federal District of the Russian Federation, the Voronezh Regional Children's Clinical Hospital No. 1, the V. D. Seredavin Samara Regional Clinical Hospital, and the Republican Children's Clinical Hospital of the Republic of Bashkortostan.

Inclusion criteria: 1) age up to 18 years; 2) presence of polytrauma; 3) need for ICU treatment; 4) duration of ICU treatment at least 10 days.

Exclusion criteria: 1) organic brain damage; 2) congenital and hereditary comorbidities.

The study included 203 children with severe polytrauma who required ICU treatment between 2010 and 2019. The mean age of the children included in the study was 9.5 [4–14] years. There were 129 boys (65.55%) and 74 girls (36.45%). Patient characteristics are shown in Table 1.

The parameters studied were systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), heart rate (HR), shock index (HR/SBP ratio), capillary hemoglobin oxygen saturation (SpO_2), blood chloride and lactate levels, serum alanine aminotransferase (ALT) and aspartate aminotransferase (AST) levels, activated partial thromboplastin time (APTT), fluid infusion volume (as a percentage of age-specific fluid requirements), catecholamine index, body surface area, urine output, and disease outcome. The catecholamine index was calculated using the formula:

Dopamine, μg/kg/min +
dobutamine, μg/kg/min +
epinephrine, μg/kg/min × 100 +
norepinephrine, μg/kg/min × 100.

The study included several phases evaluated using cross-sectional analysis and case-control evaluation.

The study was conducted using open-source software Linux OS (Fedora 33), Python 3, analytical libraries (pandas, matplotlib, sklearn), and graphical data presentation tools (matplotlib, seaborn).

Normality of the data set distribution was tested using the Shapiro–Wilk test. Since the data set distribution was not normal, all results were presented as median *(Me)* and lower *(LQ)* and upper *(UQ)* quartiles. Non-parametric statistical methods were used to analyze the significance of differences between groups. The Wilcoxon test was used to test the significance of differences between two independent groups, and the Kruskal–Wallis test was used to evaluate indicators in three or more independent groups. The Friedman test was used to assess the significance of differences between two or more dependent groups (with repeated observations). Two-sided *P*-values were used in all tests, and the critical level of significance was set at $P<0.05$.

The results of the statistical analysis and the executable Python notebook code are publicly available at https://github.com/docinit/hormone_therapy_in_children_with_multiple_injuries.

Results

When analyzing the changes in the studied parameters over the entire treatment period in the ICU, we found that 11 out of 14 parameters had statistically significant differences ($P<0.05$) compared to the mean values for the following 10 days of treatment (Table 2).

The differences found indicate that patients remained unstable and required intensive care on day 1 of treatment in the hospital. There were fewer significant differences on days 2 and 3–10, as well as on days 3 and 4–10 of treatment.

In the second phase of the study, we created nine groups of patients according to CS use and disease outcome: 1 — all patients; 2 — all patients who did not receive CS; 3 — all patients who received CS; 4 — surviving patients; 5 — surviving patients who did not receive CS; 6 — surviving patients who received CS; 7 — non-survivors; 8 — non-survivors who did not receive CS; 9 — non-survivors who received CS.

On different days of observation in each group there was a varying number of significant differences: the maximum number of significant differences in parameters ($P<0.05$) was found in groups 1, 3, 4 and 6 on admission to the ICU. In the following days, the number of parameters with significant differences decreased.

Thus, we rejected the hypothesis that the use of CS does not affect clinical and laboratory parameters in children with polytrauma and accepted an alternative hypothesis, which implied that the surviving patients who received CS had significant intragroup differences in the studied parameters on the first and subsequent observation days (Table 3).

The next phase of the study revealed intergroup differences in the relationship between immediate outcomes and the use of CS during the first seven days of ICU treatment (Table 4).

In most cases, a significant difference was found between the clinical and laboratory parameters of survivors and non-survivors who received CS, as well as the group of non-survivors who did not receive CS.

Table 1. Patient characteristics, *N* (%) or *Me (LQ–HQ)*.

Parameter	Value
Sex	
Male	129 (63.55)
Female	74 (36.45)
Characteristics of injuries	
AIS, points	36.81 (25–48)
PTS, points	5.2 (2–8)
Traumatic brain injury + thoracic trauma + abdominal trauma + skeletal trauma	45 (22.16)
Traumatic brain injury + thoracic trauma + abdominal trauma	47 (23.15)
Traumatic brain injury + thoracic trauma + skeletal trauma	69 (33.99)
Traumatic brain injury + abdominal trauma + skeletal trauma	84 (41.3)
Traumatic brain injury + thoracic trauma	71 (34.9)
Traumatic brain injury + abdominal trauma	92 (45.32)
Traumatic brain injury + skeletal trauma	174 (85.71)
Multiple musculoskeletal injuries	181 (89.16)
Motor vehicle injury	63 (31.03)
Fall from a height	58 (28.57)
Intracranial hematoma	28 (13.79)
Subarachnoid hemorrhage	48 (23.64)
Intraventricular hemorrhage	10 (4.23)
Use of corticosteroids	
Administered	113 (55.67)
Not administered	90 (44.33)
Used only during day 1 of treatment in ICU	12 (5.91)
Outcome	
Survived	184 (90.64)
Died	19 (9.36)
Duration of mechanical ventilation, hours	3.11 (0–4.06)
Duration of treatment in the ICU, days	6.93 (1–8)

Note. AIS — Abbreviated Injury Scale; PTS — Pediatric Trauma Score.

Table 2. Clinical and laboratory parameters in children with polytrauma.

Parameter	Values during ICU stay		*P*-value
	On day 1	During days 2–10	
Systolic blood pressure, mm Hg	110.0 (102.7–117.2)	108.0 (95.0–120.0)	0.005
Diastolic blood pressure, mm Hg	64.33 (58.9–70.0)	61.0 (55.0–70.0)	0.0194
Mean blood pressure, mm Hg	79.78 (73.3–84.78)	77.33 (68.3–86.7)	0.0080
Heart rate, per minute	105.71 (94.0–115.6)	110.0 (92.0–125.0)	<0.001
Shock index	0.95 (0.83–1.11)	1.0 (0,83–1.24)	<0.001
SpO_2, %	98.78 (98.0–99.8)	99.0 (98,0–100.0)	0.6846
Chloride, mmol/L	108.9 (104.6–112.9)	108.74 (104.0–112.0)	0.6023
Lactate, mmol/L	1.2 (0.0–1.7)	1.1 (0.0–2.6)	0.0013
Amylase, IU/L	35.3 (0.0–94.0)	18.3 (0.0–49.7)	<0.001
Alanine aminotransferase, IU/L	39.48 (18.98–77.55)	39.6 (15.2–101.5)	<0.001
Aspartate aminotransferase, IU/L	55.81 (34.06–110.0)	62.5 (28.5–163.4)	<0.001
Activated partial thromboplastin time, s	28.9 (0.0–33.09)	25.8 (0.0–31.0)	<0.001
Fluid infusion volume, % of age-related requirement	118.53 (98.96–138.8)	84.42 (60.99–130.5)	<0.001
Catecholamine index	0.0 (0.0–5.3)	0.0 (0.0–5.0)	0.0721

We further compared the values of the studied parameters for all patients on the first and subsequent days of treatment, forming groups for pairwise comparison (Table 5).

We found that the values of clinical and laboratory parameters differed significantly between patients who received CS only on the first day of treatment and those who received it in later periods; these differences were not characteristic of non-survivors, unlike survivors. The groups of patients were similar in terms of outcome (Table 6).

When CS were administered on any of the days of treatment in the ICU, significant differences in all analyzed parameters were observed between non-survivors and survivors. We also found significant differences in the width of the ranges of values of the studied clinical and laboratory parameters between the created groups of patients, with a narrower range of values in children who received CS. The most pronounced differences between patients who received CS on different days of treatment in the ICU were observed when comparing children who received CS only on day 1 (on admission to the hospital). In particular, differences were found in chloride levels, volume of fluid infusion, and frequency of catecholamine use (all of which were lower in children who received CS on day 1).

Systolic blood pressure levels with the use of CS in children with fatal polytrauma deserve special attention (see Figure). Children who did not receive

Table 3. Analysis of paired samples of patients in the first seven days of treatment in ICU.

Values	Values in groups		
	1 (all)	**2 (all without steroids)**	**3 (all with steroids)**
Chloride, mmol/L	110.0 (106.0–116.75) *P=0.0002	110.85 (106.75–116.0) P=0.2838	110.0 (105.3–117.0) P=0.0007
Alanine aminotransferase, IU/L	41.3 (21.21–93.0) P=0.0029	44.8 (22.0. 103.55) P=0.0242	40.9 (21.02. 85.64) P=0.176
Aspartate aminotransferase, IU/L	58.75 (36.0–120.65) p<0.001	60.4 (40.04–125.0) p<0.001	57.0 (35.3–118.52) P=<0.001
Amylase, IU/L	51.3 (0.0–120.69) p<0.001	50.5 (19.22–101.1) P=0.0019	51.3 (0.0–140.43) p<0.001
Diastolic blood pressure, mm Hg	62.0 (55.0–70.0) P=0.0019	63.0 (58.0–72.0) P=0.0938	61.0 (55.0. 70.0) P=0.0078
Urine output, mL/kg	48.0 (33.24–75.5) P=0.0009	48.23 (34.75–79.17) P=0.2918	47.83 (32.94–74.5) P=0.0011
Shock index	0.91 (0.76–1.09) P=0.0001	0.97 (0.74–1.11) P=0.7597	0.9 (0.77–1.08) p<0.001
Fluid infusion volume, % of age-related requirement	118.33 (96.21–147.46) P=0.0	119.03 (99.96. 147.58) P=0.1117	118.26 (94.2. 145.08) P=0.0001
Catecholamine index	5.0 (0.0–7.5) P=0.0057	2.75 (0.0–7.5) P=0.4063	5.0 (0.0–7.5) P=0.0233
Lactate, mmol/L	1.2 (0.15–1.9) P=0.0004	1.4 (1.0–1.8) P=0.6424	1.2 (0.0–2.08) P=0.0001
Systolic blood pressure, mm Hg	110.0 (100.0–120.0) P=0.0002	112.0 (100.0–120.25) P=0.1962	110.0 (100.0–120.0) P=0.0002
Mean blood pressure, mm Hg	78.33 (71.33–87.67) P=0.0003	80.0 (71.33–88.67) P=0.0638	78.33 (71.42–87.33) P=0.0011
Heart rate, per minute	102.0 (88.0–118.0) P=0.0118	102.5 (89.0–116.25) P=0.6667	102.0 (85.25–118.0) P=0.0149
Parameter	**4 (survivors)**	**5 (survivors not receiving steroids)**	**6 (survivors receiving steroids)**
Chloride, mmol/L	110.0 (105.0–115.0) p<0.001	110.0 (105.5–116.0) P=0.0523	110.0 (105.0–115.0) P=0.0001
Alanine aminotransferase, IU/L	38.48 (19.95–89.52) P=0.0004	44.4 (22.25–117.35) P=0.0117	33.7 (19.3–71.0) P=0.0738
Aspartate aminotransferase, IU/L	60.4 (43.85–112.95) p<0.001	60.4 (43.85–112.95) p<0.001	50.6 (33.2–95.0) p<0.001
Amylase, IU/L	63.85 (27.0–143.52) p<0.001	55.7 (27.5–102.85) P=0.0019	69.4 (27.0–171.2) p<0.001
Diastolic blood pressure, mm Hg	65.0 (60.0–72.0) P=0.4422	65.0 (60.0–72.0) P=0.4422	61.0 (55.0–70.0) P=0.0001
Urine output, mL/kg	47.83 (32.98–75.0) P=0.0033	48.46 (34.52–79.17) P=0.3763	47.5 (32.22–73.33) P=0.0078
Shock index	0.93 (0.73–1.09) P=0.8015	0.93 (0.73–1.09) P=0.8015	0.89 (0.75–1.06) p<0.001
Catecholamine index	116.16 (94.27–144.06) p<0.001	114.7 (98.83–145.83) P=0.093	117.23 (92.59–143.75) P=0.0001
Lactate, mmol/L	1.3 (0.0–5.0) P=0.6135	1.3 (0.0–5.0) P=0.6135	5.0 (0.0–7.0) P=0.0144
Systolic blood pressure, mm Hg	1.3 (0.9–1.9) P=0.0003	1.3 (1.0–1.7) P=0.3905	1.3 (0.8–2.0) P=0.0002
Mean blood pressure, mm Hg	115.0 (100.0–120.0) P=0.332	115.0 (100.0–120.0) P=0.332	110.0 (100.0–120.0) P=0.0
Heart rate, per minute	78.83 (72.0–87.33) P=0.0	81.0 (73.17–88.67) P=0.2954	78.33 (71.67–86.67) P=0.0
Catecholamine index	100.0 (88.0–115.0) P=0.6786	100.0 (88.0–115.0) P=0.6786	100.0 (84.0–116.0) P=0.0015
Parameter	**7 (non-survivors)**	**8 (non-survivors receiving steroids)**	**9 (non-survivors receiving steroids)**
Activated partial thromboplastin time, s	24.5(0.0–36.15) P=0.0035	25.0 (0.0–31.5) P=0.0983	24.0 (0.0–37.0) P=0.1185
Catecholamine index	7.5 (4.0–14.0) P=0.0073	14.0 (14.0–30.0) P=0.1265	5.0 (2.5–10.0) P=0.0364

Note. * — all P-values are presented as comparisons between the parameters of the first day and those of the following seven days of observation.

Table 4. Comparative analysis of patient samples during the first seven days of ICU treatment.

Values	Values in groups			*P*-value
	6 (survivors receiving steroids)	9 (non-survivors receiving steroids)	8 (non-survivors not receiving steroids)	
Catecholamine index, LQ	5.571	7.7819	14.9828	0.0000
Lactate, LQ	1.2085	0.5157	0.3655	0.0000
SpO_2, UQ	98.7448	98.2378	99.3208	0.0001
Activated partial thromboplastin time, LQ	26.9007	15.3725	14.1115	0.0004
Systolic blood pressure, LQ	109.361	101.8029	96.7571	0.0060
Diastolic blood pressure, LQ	62.127	57.9126	53.8308	0.0111
Chloride, LQ	110.3991	112.8445	112.6637	0.0159
Mean blood pressure, LQ	77.9618	72.7039	68.4225	0.0174
Aspartate aminotransferase, LQ	87.0879	118.9305	62.3428	0.0194
Amylase*, UQ	167.2604	31.2796	90.0558	0.0213
Amylase*, LQ	117.0766	0.6165	6.2633	0.0248
Lactate, UQ	1.6116	1.7959	1.2822	0.0373
Catecholamine index, UQ	9.5239	26.322	32.2077	0.0382
Systolic blood pressure, UQ	112.6329	112.3789	113.3381	0.0383
Alanine aminotransferase, LQ	64.2138	74.3447	41.1377	0.0437

Note. UQ — upper quartile; LQ — lower quartile.

Table 5. Clinical and laboratory in relation to the use of corticosteroids in ICU.

Parameter	Values in relation to the time of steroid administration		*P*-value
	Only on day 1	On any day	
Activated partial thromboplastin time, s	27.8 (0–34.05)	29.2 (26.96–33.68)	0.0461
Amylase	49.3 (0–172.03)	33 (0–64.48)	0.0215
Urine output, mL/kg	42.5 (28–58.15)	51.42 (29.06–83.33)	0.0475
Catecholamine index	4.5 (0–7.5)	0 (0–4.38)	<0.001
Lactate	1.2 (0–1.9)	0 (0–1.3)	0.0001
Parameter	**Only on day 1**	**Any day except for day 1**	
Chloride	108 (102.3–110.75)	111 (106–121)	<0.001
Activated partial thromboplastin time, s	29.2 (26.96–33.68)	32 (28.78–34.8)	0.0100
Amylase	33 (0–64.48)	72 (50.08–129.7)	<0.001
Shock index	0.87 (0.78–1.07)	0.97 (0.81–1.11)	0.0900
Fluid infusion volume, % of age-related requirement	107.43 (82.25–131.56)	129.79 (109.69–160.27)	<0.001
Catecholamine index	0 (0–4.38)	5 (1.25–7.5)	<0.001
Lactate	0 (0–1.3)	1.1 (0–1.6)	<0.001
Parameter	**Only on day 1**	**Not administered**	
Catecholamine index	0 (0–4.38)	0 (0–5)	0.0200
Lactate	0 (0–1.3)	1.1 (0–1.7)	<0.001
Parameter	**Any day**	**Not administered**	
Amylase	61 (0–141.5)	39 (0–78.98)	<0.001
Catecholamine index	5 (0–7)	0 (0–5)	<0.001

CS had higher blood pressure values during the first three days of treatment in the ICU, with a decrease on day 5 and a tendency to hypertension on days 6–7. When CS were administered, the patients' blood pressure levels remained stable during the first seven days after trauma.

Clinical and laboratory signs in patients who received CS only on day 1 of treatment in the ICU were as close as possible to age-related reference values, in contrast to patients who received CS on other days of treatment in the ICU.

Discussion

Corticosteroids are among the few drugs that are widely used despite the lack of clear evidence of their efficacy and safety, especially in pediatric practice. In recent years, several studies have focused on the evaluation of steroid levels in patients after trauma and the efficacy of their administration for stabilization, indicating the relevance of the issue under consideration and the need for a thorough reassessment of the available data [19–24].

The results obtained suggest that the use of steroids provides primary stabilization of the patient and promotes the restoration of key biochemical parameters. The administration of corticosteroid therapy on the first day has the greatest effect, and its efficacy can serve as a criterion for a favorable outcome, since no significant differences were observed in the group of non-survivors regardless of the use of corticosteroids, whereas a significant positive evolution of the evaluated parameters was observed in the group of survivors with the use of corticosteroids. We suggest that the use of corticosteroids led to a stabilization of homeostasis. In particular, the lower limit of the interquartile range of systolic blood pressure was lower in patients

Table 6. Treatment outcomes in ICU in relation to the use of corticosteroids.

Parameter	Values in relation to the time of steroid administration		*P*-value
	Survivors	Non-survivors	
Chloride	108.72 (104–114)	111.2 (108.74–124)	0.0001
SpO_2, %	99 (98–100)	98 (98–99)	<0.001
Alanine aminotransferase	36.75 (20.5–71.1)	71 (39.375–113)	0.0108
Activated partial thromboplastin time, s	30 (24–35)	24 (0–38)	0.0022
Amylase	61 (19.6625–129.775)	0 (0–0)	<0.001
Diastolic blood pressure	65 (60–73)	59.5 (46.75–70)	0.0005
Catecholamine index	2.5 (0–5)	8 (5–20)	<0.001
Lactate	1.2 (0–1.8)	0 (0–1.1)	<0.001
Systolic blood pressure	110 (104–120)	103 (86.5–117)	0.0063
Mean blood pressure	81.333 (73.3333–88.3333)	73.333 (60–86.8333)	0.0011
	Not administered on day 1		
SpO_2, %	99 (98–100)	98 (98–99)	0.0491
Catecholamine index	2.5 (0–5)	8 (5–20)	0.0058
	Administered on any day		
Chloride	108.87 (105–115)	120 (108.74–139)	<0.001
SpO_2, %	99 (98–100)	98 (98–99)	<0.001
Alanine aminotransferase	36.75 (20.5–71.1)	71 (39.375–113)	<0.001
Aspartate aminotransferase	48.3 (30–83.3875)	111 (42.1–183)	<0.001
Amylase	61 (19.6625–129.775)	0 (0–0)	<0.001
Diastolic blood pressure	65 (60–73)	59.5 (46.75–70)	0.0005
Urine output, mL/kg	46.733 (30.5956–72.5)	45.685 (32.75–70.8576)	0.2074
Shock index	0.933 (0.7727–1.1)	0.991 (0.8385–1.1919)	0.0272
Fluid infusion volume, % of age-related requirement	116.583 (95.027–142.743)	125.884 (93.714–147.917)	0.3323
Catecholamine index	2.5 (0–5)	8 (5–20)	<0.001
Lactate	1.2 (0–1.8)	0 (0–1.1)	<0.001
Systolic blood pressure	110 (104–120)	103 (86.5–117)	<0.001
Mean blood pressure	81.333 (73.333–88.3333)	73.333 (60–86.8333)	0.0001
Heart rate	106 (90–120)	106 (90–121.25)	0.6672
	Administered on day 1		
SpO_2, %	99 (98–100)	98 (98–99)	0.0080
Diastolic blood pressure	65 (60–73)	59.5 (46.75–70)	0.0189
Fluid infusion volume, % of age-related requirement	116.6 (95.03–142.7)	125.9 (93.7–147.9)	0.0100
Catecholamine index	2.5 (0–5)	8 (5–20)	0.0070
Systolic blood pressure	110 (104–120)	103 (86.5–117)	0.0415
Mean blood pressure	81.333 (73.3–88.3)	73.333 (60–86.83)	0.0239
Catecholamine index	5 (0–7)	0 (0–5)	<0.001

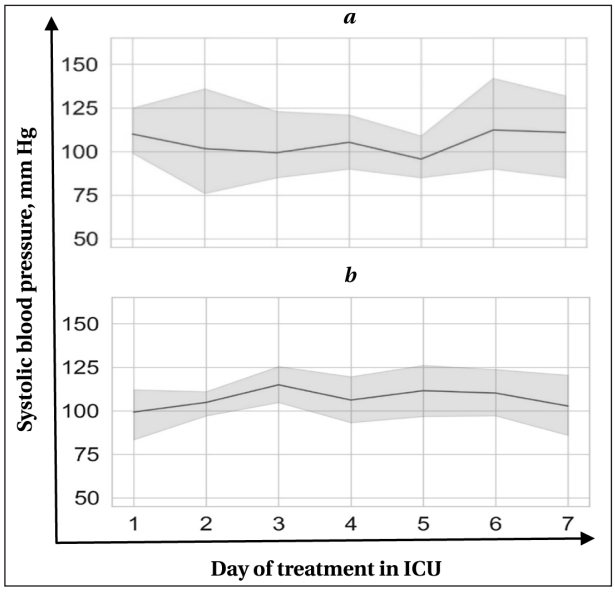

Fig. Systolic blood pressure in children with fatal polytrauma in relation to corticosteroid use (shaded area corresponds to 95% confidence interval).
Note. *a* — no corticosteroids administered; *b* — corticosteroids were administered.

who did not receive corticosteroids than in those who did, both in survivors and non-survivors (*P*=0.006).

Most likely, this was due to the maximum intensity of the therapeutic effect of CS on the first day after the trauma. The forced use of CS later in the post-traumatic period indicates instability of the patient's condition, has minimal therapeutic effect and serves as a diagnostic marker of unfavorable outcome in children with polytrauma.

The necessity of using CS and their effectiveness in patients with severe traumatic brain injury is demonstrated by the work of Prasad G. L., who showed that the use of dexamethasone at an initial dose of 12 mg/day in adult patients with mild to moderate traumatic brain injury for six days, with a gradual reduction of the dose, helps prevent delayed cerebral edema. The author noted sustained improvement in all patients: the mean time from the first dexamethasone injection to resolution of neurological symptoms was 3.8 days. No complications related to the use of CS were reported [19].

In the 2023 publication, Prasad G. L. discusses the need to re-evaluate the efficacy of CS use in

cerebral edema that cannot be controlled with osmotic diuretics [20].

The role of CS in the development of the stress response and its potential use in the treatment of severe polytrauma is also supported by the study by Bentley C. et al. who examined the levels of adrenal hormones in adult patients during the first hour after injury and found that the levels of cortisol and 11-hydroxyandrostenedione increase rapidly and significantly [23].

Kwok A. M. et al. (2020) also demonstrated that low cortisol concentrations in severe adult polytrauma are associated with the need for large volumes of blood products, vasopressors, and increased mortality. They suggest that testing blood cortisol concentrations on admission to hospital may be useful in identifying high-risk patients [24].

In 2023, a literature review on the early use of CS for hemorrhagic shock in adult patients reported a lack of research on this topic in recent years, despite the wide availability of steroids and their use in routine clinical practice, suggesting the need for modern multicenter studies [22].

The positive therapeutic effects of CS in pediatric ICU patients are also confirmed in the study by Corbet Burcher G. et al. (2018), which showed that their use contributes to the reduction of post-traumatic stress in children with sepsis and meningoencephalitis, although it is associated with a decrease in evening salivary cortisol concentration [21].

Conclusion

The administration of corticosteroids in children with severe polytrauma on the first day of treatment in the ICU helped to stabilize hemodynamic parameters and reduce signs of shock. A positive response to steroids in children with polytrauma can be considered a marker of favorable prognosis throughout their treatment in the ICU.

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