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Peculiarities of clinical and laboratory diagnostics and intensive therapy of acute poisoning by cauterizing substances in children

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ABSTRACT

The relevance of the study problem is that among all chemical poisonings, the proportion of cauterizing substances is up to 20%, and fatal cases are about 3%. Diseases are characterized by severe medical, social and economic consequences.

Aim: Comparison of diagnostic indicators and the volume of intensive care in children with poisoning by cauterizing substances.

Materials and methods. A prospective cohort study was conducted in the ICU "Children's City Clinical Hospital No. 1" in Novosibirsk in 2024. The study included 39 patients receiving intensive care for poisoning with cauterizing substances, codes according to ICD-10 — T54.2; T54.3; T57.2. The median age of the patients was 2 years (1; 2). All patients were admitted to the ICU within the first 2 hours after exposure to the etiological factor. Two groups were formed depending on the chemical structure of the cauterizing substance (group 1 included 17 children with acid poisoning; group 2 — 16 people with alkali poisoning). The study was conducted in 3 stages: days 1, 2, and 3 of stay in the ICU.

Results. A significant increase in inflammatory markers (leukocytes, C-reactive protein) was detected in group 1. Free hemoglobin in urine was not detected in any of the cases. Changes in esophagogastroduodenoscopy in the groups were comparable in terms of the frequency of diagnosis of erythema (p=0,532) and erosions (p=0,291), ulcers were diagnosed mainly with local acid exposure (p=0,043). The incidence of toxic nephritis in the two groups was 57 and 43% (p=0,537), and the incidence of confirmed pneumonitis was 75 and 25% (p=0,324). Forced diuresis was performed for all patients within 24 hours, the balance of infusion and diuresis was achieved by prescribing a loop diuretic in 30 patients. Indications for hemotransfusion are set for 2 children of the 1st group. Aspiration pneumonitis and local edematous syndrome were stopped by the appointment of systemic glucocorticosteroids in 100% of cases, antibacterial therapy in 88%, and inhalation therapy in 30% in equal proportions in groups. A higher, but not reaching the level of statistical significance, need for esophageal bougienage was determined for group 1 in 80% and for group 2 — 20% of cases (χ^2=2,970, p=0,085).

Conclusion. Chemical composition of cauterizing substances in mild and moderate poisonings had no significant effect on clinical and laboratory parameters. Acids in comparison with alkali, produced more severe changes in FGDS and higher frequency of somatic complications.

Keywords: poisoning, cauterizing substances, acids, children, forced diuresis

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Особенности клинико-лабораторной диагностики и интенсивной терапии острых отравлений веществами прижигающего действия у детей

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АННОТАЦИЯ

Актуальность проблемы исследования: среди всех химических отравлений доля веществ прижигающего действия составляет до 20% с летальностью около 3% и тяжелыми медицинскими, социальными и экономическими последствиями.

Цель исследования: сравнение диагностических показателей и необходимых объемов интенсивной терапии у детей с острыми отравлениями веществами прижигающего действия в зависимости от их химического состава.

Материалы и методы. На базе государственного бюджетного учреждения здравоохранения Новосибирской области «Детская городская клиническая больница № 1» было выполнено проспективное когортное исследование в 2024 г. В исследование включены 39 пациентов, получавших интенсивную терапию по поводу отравлений веществами прижигающего действия, коды по МКБ-10 — Т54.2; Т54.3; Т57.2. Медиана возраста пациентов составила 2 года (1; 2). Все пациенты поступали в отделение реанимации и интенсивной терапии (ОРИТ) в течение первых двух часов после воздействия этиологического фактора. Сформированы две группы в зависимости от химической структуры прижигающего вещества: 1-я группа включала 17 детей с отравлениями кислотами; 2-я группа — 16 человек с отравлениями щелочами. Исследование проведено на трех этапах, которые соответствовали 1-, 2- и 3-м суткам нахождения в ОРИТ.

Результаты. В группе 1 определен значительный рост воспалительных маркеров (лейкоциты, С-реактивный белок). Свободного гемоглобина в моче не определено ни в одном случае. Изменения по фибродуоденогастроскопии в группах сопоставимы по частоте диагностики эритемы (p=0,532) и эрозий (p=0,291), язвы диагностированы при местном воздействии кислот значимо чаще, чем при воздействии щелочей (p=0,043). При сравнении по критерию χ^2 Пирсона частота развития токсического нефрита в двух группах составила 57 и 43% соответственно (p=0,605), рентген-подтвержденного пневмонита — 75 и 25% (p=0,009). Форсированный диурез проведен для всех пациентов в течение 24 часов, баланс инфузии и диуреза достигнут назначением петлевого диуретика у 30 пациентов. В 1-й группе двоим детям проведена трансфузия эритроцитарной взвеси. Аспирационный пневмонит, локальный отечный синдром купированы назначением системных глюкокортикостероидов в 100% случаев, антибактериальной терапии — в 88%, ингаляционной терапии — в 30% при отсутствии межгрупповой разницы. Более высокая, но не достигающая уровня статистической значимости, потребность в бужировании пищевода определена для 1-й группы в 80% и для 2-й группы — в 20% случаев (χ^2=2,970, p=0,085).

Вывод. Химический состав веществ прижигающего действия при отравлениях легкой и средней степеней тяжести не оказывал значимого влияния на клинико-лабораторные показатели. Отравления кислотами, в сравнении с отравлениями щелочами, давали более тяжелые изменения по фибродуоденогастроскопии и более высокую частоту соматических осложнений.

Ключевые слова: отравления, вещества прижигающего действия, кислоты, дети, форсированный диурез

Как цитировать
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INTRODUCTION

Acute poisonings by cauterizing substances (CS) occupy a significant place in the structure of acute poisonings of chemical etiology. According to Federal State Budgetary Institution "Scientific and Practical Toxicological Center of FMBA of Russia", 12–16% of all acute poisonings are caused by CS. The most common substances in the structure of household acute poisonings are acids and alkalis. According to data from specialized centers for the treatment of poisoning in Russia, poisonings with CS accounted for up to 7.4% of the reasons for hospitalization of patients, of which 69.6% of cases were due to vinegar essence [11]. Among regions, mortality rate in adults poisoned by CS was from 15 to 30% [7]. Poisonings with CS are characterized by severe medical, social, and economic consequences (expensive treatment, long period of disability, invalidity, high mortality rate). Among the causes of hospitalization in children, poisonings by cauterizing substances rank 3rd to 4th (accounting for up to 7% of the total flow of patients with acute chemical poisonings).

In cases of acute poisoning by cauterizing substances, a chemical variant of burn disease develops due to their local cauterizing effect and systemic resorptive action [1]. Burns of chemical etiology have several features. The mechanism of action of chemical burns, unlike thermal injury, precludes self-healing. The progressive nature of chemical damage is due to changes in the biochemical and physical properties of the affected tissues [9]. The cauterizing effect is most pronounced in the gastrointestinal tract and respiratory tract [3]. Cauterizing poisons have a resorptive (systemic toxic) effect, the severity of which is directly proportional to the area of the burn [8]. The most important pathogenetic mechanism of acute chemical injury is exotoxic shock. Its development is caused by absolute hypovolemia due to internal and external plasma losses and the pain factor. Oral poisoning by acetic acid causes intravascular hemolysis of erythrocytes, which, in combination with exotoxic shock, leads to the development of disseminated intravascular coagulation (DIC syndrome). The rate of progression and severity of pathological changes in the hemostatic system depend on the severity of poisoning and the timing of the initiation of intensive therapy [10]. The transport of free hemoglobin through the renal tubules causes their necrosis by the mechanism of hemoglobinuric nephrosis [6]. Damage to the respiratory tract can be caused by the direct effect of CS as a result of vomit aspiration. Frequently, respiratory disorders are the primary cause of fatal outcome [4]. The development of reactive pancreatitis in cases of CS poisoning, which is caused by microcirculation disorders and the direct influence on pancreas can be confirmed by laboratory examination of amylase activity in the blood and urine [14].

AIM

The aim of the study is to compare diagnostic indicators and amount of intensive therapy in children with acute poisonings caused by CS depending on their chemical structure.

MATERIALS AND METHODS

A prospective cohort study was conducted in 2024 at the Somatic Intensive Care Unit (ICU) of the FBIH NSO "Children State Clinical Hospital No.1". 39 children hospitalized in ICU with CS poisonings were included in the study. After applying exclusion criteria: duration of stay in ICU less than 3 days, incomplete data, transfer to another hospital within the first three days of admission, 33 patients were involved. Based on the chemical structure of the active agent, two groups were formed: Group 1 included 17 patients with acid poisonings, and Group 2 included 16 patients with alkali poisonings.

Group 1 consisted of children with acute poisonings by acids (organic) and oxidizers (potassium permanganate — 23%).

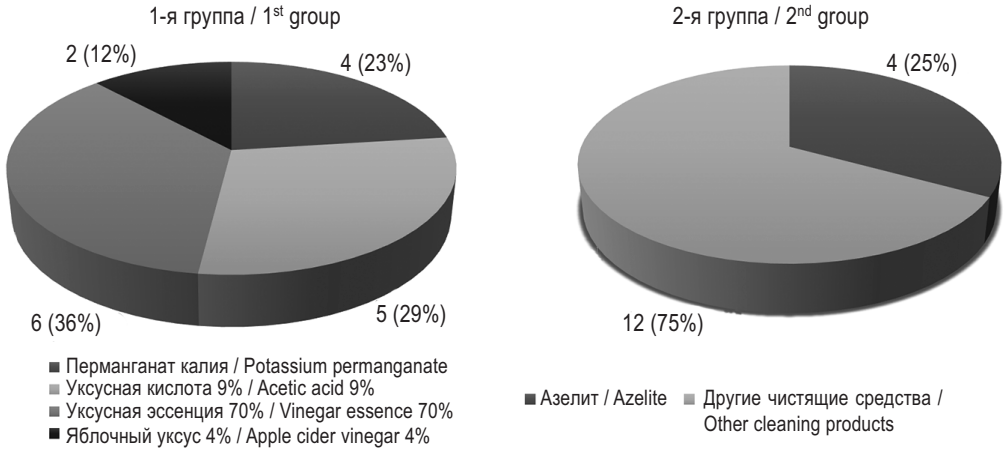

Fig. 1. Frequency of detection of cauterizing substances in groups

Рис. 1. Периодичность обнаружения веществ прижигающего действия в группах

Table 1. Characterization of groups of children with acute poisoning by cauterizing agents

Таблица 1. Характеристика групп детей с острыми отравлениями веществами прижигающего действия

Показатель Parameter	Группа 1 Group 1 n=17	Группа 2 Group 2 n=16	Критерий U, p Criteria U, p
Возраст, лет Age, years	1,5 (1; 2)	2 (1; 2)	p=0,769
Масса тела, кг Body weight, kg	12,7 (11,2; 14,2)	13,1 (11,4; 14,3)	p=0,688
S тела, м^2 S body, m^2	0,53 (0,47; 0,58)	0,55 (0,5; 0,59)	p=0,846
Койко-дни в ОРиТ Bed-days in the ICU	1–3 дня 1–3 days (1 пациент — 4 дня 1 пациент — 10 дней) (1 patient 4 days 1 patient 10 days)	1–3 дня 1–3 days	p=0,135

In Group 2, the causes of poisoning were: the cleaning agent “Azelit” in four children, stove cleaners “Sanita” (2), “Magic Plate” (2), “Faberilio” (1), and pipe cleaners — “Tornado” (2), “Antizasor granules” (3), plumbing cleaner “Sanoks” (2) (Fig. 1).

The Groups were similar in age, anthropometric data, duration of treatment in ICU after chemical burn (Table 1).

The values of clinical and laboratory parameters were recorded at three time points, corresponding to days 1, 2, and 3 of ICU stay. According to the study stages, the following hematological parameters were recorded: white blood cell count, platelet count, haemoglobin level, hematocrit (using the Celltac ES hematology analyzer (MEK-7300)), and urine parameters (Urilit-150). The biochemical profile was determined using the Miura 200 automatic biochemical analyzer: albumin, total protein, urea, creatinine, glucose, alanine aminotransferase (ALT), aspartate aminotransferase (AST), lactate dehydrogenase (LDH), total bilirubin, potassium, calcium, C-reactive protein. Coagulation parameters included: prothrombin time, prothrombin ratio, activated partial thromboplastin time, INR (using the KoaTect-4 automatic coagulometer). Acid-base balance was determined using the EDAN i15 analyzer. The volumes of intensive therapy and the cumulative fluid balance were assessed at each stage. Statistical processing was performed using Microsoft Office Excel 2010 and SPSS 20.0 software. Mathematical analysis was conducted using non-parametric statistical methods. In tables and graphs, the results are presented as Me (25th and 75th percentiles). For comparing two related samples, the Wilcoxon signed-rank test was used; for intergroup indicators, the Mann–Whitney U-test and Pearson’s χ^2 test were used. The predictive value of an indicator was assessed using ROC analysis. The null hypothesis was rejected at $p < 0.05$.

RESULTS AND DISCUSSION

There were no significant differences between groups in the studied clinical and biochemical indicators on all stages with the exception of higher inflammatory response markers in Group 1: C-reactive protein 12 mg/L (7; 15) vs. 5 mg/L (3; 11) on admission, p=0.017; at stage 2 — 10 mg/L (8; 17) vs. 5 mg/L (3; 9), p=0.024; at stage 3 — 15 mg/L (10; 21) vs. 6 mg/L (3; 7), p=0.003. Hemoglobin levels in the groups corresponded to mild anemia that did not require treatment. LDH activity exceeded the reference values by 2–3 times in both groups, showing no significant dynamics in Group 2 but a significant increase in Group 1 by day 3 (p=0.041).

The study groups were similar in the types of intensive care (respiratory, hemodynamic, and nutritional support, symptomatical therapy) (Table 2). Group 1 showed a greater need for parenteral nutrition, hemotransfusions, and opioid use, but without statistical significance. The prescriptions of systemic glucocorticosteroids, antibiotics, forced diuresis method were similar in both groups. A significant intergroup difference in cumulative negative balance (p=0.043) over the first two days of intensive care in the ICU was observed. Ascorbic acid was administered as antidotal therapy in cases of potassium permanganate poisoning.

All cases with complications were analysed and classified as early (within 7 days after poisoning) and late (4–6 week after hospitalization). The earliest complication in all groups was anemia, which did not require therapy. In Group 1, toxic pneumonitis was diagnosed significantly more frequently, necessitating expanded volumes of respiratory support. In severe cases, patients required mechanical ventilation (MV) (n=2). The frequency of toxic nephritis not requiring renal replacement therapy and of reactive pancreatitis was lower in Group 2 (Fig. 2).

Based on the results of fibroesophagogastroduodenoscopy (FEGDS) performed within the first 24 hours of admission to the ICU, severe esophageal mucosal damage in the form of ulcers was more frequently detected in Group 1 — up to 35% (n=6). In Group 2, damage more often manifested as erosions — in 57% (n=9). Erythematous changes were found equally in Groups 1 and 2 (25–30%). Analysis of late complications based on control FEGDS results revealed a higher incidence of esophageal stricture in Group 1 (Fig. 3). These same patients underwent endoscopic esophageal bougienage. For one patient from Group 1, a gastrostomy was placed

Table 2. Intensive care unit in groups of children with acute poisoning by cauterizing agents

Таблица 2. Направления интенсивной терапии в группах детей с острыми отравлениями веществами прижигающего действия

Составляющие интенсивной терапии Components of intensive care		Группа 1 Group 1	Группа 2 Group 2	Критерий p, критерий χ^2 Criteria p, criteria χ^2
Респираторная поддержка Respiratory support	Респираторная поддержка (искусственная вентиляция легких) / Respiratory support (artificial ventilation of the lungs)	2 (10%)	1 (6%)	χ^2=0,045 p=0,875
Гемодинамическая поддержка Hemodynamic support	Катетеризация центральной вены / Central venous catheterization	13 (76%)	8 (50%)	χ^2=2,5 p=0,114
	Форсированный диурез / Forced diuresis	17 (100%)	16 (100%)	–
	Поддерживающая инфузионная терапия / Supportive infusion therapy	12 (70%)	7 (44%)	χ^2=2,43 p=0,166
	Энтеральное питание / Enteral nutrition	9 (53%)	7 (44%)	χ^2=0,279 p=0,732
	Парентеральное питание / Parenteral nutrition	5 (29%)	1 (6%)	χ^2=2,97 p=0,085
	Гемотрансфузия / Blood transfusion	2 (12%)	0	χ^2=2,004 p=0,157
	Кумулятивный баланс на 1-е сутки / Cumulative balance for a day	–250 мл	–200 мл	U=111 p = 0,366
	Кумулятивный баланс на 2-е сутки / Cumulative balance for 2 days	–445 мл	–150 мл	U=22 p = 0,043
Симптоматическая терапия Symptomatic therapy	Диуретики / Diuretics	15 (88%)	15 (94%)	χ^2=0,3 p=0,582
	Наркотические анальгетики / Narcotic analgesics	5 (29%)	1 (6%)	χ^2=2,97 p=0,085
	Системный глюкокортикостероид / Systemic glucocorticosteroid	17 (100%)	16 (100%)	–
	Антибактериальная терапия / Antibacterial therapy	15 (88%)	14 (87%)	χ^2=0,004 p=0,948
	Ингаляционная терапия / Inhalation therapy	4 (23%)	6 (37%)	χ^2=0,762 p=0,383
	1% Аскорбиновая кислота / 1% Ascorbic acid	3 (17%)	0	

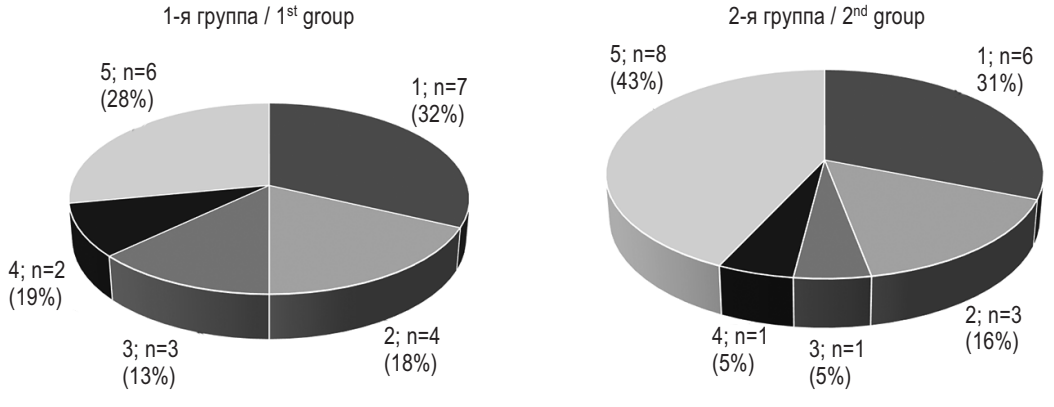

Fig. 2. The structure of early complication in 2 groups of children with acute poisoning by cauterizing agents: 1 — anemia; 2 — toxic nephritis; 3 — toxic pneumonitis; 4 — reactive pancreatitis; 5 — no complications

Рис. 2. Структура ранних осложнений в двух группах детей с острыми отравлениями веществами прижигающего действия: 1 — анемия; 2 — токсический нефрит; 3 — токсический пневмонит; 4 — реактивный панкреатит; 5 — нет осложнений

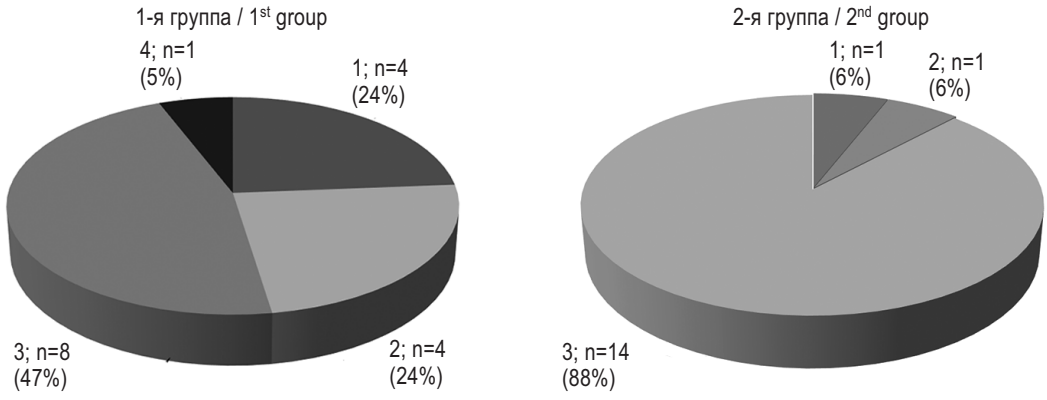

Fig. 3. The structure of late complication in two groups of children with acute poisoning by cauterizing agents: 1 — esophageal stricture; 2 — bougienage; 3 — no complications; 4 — gastrostomy

Рис. 3. Структура поздних осложнений в двух группах детей с острыми отравлениями веществами прижигающего действия: 1 — стриктура пищевода; 2 — бужирование; 3 — нет осложнений; 4 — гастростомия

due to severe cicatricial esophageal stenosis to enable enteral nutrition.

A comparative analysis of clinical and laboratory parameters in patients with acid and alkali poisonings revealed that the most significant difference between the groups was a higher level of C-reactive protein in the acid poisoning group. This reflects the risk of a systemic inflammatory response caused by the development of coagulative tissue necrosis. In both groups leucocytosis and increased LDH were the same. The prognostic ability of inflammatory response markers for complications was assessed in Group 1 using ROC analysis; insufficient data were available in Group 2. Leukocytosis upon admission exceeding 13×10^{12}/L (Se 81%; Sp 85%) and an increase in C-reactive protein above 11 mg/L within the first 24 hours (Se 67%; Sp 75%) were associated with a high risk of somatic complications: AUROC 0.78 (CI 0.59; 0.99), p=0.043, and AUROC 0.76 (CI 0.57; 0.96), p=0.047, respectively.

The obtained data confirm the limited informativeness of routine laboratory tests for assessing the depth and extent of chemical damage, making endoscopic diagnostics a mandatory component of the examination [13]. The results of endoscopic studies performed within the first 24 hours after poisoning revealed more severe damage to the esophageal mucosa in the acid poisoning group. This is consistent with the literature data on the high frequency of cicatricial strictures of the esophagus in the late period in this pathology [12]. In both groups, the development of anemia was observed, mainly mild, but the pathogenetic mechanisms of its occurrence were not explained by the course of hemolysis. Acid poisoning was associated with a higher risk of developing early complications, including toxic nephritis, pneumonitis, and pancreatitis, which did not contradict the data obtained over 20 years of observation [2]. Prevention of cicatricial esophageal strictures included early endoscopic esophageal bougienage and systemic glucocorticosteroids to suppress the inflammatory process leading to tissue fibrosis. Forced diuresis, regardless of the nature of the toxic substance, was an important component of intensive care [11]. Frequent need for respiratory support, the need for artificial ventilation in severe cases, severe pain requiring opioid analgesics, and the use of parenteral nutrition were observed in intensive care for acid poisoning [5].

An interesting epidemiological feature revealed in this study was a decrease in the frequency of severe caustic alkali poisonings, which is associated with the reduced use of sodium hydroxide in modern household chemical products [11]. This underscores the importance of constant parental monitoring of the spectrum of potentially hazardous substances in households with young children.

CONCLUSION

The chemical composition of cauterizing substances in cases of mild to moderate poisoning did not have a significant impact on clinical and laboratory parameters. Compared to alkali poisonings, acid poisonings resulted in more severe findings on fibroesophagogastroduodenoscopy and a higher frequency of somatic complications.

ADDITIONAL INFORMATION

Author contribution. All authors made a substantial contribution to the conception of the study, acquisition, analysis, interpretation of data for the work, drafting and revising the article, final approval of the version to be published and agree to be accountable for all aspects of the study.

Competing interests. The authors declare that they have no competing interests.

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Consent for publication. Written consent was obtained from legal representatives of the patients for publication of relevant medical information within the manuscript.

ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ

Вклад авторов. Все авторы внесли существенный вклад в разработку концепции, проведение исследования и подготовку статьи, прочли и одобрили финальную версию перед публикацией.

Конфликт интересов. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи.

Источник финансирования. Авторы заявляют об отсутствии внешнего финансирования при проведении исследования.

Информированное согласие на публикацию. Авторы получили письменное согласие законных представителей пациентов на публикацию медицинских данных.

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