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# Predictors of Adverse Outcomes in Acute Poisoning in Children

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## Summary

Poisoning is one of the most common causes for hospitalization of pediatric patients, often requiring admission to an intensive care unit (ICU).

**Aim.** To identify predictors of adverse outcomes in children with acute poisoning requiring ICU care.

**Materials and Methods.** A single-center, observational, retrospective study was conducted involving 262 children with severe poisoning. The median age was 15 [13-16] years. Patients were divided into two groups based on the clinical course of the poisoning: favorable and unfavorable. Hospitalization outcomes included duration of mechanical ventilation (MV), length of ICU stay, presence of complications (aspiration syndrome, seizures, etc.), and in-hospital mortality.

**Results.** The presence of toxic hepatitis/pancreatitis on admission increased the odds of adverse outcome by 4.63-fold, acute kidney injury by 5.32-fold, the need for MV by 14.34-fold, and aspiration pneumonia by 19.23-fold. The most significant markers of adverse outcomes during ICU care included shock (odds ratio OR=4.35), coagulopathy (OR=9.94), and hypocoagulation (OR=29.4). For assessing the severity of multiple organ dysfunction syndrome (MODS) in children with acute intoxication, the Marshall J. C. criteria showed the highest prognostic value (AUROC=0.894; sensitivity = 87.0%; specificity = 81.9%). A mathematical model was developed to predict the likelihood of adverse outcome in acute poisoning in children. The model includes 13 parameters: presence of pneumonia and seizures, need for MV, systolic and mean arterial pressure, catecholamine index, hemoglobin concentration, red and white blood cell counts, blood pH and glucose levels, $SpO_2/FiO_2$ ratio, and international normalized ratio (INR). The model demonstrated high predictive accuracy (accuracy=0.938; sensitivity=94.2%; specificity=92.5%; AUROC=0.981).

**Conclusion.** Impaired consciousness, severe hypoxemia, coagulopathy and acute liver failure are the main markers of severe acute poisoning in children.

***Keywords: poisoning, children, intensive care unit, prognosis, outcome.***

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

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## Introduction

Poisoning by toxic substances and drugs remains one of the most common causes of emergency department visits and intensive care unit (ICU) admissions in both adult and pediatric populations [1–5].

In recent years, there has been a steady increase in the number of pediatric cases of acute exogenous poisoning requiring intensive care [6–9]. The most common poisonings in children involve neurotoxic agents, nonsteroidal anti-inflammatory drugs (NSAIDs), and cardiovascular drugs [10]. Among neuroactive substances, benzodiazepine overdoses predominate, while paracetamol is the leading NSAID involved, reflecting its widespread use in pediatric medicine [10, 11].

Narcotic and psychotropic drug poisoning has emerged as a critical global public health challenge [9]. According to the World Health Organization

(WHO), 1 in 17 people aged 15–64 years used such substances in 2021. Reported cases will increase by 23% between 2011 (240 million) and 2021 (296 million), affecting 5.8% of the global population in this age group [9].

Each year in the United States, approximately 50,000 children present to emergency departments after unintentionally ingesting potentially toxic substances, with approximately 9,000 requiring hospitalization. Among children under the age of five, opioids are the leading cause of fatal poisonings. The proportion of opioid-related poisoning deaths has risen sharply, accounting for 52.2% of pediatric poisoning deaths in 2018, compared with 24.1% in 2005 [10, 12].

Li et al. (2021) note that while the incidence of accidental pediatric poisoning has decreased in recent years, the mortality rate has remained unchanged. In children aged 0–5 years, the risk of a fatal outcome is equivalent whether the toxic agent is a pharmaceutical or non-pharmaceutical substance. However, in older children, poisoning by non-pharmaceutical toxicants is associated with significantly higher mortality: the odds ratio increases to 2.38 (95% CI, 1.58–3.58) for children aged 6–12 years and to 3.04 (95% CI, 2.51–3.69) for adolescents (13–19 years) [13].

Of particular concern is the increase in suicide attempts involving pharmaceuticals, which accounted for 40.63% of fatal poisonings in children aged 6–12 years and 48.66% in adolescents (13–19 years), especially those with behavioral disorders. Non-pharmaceutical poisons were involved in 31.15% of suicide-related fatal poisonings in the 13–19 age group [13–15].

M. Junuzovic et al. (2022) reported that poisoning as a method of suicide occurred in 4% of pediatric cases [16]. These findings are consistent with observational studies identifying drugs as the most common cause of serious poisoning in children [17–20].

Cannabis-based products remain the most widely used substances worldwide, with 219 million users (4.3% of the global adult population) in 2021. Approximately 60 million people used opioids for non-medical purposes, including 31.5 million who used opiates — the main cause of fatal overdoses [9, 21, 22].

Recent studies highlight a steady increase in pediatric cannabis derivative poisonings associated with legalization in several countries. However, research on treatment protocols and family education for these patients remains critically limited [21–23].

In particular, few studies have evaluated outcomes or predictors of poor prognosis in severe pediatric poisonings. Early identification of high-risk patients upon admission to the ICU could significantly improve outcomes, underscoring the rationale for this study.

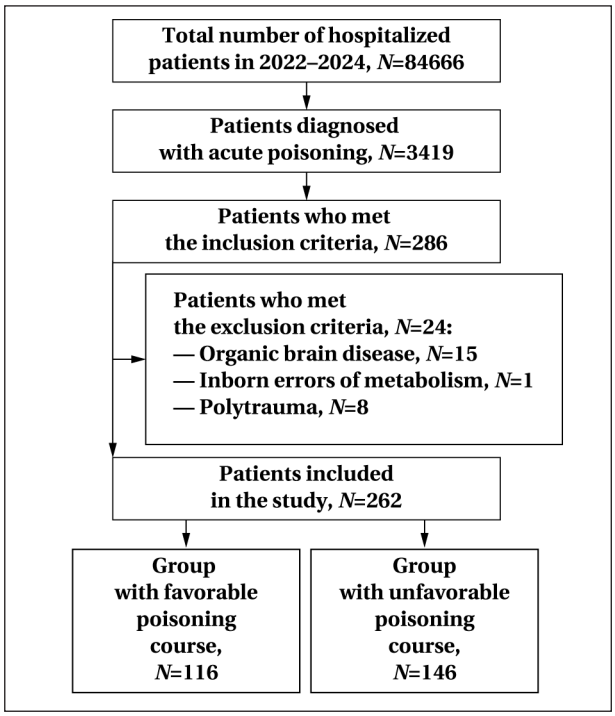


**Fig. 1. Patient selection flowchart.**

The study aim was to identify risk factors and predictors of unfavorable course in children with acute poisoning requiring intensive care.

## Materials and Methods

We conducted a single-center, observational, retrospective study approved by the local ethics committee of the St. Petersburg State Pediatric Medical University, Russian Ministry of Health (Protocol No. 19/02, dated November 17, 2022).

Inclusion criteria

- Age 0–18 years
- Severe intoxication
- Impaired consciousness (stupor or coma)
- Need for intensive care treatment

Exclusion Criteria

- Organic brain disease
- Inborn errors of metabolism
- Genetic diseases
- Polytrauma

The study included 262 children (148 boys [56.5%] and 114 girls [43.5%]) aged 0–18 years who were admitted to the Department of Anesthesiology, Resuscitation and Intensive Care at Filatov Children's City Clinical Hospital No. 5 (2022–2024) (Fig. 1).

The most frequent poisoning agents were:

- Methadone (24.0%)
- Sedatives-hypnotics such as neuroleptics, tricyclic antidepressants, GHB precursors, anticonvulsants (24.0%)
- Ethanol (22.0%)
- Psychoactive substances such as cannabinoids, amphetamines, synthetic cannabinoids («spice»), hallucinogenic mushrooms (18.0%)

• Other substances such as muscle relaxants (baclofen, tizanidine), cardiovascular drugs (propafenone, clonidine, propranolol, cinnarizine), decongestants (naphazoline), antihistamines (cetirizine, diphenhydramine), antiemetics (dimenhydrinate, metoclopramide), hemorheologic agents (pentoxifylline), NSAIDs (acetaminophen), local anesthetics (lidocaine, benzocaine), cyanide (12.0%).

All patients underwent

• comprehensive clinical and laboratory evaluation

• toxicologic screening (blood and urine) to identify toxicants

To verify the diagnosis of acute respiratory distress syndrome (ARDS), the $SpO_2/FiO_2$ ratio and the oxygenation index (OI) were calculated. The OI was calculated using the following formula [5]:

$$OI=(MAP\times FiO_2\times 100\%)/PaO_2.$$

The catecholamine index was used to assess the intensity of catecholamine support. It was calculated according to the following formula [114]:

Catecholamine index = Dopamine (μg/kg/min) + Dobutamine (μg/kg/min) + Epinephrine (μg/kg/min) + Norepinephrine (μg/kg/min).

Patients were divided into two groups based on their clinical and laboratory status: those with a favorable course of poisoning (*N*=116) and those with an unfavorable course (*N*=146). Classification was based on seven severity criteria:

- Multiple organ dysfunction
- Seizures
- Need for mechanical ventilation
- Coagulopathy (prothrombin index <67%)
- Acidosis with pH <7.25
- Lactate concentration >2.5 mmol/L
- $SpO_2/FiO_2$ ratio < 300

Patients with five or more of these criteria were assigned to the unfavorable course group.

The hospitalization outcomes studied included the duration of mechanical ventilation, length of stay in the ICU, the presence of complications (such as aspiration syndrome, seizures, and others), and in-hospital mortality. In-hospital mortality was considered the primary endpoint, while all other endpoints were considered secondary.

For statistical analysis, direct access to electronic medical records was obtained through the medical information system, and all necessary frequency and quantitative data were available. Descriptive statistics were used throughout the analysis. Absolute and relative frequencies were calculated for binary and categorical variables. For continuous variables, median and interquartile range *(Q1–Q3)* were reported. The Shapiro–Wilk test was used to assess normality of data distribution. Differences in continuous variables between two independent groups were analyzed using the Mann–Whitney *U* test. Associations between continuous and binary variables were assessed by calculating odds ratios (OR) with their 95% confidence intervals (95% CI). For categorical variables with outcome frequencies less than 5 in any of the groups, Fisher's exact test was used.

Regression analysis and prognostic model development were based on univariate and multivariate logistic regression because the dependent variable was binary. Predictor selection was optimized using stepwise logistic regression with Akaike's information criterion ($\triangle AIC < 0.1$). The model initially included 28 clinical and laboratory variables (e.g., presence of arrhythmias, systolic, diastolic, and mean arterial pressure, heart rate, etc.). A total of 15 iterations were performed to define the final set of predictors.

Collinearity among potential predictors was assessed by correlation analysis based on variable types and distribution characteristics. Pearson's correlation coefficient was used for parametric variables, Spearman's rank correlation for nonparametric data, and Pearson's contingency coefficient for categorical variables. Predictors with statistically significant correlations greater than 0.5 with several other variables (i. e., accounting for more than 25% of the common variance) were excluded from the model.

Estimation of regression coefficients was performed using maximum likelihood, implemented via the glm function for binomial distribution and the MASS package for stepwise logistic regression in the R programming environment. To evaluate the predictive performance of clinical and laboratory variables, scoring systems, and the final model, ROC analysis was performed, including ROC curve construction and calculation of AUROC, accuracy, sensitivity, and specificity. The optimal cutoff point was determined using the Youden index (*J*-index) in MedCalc software.

For all statistical tests, regression and correlation coefficients, and odds ratios, the significance threshold was set at $P<0.05$. All tests were performed as two-tailed. All regression analyses were performed in *R* using dedicated libraries (MASS, ROCR, meta) and custom R scripts. Figure 2 was generated in *R* using the graphical functions of the meta package.

## Results

The median age of the children included in the study was 15.0 years [IQR: 13.0–16.0]. The distribution of participants by sex and age is shown in Table 1. The majority of patients (70.0%) were between 14 and 18 years of age. There was a significantly higher proportion of boys compared to girls (43.5% vs. 26.3%).

The overall mortality rate was 0.76% (*N*=2), observed exclusively in the group of patients with an unfavorable course of poisoning; no deaths occurred in those with a favorable course (*P*=0.505).

Patients with an unfavorable course had a significantly longer time to regain consciousness (21.0 vs. 12.2 hours; $P<0.001$), duration of mechanical ventilation (2.0 vs. 0 days; $P<0.001$), and ICU stay (3.2 vs. 1.0 days; $P<0.001$).

**Table 1. Distribution of patients by age and sex, *N* (%).**

| Age (years) | Boys, *N* (%) | Girls, *N* (%) | Total, *N* (%) |
|---|---|---|---|
| <1 year | 1 (0.4) | 1 (0.4) | 2 (0.8) |
| 1–3 | 11 (4.2) | 17 (6.5) | 28 (11.0) |
| 3–7 | 11 (4.2) | 10 (3.8) | 21 (8.0) |
| 7–10 | 4 (1.5) | 1 (0.4) | 5 (2.0) |
| 11–14 | 7 (2.7) | 16 (6.1) | 23 (9.0) |
| 14–18 | 114 (43.5) | 69 (26.3) | 183 (70.0) |
| **Total** | **148 (56.5)** | **114 (43.5)** | **262 (100.0)** |

**Table 2. Clinical and laboratory status on the first day of ICU treatment and during the entire stay in the ICU according to poisoning characteristics, *N* (%) or *Me (Q1–Q3)*.**

| Parameter | Values in groups | | *P value* |
|---|---|---|---|
| | Favorable course, *N*=116 | Unfavorable course, *N*=146 | |
| Age, years | 15 [4–16] | 15 [14–16] | 0.001 |
| Sex | | | |
| Boys | 61 (52.6) | 87 (59.6) | <0.001 |
| Girls | 55 (47.4) | 59 (40.4) | |
| Mechanical ventilation | 8 (6.9) | 123 (84.2) | <0.001 |
| Acute kidney injury on day 1 in ICU | 3 (2.6) | 18 (12.3) | 0.004 |
| Toxic hepatitis/pancreatitis on day 1 in ICU | 7 (6.0) | 33 (22.6) | <0.001 |
| Arrhythmia on day 1 in ICU | 13 (11.2) | 17 (11.6) | 0.952 |
| Pneumonia on day 1 in ICU | 2 (1.7) | 35 (24.0) | <0.001 |
| Seizures on day 1 in ICU | 7 (6.03) | 22 (15.1) | 0.021 |
| Seizures during entire ICU stay | 7 (6.03) | 22 (15.1) | 0.021 |
| Hypocoagulation during entire ICU stay | 3 (2.6) | 64 (43.8) | <0.001 |
| Coagulopathy during entire ICU stay | 12 (10.3) | 78 (53.4) | <0.001 |
| Thrombocytopenia during entire ICU stay | 4 (3.4) | 20 (13.7) | 0.004 |
| Shock during entire ICU stay | 6 (5.2) | 28 (19.2) | <0.001 |
| Anemia during entire ICU stay | 5 (4.3) | 21 (14.4) | 0.006 |
| Acute liver failure during entire ICU stay | 11 (9.5) | 43 (29.5) | 0.005 |
| Acute kidney injury during entire ICU stay | 6 (5.2) | 20 (13.7) | 0.022 |
| PEMOD score, points | 3 [2–3] | 5 [4–7] | 0.001 |
| PELOD score, points | 1 [1–1] | 11 [2–21] | 0.001 |
| MOD score by Marshall criteria, points | 0 [0–0] | 2 [1–3] | 0.001 |
| pSOFA score, points | 3 [3–4] | 6 [4–7] | 0.001 |
| GCS score, points | 8.5 [7–10] | 6 [5–9] | 0.001 |
| Glasgow-Pittsburgh score, points | 28 [25.5–29] | 20 [15–26] | 0.001 |
| FOUR score, points | 12 [11–12] | 7 [4–11] | 0.001 |
| **Laboratory parameters** | | | |
| Leukocytes, $\times 10^9$/L | 11.45 [9.10–14.95] | 14.55 [10–21] | 0.001 |
| Glucose, mmol/L | 6.3 [5.5–7.5] | 7.2 [6.0–10.7] | 0.001 |
| Urea, mmol/L | 4.1 [3.4–5.0] | 4.9 [3.7–5.9] | 0.001 |
| Creatinine, μmol/L | 70 [47–82] | 80 [61–113] | <0.001 |
| Alanine aminotransferase (ALT), U/L | 15 [13–18] | 16 [12–29] | 0.042 |
| Aspartate aminotransferase (AST), U/L | 29 [23–34] | 37 [27–54.5] | <0.001 |
| Creatine phosphokinase (CPK), U/L | 173.5 [113–276] | 204.5 [124–408] | 0.044 |
| **Acid-base balance parameters** | | | |
| pH | 7.33 [7.30–7.36] | 7.26 [7.19–7.33] | <0.001 |
| Base deficit, mmol/L | –3.4 [–5.0–(–1.5)] | –4.6 [–8.0–(–2.0)] | <0.001 |
| Lactate, mmol/L | 2.2 [1.6–3.3] | 3.0 [1.9–5.0] | <0.001 |
| $SpO_2/FiO_2$ ratio | 471 [466–476] | 250 [200–330] | <0.001 |
| Coagulation parameters | | | |
| Prothrombin index, % | 85 [78–93] | 75.5 [60–83.5] | <0.001 |
| INR | 1.17 [1.08–1.23] | 1.23 [1.17–1.36] | <0.001 |

**Note.** PELOD — Paediatric Logistic Organ Dysfunction; PEMOD — Pediatric Multiple Organ Dysfunction Score; pSOFA — Paediatric Sequential Organ Failure Assessment; INR — International Normalized Ratio; MOD — Multiple Organ Dysfunction; GCS — Glasgow Coma Scale; FOUR — Full Outline of UnResponsiveness Score.

Among patients with a favorable course, only 25% remained unconscious after thirteen hours of treatment, while over 50% of patients in the unfavorable group were still unconscious at that time. By twenty hours, 50% of patients in the unfavorable group had regained consciousness; however, even after forty-seven hours, 25% remained unconscious. In contrast, nearly all patients with a favorable course had regained consciousness by that time.

The unfavorable course of acute poisoning was associated with significantly higher scores on all multiple organ dysfunction scales, decompensated acidosis, marked base deficit, and hyperlactatemia. These patients also had a decreased $SpO_2/FiO_2$ ratio and an increased INR,

**Table 3. Prognostic significance of clinical and laboratory parameters in assessing the likelihood of unfavorable course.**

| Parameter | Significance | | | | | |
|---|---|---|---|---|---|---|
| | Area under the curve (AUC) | *P* | *J*-Index | Optimal cutoff value | Sensitivity (%) | Specificity (%) |
| $FiO_2$ | 0.852 | <0.001 | 0.71 | >0.3 | 70.87 | 100 |
| $SpO_2/FiO_2$ | 0.853 | <0.001 | 0.69 | <300 | 69.2 | 100 |
| Oxygenation index | 0.838 | <0.001 | 0.54 | >3 | 64.5 | 88.89 |
| pH | 0.742 | <0.001 | 0.41 | ⩽7.26 | 53.2 | 87.8 |
| PTI | 0.721 | <0.001 | 0.33 | ⩽69.5 | 35.0 | 98.1 |
| $pCO_2$ | 0.714 | <0.001 | 0.35 | >52 | 42.96 | 92.17 |
| INR | 0.697 | <0.001 | 0.31 | >1.17 | 74.1 | 57.3 |
| AST | 0.682 | <0.001 | 0.32 | >37 | 49.3 | 82.9 |
| Creatinine | 0.654 | <0.001 | 0.26 | >86 | 45.1 | 81.4 |
| Glucose | 0.643 | <0.001 | 0.26 | >7.6 | 47.6 | 78.3 |
| Lactate | 0.626 | <0.001 | 0.24 | >2.5 | 62.4 | 61.7 |
| Albumin | 0.578 | 0.043 | 0.13 | ⩽39.4 | 31.4 | 81.3 |
| Potassium | 0.584 | 0.018 | 0.19 | >4.6 | 35.3 | 84.4 |
| Leukocytes | 0.625 | <0.001 | 0.27 | >15.2 | 48.6 | 78.5 |

**Note.** $FiO_2$ — Fraction of inspired oxygen; PTI — Prothrombin index; $pCO_2$ — Partial pressure of carbon dioxide in blood; INR — International normalized ratio; AST — Aspartate aminotransferase.

**Table 4. Discriminatory power of multiple organ failure scoring systems in assessing the severity of multiple organ dysfunction in children with severe acute poisoning during the first 24 hours in the intensive care unit.**

| Scoring System | Significance | | | | | |
|---|---|---|---|---|---|---|
| | AUROC | *P* | *J*-Index | Optimal cutoff value | Sensitivity (%) | Specificity (%) |
| Marshall criteria | 0.894 | <0.001 | 0.69 | >0 | 87.0 | 81.9 |
| PELOD | 0.831 | <0.001 | 0.63 | >1 | 83.6 | 79.3 |
| PEMOD | 0.849 | <0.001 | 0.64 | >3 | 77.4 | 87.1 |
| pSOFA | 0.837 | <0.001 | 0.59 | >4 | 65.1 | 93.9 |

**Note.** PELOD — Paediatric Logistic Organ Dysfunction; PEMOD — Pediatric Multiple Organ Dysfunction Score; pSOFA — Paediatric Sequential Organ Failure Assessment.

with all differences reaching statistical significance (Table 2).

The prognostic value of the clinical and laboratory parameters on admission to the ICU was assessed using ROC analysis (Table 3).

Among all oxygenation parameters, the $SpO_2/FiO_2$ ratio had the highest prognostic value. The severity of acid-base disturbances was more strongly associated with blood pH than with lactate level. Among the metabolic markers, aspartate aminotransferase, creatinine, and glucose showed the greatest discriminatory power, whereas albumin served only as an indirect indicator of overall disease severity.

The criteria proposed by J. Marshall (Table 4) showed the highest prognostic value for assessing the severity of multiple organ dysfunction in children with acute poisoning.

Toxic hepatitis or pancreatitis at the time of admission was associated with a 4.55-fold increase in the risk of an unfavorable course of acute poisoning [95% CI, 1.93–10.71], while acute kidney injury conferred a 5.29-fold increase in risk [95% CI, 1.52–18.45]. The need for mechanical ventilation markedly elevated the risk, with an odds ratio of 72.19 [95% CI, 31.0–168.1], and the presence of aspiration pneumonia was associated with a 14.14-fold increase in risk [95% CI, 3.32–60.1] (Table 5).

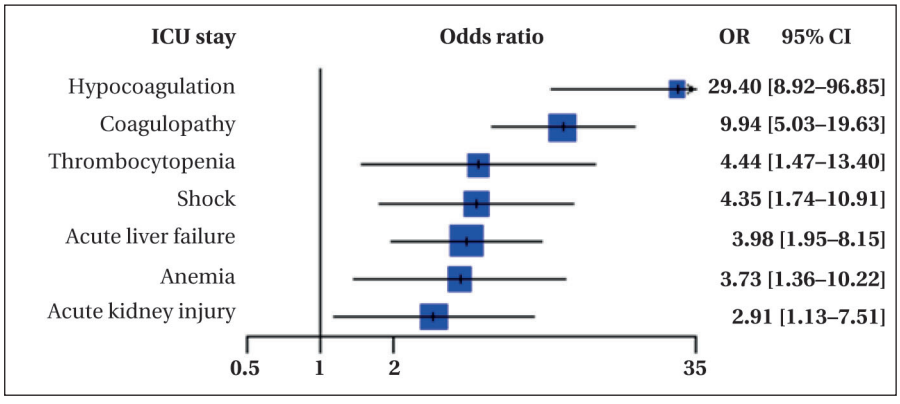


**Fig. 2. Odds ratios for unfavorable poisoning course based on clinical and laboratory parameters throughout the ICU treatment period.**

Shock (OR=4.35; 95% CI, 1.74–10.91), coagulopathy (OR=9.94; 95% CI, 5.03–19.63), and hypocoagulation (OR=29.4; 95% CI, 8.92–96.85) observed during treatment in the ICU were the most significant markers reflecting disease severity and increasing the likelihood of an unfavorable course (Fig. 2).

Based on the identified risk factors, a multivariate

**Table 5. Odds ratios for unfavorable course in children with acute poisoning based on clinical and laboratory status on admission to the ICU.**

| Parameter | Odds Ratio (OR) | 95% Confidence Interval (CI) |
|---|---|---|
| Mechanical ventilation | 72.19 | 31.0–168.1 |
| Pneumonia | 14.14 | 3.32–60.1 |
| Acute kidney injury | 5.29 | 1.52–18.45 |
| Toxic hepatitis / pancreatitis | 4.55 | 1.93–10.71 |
| INR >1.17 | 3.41 | 2.0–5.78 |
| Leukocytes >15.2 × $10^9$/L | 3.36 | 1.95–5.8 |
| Creatinine >86 µmol/L | 3.34 | 1.91–5.82 |
| Glucose >7.6 mmol/L | 3.27 | 1.90–5.64 |
| Potassium >4.6 mmol/L | 3.18 | 1.75–5.76 |
| Lactate >2.5 mmol/L | 2.77 | 1.67–4.58 |
| Seizures | 2.73 | 1.14–6.72 |
| Cardiac arrhythmias | 1.04 | 0.49–2.25 |

logistic regression model was developed to predict an unfavorable course of acute poisoning in children, taking into account the patient's clinical and laboratory status (Table 6).

The coefficients for the variables pH and INR were reported as per 1 unit of measurement. Actually, these parameters vary within a range of 0.01 units, so the odds ratios calculated per whole unit yield extremely large or small values. In order to assess the true impact of these parameters on the risk of serious course, it was necessary to adjust them to plausible ranges (Table 7).

The presented model has the following characteristics: a cutoff of 0.481, a prognostic accuracy of 93.8% [95% CI, 90.9–96.7], a sensitivity of 94.2% [95% CI, 90.4–98.0], a specificity of 92.5% [95% CI, 87.7–97.3] and an AUROC of 0.981 (Fig. 3).

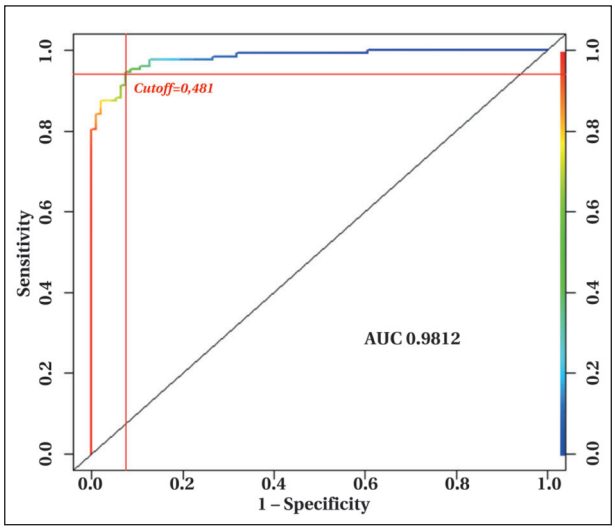


**Fig. 3. ROC curve of the predictive model for unfavorable course in severe pediatric poisoning cases.**

**Table 7. Odds ratios for actual pH and INR ranges.**

| Parameter | pH (per 0.01 unit) | INR (per 0.01 unit) |
|---|---|---|
| Coefficient | –0.195 | 0.158 |
| Standard Error | 0.054 | 0.039 |
| *Z*-score | –3.56 | 4.06 |
| *P value* | <0.001 | <0.001 |
| Odds Ratio | 0.82 | 1.17 |
| 95% CI (Lower) | 0.74 | 1.09 |
| 95% CI (Upper) | 0.92 | 1.27 |

## Discussion

The most common complications of severe acute poisoning in children include coagulopathy, toxic damage to the liver and pancreas, and aspiration of gastric contents. However, a favorable outcome is observed in the majority of cases, with the duration of hospitalization not exceeding seven days. Fatal outcomes were observed in only two cases in the present study, which is consistent with global statistics.

The primary markers of severity on admission to the ICU, indicating a high likelihood of complications, were the need for invasive mechanical ventilation, aspiration pneumonia, and signs of acute liver and kidney injury.

When discussing risk factors for adverse outcomes in severe acute poisoning in children, it is important to emphasize that the most significant

**Table 6. Data set analysis using multiple logistic regression.**

| Parameter | Coefficient | Standard error | *Z*-score | *P value* | Adjusted OR | 95% CI lower | 95% CI upper |
|---|---|---|---|---|---|---|---|
| Intercept | 143.72 | 43.52 | 3.02 | 0.001 | — | — | — |
| Need for mechanical ventilation | 2.35 | 0.91 | 2.60 | <0.001 | 10.49 | 1.76 | 62.40 |
| Systolic blood pressure | –0.09 | 0.06 | –1.52 | 0.129 | 0.91 | 0.81 | 1.03 |
| Mean arterial pressure | 0.18 | 0.08 | 2.10 | 0.036 | 1.20 | 1.02 | 1.40 |
| Pneumonia | 2.88 | 1.80 | 1.61 | 0.106 | 17.81 | 0.53 | 594.90 |
| Seizures | 2.02 | 1.00 | 2.01 | 0.044 | 7.54 | 1.06 | 53.52 |
| Hemoglobin | –0.06 | 0.03 | –1.85 | 0.047 | 0.94 | 0.89 | 1.00 |
| RBC | 1.77 | 0.99 | 1.80 | 0.071 | 5.87 | 0.84 | 40.87 |
| WBC | –0.11 | 0.06 | –2.08 | 0.037 | 0.90 | 0.80 | 1.01 |
| Catecholamine index | –0.14 | 0.08 | –1.68 | 0.094 | 0.87 | 0.74 | 1.02 |
| Glucose | 0.29 | 0.14 | 2.01 | 0.045 | 1.34 | 1.02 | 1.76 |
| pH | –19.58 | 5.49 | –3.56 | <0.001 | — | — | — |
| $SpO_2/FiO_2$ ratio | –0.027 | 0.005 | –5.38 | <0.001 | 0.97 | 0.96 | 0.98 |
| INR | 15.88 | 3.91 | 4.06 | <0.001 | — | 3701.15 | — |

**Note.** Odds ratio for unfavorable course = exp (143.72 + 2.35 × [Mechanical Ventilation Need] – 0.09 × [Systolic BP] + 0.18 × [MAP] + 2.88 × [Pneumonia] + 2.02 × [Seizures] – 0.06 × [Hemoglobin] + 1.77 × [RBC] – 0.11 × [WBC] – 0.14 × [Catecholamine Index] + 0.29 × [Glucose] – 19.58 × [pH] – 0.027 × [$SpO_2/FiO_2$] + 15.88 × [INR]).

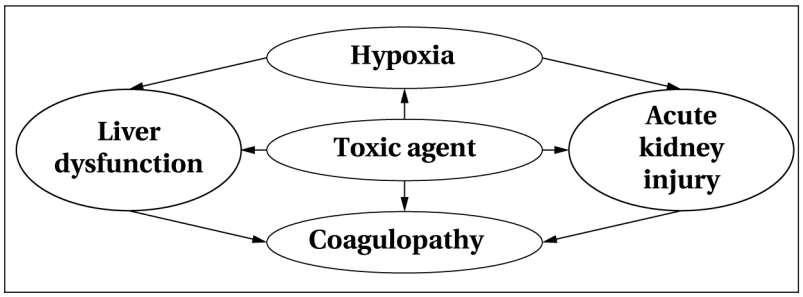


**Fig. 4. The deadly quartet in acute pediatric poisoning (original illustration by the authors).**

factors include hypocoagulation, shock, acute liver dysfunction or failure, and acute kidney injury — especially when these complications occur within the first 24 hours of treatment. These findings are consistent with data reported by other investigators [10, 24–27].

In a study of adults, S. T. Chang et al. found that acute kidney injury occurred in 66% of methanol poisoning cases and increased the risk of in-hospital mortality by approximately 20-fold [25].

Y. Atighi et al. demonstrated that in children with acute methadone poisoning, predictors of complications and adverse outcomes include respiratory distress and severe depression of consciousness [26].

The most common causes of fatal outcomes in acute pediatric poisoning are mixed-origin hypoxia, acute liver injury, and renal damage. These conditions lead to hemostatic dysfunction and coagulopathy, which exacerbate each other and form a «deadly quartet» (Fig. 4) — a concept analogous to the lethal triad observed in polytrauma.

In conclusion, maximizing early, targeted, pathogenesis-based therapy to address these pathologic syndromes can significantly improve outcomes, reduce complication rates, and minimize deaths in pediatric acute poisoning [1, 24, 28–30].

## Conclusion

Impaired consciousness, severe hypoxemia, coagulopathy, acute liver failure, and renal injury are the primary markers of severity in acute pediatric poisoning.

Risk factors for adverse course include $SpO_2/FiO_2$ ratio <300 (sensitivity 69.2%, specificity 100%), oxygenation index > 3 (sensitivity 69.2%, specificity 100%), INR > 1.17 (sensitivity 74.1%, specificity 57.3%), lactate level > 2.5 mmol/L (sensitivity 62.4%, specificity 61.7%).

A mathematical model for predicting adverse outcomes in acute pediatric poisoning that incorporates 13 key homeostasis parameters (such as need for mechanical ventilation, catecholamine index, $SpO_2/FiO_2$, pH, international normalized ratio) demonstrates high predictive power (AUROC=0.981; sensitivity 94.2%, specificity 92.5%) and accuracy (93.8%).

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