



DOI: <https://doi.org/10.17816/PED1355-21>

Research Article

NEWBORNS DEATH RISK FACTORS AFTER SURGICAL INTERVENTIONS IN THE EARLY NEONATAL PERIOD

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For citation: Bezhenar VF, Ivanova LA, Ivanov DO, Krasnogorskaya OL. Newborns death risk factors after surgical interventions in the early neonatal period. *Pediatrician (St. Petersburg)*. 2022;13(5):5-21. DOI: <https://doi.org/10.17816/PED1355-21>

BACKGROUND: The mortality rate of children operated on in the early neonatal period remains high, despite the combined efforts of surgeons, anesthesiologists, clinical pharmacologists, and many other specialists.

AIM: to determine the risk of death of children in the period of birth, after surgical interventions carried out in the period of the neonatal period.

MATERIALS AND METHODS: A retrospective study was conducted between two groups of children treated at the Perinatal Center of the Pediatric University. The main group included 77 newborns operated on in the early neonatal period and died in the first 28 days of life. The control group included 287 children operated on in the perinatal period and survived 28 days.

RESULTS: In the main group, the percentage of defects detected prenatally was statistically significantly lower; statistically significantly more often multiple congenital malformations and congenital malformations of the cardiovascular system were diagnosed. Risk factors for the death of newborns after surgery performed in the perinatal period have been established: features of the somatic status of mothers (chronic nicotine intoxication, hypertension and arterial hypertension, chronic serum hepatitis B and C, pathology of the urinary system and thyroid gland, cervical ectopia), obstetric gynecological history (chronic inflammation of the organs of the lower floor of the genital tract, two or more abortions in multiparous women, placental insufficiency in history during a previous pregnancy, previous delivery by caesarean section), course of pregnancy (threatening abortion, acute respiratory viral infections, exacerbations of chronic infectious diseases, early toxicosis, carriage of *Cytomegalovirus* and *Herpes simplex* types 1 and 2, asymptomatic bacteriuria, gestational anemia, circulatory failure, fetal malnutrition, abnormalities in the amount of amniotic fluid diagnosed by ultrasound study in the 3rd trimester of pregnancy), childbirth (breech presentation of the fetus and meconium staining of amniotic fluid), afterbirth conditions (chlamydial and ascending infection).

CONCLUSIONS: In pregnant women with prenatally diagnosed congenital malformations of the fetus, it is necessary to conduct bacteriological studies, emergency histological examination of the placenta to identify possible microbial damage, as well as timely examination and treatment of newborns and upcoming / undergone surgery.

Keywords: infant; newborn; risk factors; cardiovascular system; metabolic diseases; prognosis; surgery.

Received: 12.08.2022

Revised: 20.09.2022

Accepted: 28.10.2022

DOI: <https://doi.org/10.17816/PED1355-21>

Научная статья

ФАКТОРЫ РИСКА СМЕРТИ НОВОРОЖДЕННЫХ ПОСЛЕ ОПЕРАТИВНЫХ ВМЕШАТЕЛЬСТВ В РАННЕМ НЕОНАТАЛЬНОМ ПЕРИОДЕ

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Для цитирования: Беженарь В.Ф., Иванова Л.А., Иванов Д.О., Красногорская О.Л. Факторы риска смерти новорожденных после оперативных вмешательств в раннем неонатальном периоде // Педиатр. – 2022. – Т. 13. – № 5. – С. 5–21.

DOI: <https://doi.org/10.17816/PED1355-21>

Актуальность. Смертность детей, прооперированных в раннем неонатальном периоде, остается высокой, несмотря на объединенные усилия хирургов, анестезиологов, клинических фармакологов и многих других специалистов.

Цель — определение факторов риска смерти детей в периоде новорожденности после оперативных вмешательств, проведенных в раннем неонатальном периоде.

Материалы и методы. Проведено ретроспективное исследование двух групп детей, проходивших лечение в Перинатальном центре Педиатрического университета. В основную группу вошло 77 новорожденных, прооперированных в раннем неонатальном периоде и погибших в первые 28 дней жизни. В контрольную группу вошло 287 детей, прооперированных в первые 7 сут и переживших 28 дней жизни.

Результаты. В основной группе статистически значимо ниже был процент пороков, выявленных пренатально; статистически значимо чаще были диагностированы множественные врожденные пороки развития и врожденные пороки развития сердечно-сосудистой системы. Установлены факторы риска гибели новорожденных детей после операции, проведенной в перинатальном периоде: особенности соматического статуса матерей (хроническая никотиновая интоксикация, гипертоническая болезнь и артериальная гипертензия, хронические сывороточные гепатиты В и С, патология мочевыделительной системы и щитовидной железы, эктопия шейки матки), акушерско-гинекологического анамнеза (хроническое воспаление органов нижнего этажа полового тракта, два и более абортa у повторнородящих, плацентарная недостаточность в анамнезе при предыдущей беременности, предшествующее родоразрешение путем кесарева сечения), течения беременности (угрожающее прерывание беременности, острые респираторные вирусные инфекции, обострения хронических инфекционных заболеваний, ранний токсикоз, носительство *Cytomegalovirus* и *Herpes simplex* 1-го и 2-го типов, бессимптомная бактериурия, гестационная анемия, недостаточность кровообращения, гипотрофия плода, аномалии количества околоплодных вод, диагностированные при ультразвуковом исследовании в 3-м триместре беременности), родов (тазовое предлежание плода и мекониальная окраска околоплодных вод), состояния последа (хламидийное и восходящее инфицирование).

Заключение. У беременных с пренатально диагностированными врожденными пороками развития плода необходимо проводить бактериологические исследования, экстренное гистологическое исследование последа для выявления возможного микробного поражения, а также своевременного обследования и лечения новорожденных и предстоящим/перенесенным хирургическим вмешательством.

Ключевые слова: младенец; новорожденный; факторы риска; сердечно-сосудистая система; метаболические заболевания; прогноз; хирургия.

Поступила: 12.08.2022

Одобрена: 20.09.2022

Принята к печати: 28.10.2022

BACKGROUND

Modern surgery in the early neonatal period has undergone significant changes in recent years. Thanks to the development of antenatal diagnostics, most congenital malformations (CMs) can now be detected even before birth. The preferred technique is currently a radical one-stage correction of developmental anomalies; however, there is also no unequivocal rejection of the staged correction of congenital defects, such as congenital heart defects [19]. The preferred approach includes minimally invasive and endosurgical interventions. Endosurgical interventions allow for the correction of CMs with minimal risk to the patient's health. However, this type of surgery is far from being possible in any hospital because the surgeon must know the anatomical and physiological characteristics of newborns, have experience in the treatment of newborns including premature ones, and master endosurgical techniques [9, 18].

Congenital heart disease is one of the most significant causes of neonatal mortality. This is partly associated with the need for surgical treatment in the first days of life, which became possible with the improvement of cardiac surgery. In recent years, noteworthy results have been achieved in the field of surgical technique, perfusion, anesthesia, and nursing of infants, especially due to the individualization approach in each case. The authors noted that the risk of cardiac surgery in the neonatal period sharply increased in the presence of other factors, such as low gestational age and low body weight [23]; however, other risk factors are currently under-investigated.

CMs and central nervous system tumors are reasons for surgical interventions in the early neonatal period. In the case of CMs of the central nervous system, mortality in the neonatal period is low; however, it reached 20% after the removal of intracranial tumors, which is most often associated with severe malignancy [14].

Many studies have focused on the issues of reducing postoperative mortality in the neonatal period; however, most of them focused on discussing the correctness and timeliness of diagnostics and formulating indications for surgical treatment [4, 6, 8, 9, 16, 22], surgical treatment methods [1, 9, 10, 20], surgery timing [19, 24], and postoperative management methods [17].

Recently, the number of children requiring surgical treatment of necrotizing enterocolitis, the so-called disease of preterm survivors, has been increasing [21, 29]. The main risk factor for the development of this condition is a low birthweight

(up to 1000 g). Since 2012, after the transition to the new live birth criteria¹, along with a gradual decrease in mortality from respiratory distress syndrome, the number of children with necrotizing enterocolitis is growing simultaneously [21, 34, 45]. According to some authors, the mortality rate from this disease ranges from 50% to 100% [2, 18, 32]. Such a high mortality rate is due to the severity and extent of the pathological process and postoperative complications [13, 16, 18]. In addition, complications and causes of postoperative death of children such as acute renal failure, which is caused by dehydration, asphyxia, sepsis, and disseminated intravascular coagulation syndrome, are described [13, 19, 49].

Thus, the analysis of literature data on postoperative neonatal deaths showed that recent research focuses on the search for modern methods and approaches to surgical treatment and improvement of diagnostic methods; however, other prognostic markers (anamnestic, clinical, and instrumental) are studied enough.

This study aimed to determine the risk factors for infant death in the neonatal period after surgical interventions performed in the early neonatal period.

MATERIALS AND METHODS

This retrospective study analyzed data from the medical records of children treated at the Perinatal Center of the St. Petersburg State Pediatric Medical University (a third-level obstetric institution) between 2013 and 2020. The “deceased” group included 77 newborns that underwent surgery in the early neonatal period (first 168 h of extrauterine life) and died within the first 28 days of life. The “survived” group included 287 children who underwent surgery in the perinatal period and survived 28 days. The study groups were comparable in terms of the indications for surgical treatment, which were conditionally divided into three groups (Table 1):

CMs: This included disorders occurring during the neonatal period (hemodynamically significant persistence of fetal communications, pneumothorax, and need for surgical treatment of necrotizing enterocolitis) [27].

Congenital and acquired metabolic disorders: The main indications for surgical treatment in both groups were CMs (Table 2). The percentage

¹ Order of the Ministry of Health and Social Development of the Russian Federation dated December 27, 2011 No. 1687n “On medical criteria for birth, the form of a birth document and the procedure for issuing it.”

Table 1 / Таблица 1

The structure of indications for surgical intervention in the study groups
Структура показаний к хирургическому вмешательству в исследуемых группах

Indicator / Показатель	Deceased / Погибшие (n = 77)	Survived / Выжившие (n = 287)	Statistical significance / Статистическая значимость
Congenital malformations / Врожденные пороки развития	61 (79.2%)	238 (82.9%)	$\chi^2 = 0.67, p = 0.416$
of which were diagnosed prenatally / из них диагностированы пренатально	40 (65.6%)	215 (90.3%)	$\chi^2 = 24.75, p = 0.000$
Conditions arising in the neonatal period / Состояния, возникшие в период новорожденности	13 (17.1%)	48 (16.7%)	$\chi^2 = 0.05, p = 0.823$
Metabolic disorders / Нарушения обмена веществ	3 (3.7%)	1 (0.4%)	$\chi^2 = 1.67, p = 0.190$

Table 2 / Таблица 2

The share of congenital malformations of various organs and systems diagnosed in children of the studied groups
Удельный вес врожденных пороков развития различных органов и систем, диагностированных у детей исследуемых групп

Indicator / Показатель	Deceased / Погибшие (n = 77)	Survived / Выжившие (n = 287)	Statistical significance / Статистическая значимость
Congenital malformations cardio-vascular system / Пороки развития сердечно-сосудистой системы	36 (59.0%)	40 (16.8%)	$\chi^2 = 46.22, p = 0.000$
Congenital malformations central nervous system / Пороки развития центральной нервной системы	—	57 (24.0%)	—
Congenital malformations gastrointestinal tract / Пороки развития желудочно-кишечного тракта	1 (1.6%)	51 (21.4%)	$\chi^2 = 22.24, p = 0.000$
Diaphragmatic hernia / Диафрагмальная грыжа	2 (3.3%)	25 (10.5%)	$\chi^2 = 3.03, p = 0.08$
Neoplasms / Новообразования	1 (1.64%)	22 (9.2%)	$\chi^2 = 5.22, p = 0.022$
Multiple malformations / Множественные пороки развития	20 (32.8%)	6 (2.5%)	$\chi^2 = 56.53, p = 0.000$
Number of operations (max–min) / Количество операций (max–min)	2.065 ± 1.681 (1–11)	1.692 ± 1.144 (1–7)	$p = 0.024$

of CMs detected prenatally was statistically significantly lower in the main group than in the control group, which became one of the risk factors for infant death in the first month of life, despite surgical interventions. This can be associated with the transfer of newborns to a specialized hospital, need for treatment, etc.

Among the CMs of the gastrointestinal tract, duodenal atresia was registered in the main group, and atresia of the esophagus, duodenum, large and small intestines, and anus was diagnosed in the control group. Cardiovascular defects were represented by congenital heart defects, coarctation of the aorta, and aneurysm of the vein of Galen in both study groups. The neoplasm group included pathological formations of various localizations (abdominal cavity, chest cavity, small pelvis, cranial ca-

vity, external localization, and including teratoma). In the main group, surgical treatment of hemangioma was performed, and in the control group, surgical treatment of sacrococcygeal teratomas, ovary formations, femoral and parietal regions, face, abdominal cavity, cranial cavity, and the retroperitoneal space. No surgical interventions for CMs of the central nervous system were performed in the main group. In the control group, hydrocephalus, rachischisis (myelocoele, meningomyelocoele, and meningomyelocoele), cranioschisis (occipital meningocele, encephalocele, encephalomeningocele, and cranio-vertebral meningocele), Arnold–Chiari syndrome, and subependymal cyst of the cerebral ventricle were registered. The number of surgeries during the first 7 days of life was statistically significantly higher in the main group than in the control group.

Thus, multiple CMs and CMs of the cardiovascular system were diagnosed statistically significantly more often in the main group, while all other groups of CMs were diagnosed more often in the control group.

STUDY RESULTS

The sex ratios in the main and control groups (boys/girls) were 57/43% and 60/40%, respectively, and the difference was statistically insignificant ($p = 0.604$). No statistically significant differences were noted in the age and social status of mothers in the main and control groups, that is, they were comparable according to these indicators (Table 3).

The distribution of mothers by blood groups I, II, III, and IV was not statistically significantly different, with 34.2%, 39.5%, 18.6%, and 7.6% and 37.5%, 34.4%, 25%, and 3.1%% in the main and control groups, respectively. The ratio of mothers with a negative Rh factor in both groups was almost equal to 14 (18.2%) and 54 (18.8%), which was statistically not significant.

Chronic nicotine intoxication, hypertension, arterial hypertension, and chronic serum hepatitis B and C were noted statistically significantly more often in mothers of deceased newborns (Table 4). Urinary system pathologies in the main and control groups included CMs (polycystic kidney disease and kidney duplication), urolithiasis and cystitis and were statistically significantly more often detected in the deceased group, whereas no statistically significant differences were found in the frequency of chronic pyelonephritis in the study groups. In both groups, liver and gastrointestinal

tract diseases included liver steatosis, cholelithiasis, calculous cholecystitis, chronic gastritis, and duodenal ulcer, and no statistically significant differences were noted. In the study groups, thrombocytopenia and thrombocytopathy, vision pathologies (mild to severe myopia and retinal angiopathy), varicose veins, chronic tonsillitis, respiratory system pathologies (chronic pharyngitis and bronchitis, bronchial asthma, and injuries in history), anemia, grade 1 and 2 obesity, injuries (fractures of the pelvis, coccyx, and long tubular bones, knee ligament rupture, closed craniocerebral injury, and cerebral concussion), skin diseases (vitiligo, psoriasis, atypical dermatitis, and neurodermatitis), hypercoagulability, hereditary thrombophilia, antiphospholipid syndrome, and diabetes mellitus were registered with equal frequency, and no statistically significant differences were noted.

Thus, the mothers of deceased newborns statistically significantly more often had chronic nicotine intoxication, urinary system and thyroid gland pathologies, and chronic serum hepatitis B and C.

Uterine fibroids, infertility (primary and secondary), congenital malformations of the genitals, endometriosis, ovarian tumors, chronic inflammation of pelvic organs (salpingoophoritis and endometritis), chronic urogenital infection (ureaplasmosis and chlamydia), menstrual disorders, and surgical treatment of gynecological diseases were detected in the study groups with equal frequency. Cervical ectropion and chronic inflammation of lower genital tract organs (vaginitis and bacterial vaginosis) were statistically significantly more common in mothers of deceased newborns (Table 5).

Table 3 / Таблица 3

Social status of mothers of newborns of the studied groups
Социальный статус матерей новорожденных исследуемых групп

Indicator / Показатель	Deceased / Погибшие ($n = 77$)	Survived / Выжившие ($n = 287$)	Statistical significance / Статистическая значимость
Registered marriage / Зарегистрированный брак	62 (80.5%)	247 (86.1%)	$\chi^2 = 0.14$, $p = 0.86$
Official place of work / Официальное место работы	51 (66.2%)	179 (62.4%)	$\chi^2 = 0.54$, $p = 0.46$
The level of education / Уровень образования			
• initial / начальное	6 (7.8%)	8 (2.8%)	$\chi^2 = 4.75$, $p = 0.09$
• average / среднее	31 (40.3%)	183 (63.8%)	
• high / высшее	40 (51.9%)	96 (33.4%)	
Pregnancy record / Учет по беременности	76 (98.7%)	283 (98.6%)	$\chi^2 = 0.07$, $p = 0.92$
Mother's age, years (max–min) / Возраст матери, лет (max–min)	30.76 ± 5.866 (17–41)	29.85 ± 5.769 (16–53)	$p = 0.255$

Table 4 / Таблица 4

Somatic morbidity of mothers of newborns of the studied groups

Соматическая заболеваемость матерей новорожденных исследуемых групп

Indicator / Показатель	Deceased / Погибшие (n = 77)	Survived / Выжившие (n = 287)	Statistical significance / Статистическая значимость
Chronic nicotine intoxication / Хроническая никотиновая интоксикация	9 (11.7%)	7 (2.4%)	$\chi^2 = 6.25, p = 0.016$
Essential hypertension and arterial hypertension / Гипертоническая болезнь и артериальная гипертензия	13 (16.9%)	19 (6.6%)	$\chi^2 = 4.52, p = 0.033$
Chronic serum hepatitis B and C / Хронические сывороточные гепатиты В и С	7 (9.1%)	7 (0.7%)	$\chi^2 = 7.04, p = 0.010$
Chronic pyelonephritis/ Хронический пиелонефрит	10 (13.0%)	21 (6.5%)	$\chi^2 = 1.56, p = 0.211$
Pathology of the urinary system / Патология мочевыводящей системы	14 (18.2%)	2 (0.7%)	$\chi^2 = 5.85, p = 0.016$
Pathology of the gastrointestinal tract and liver / Патология желудочно-кишечного тракта и печени	18 (23.4%)	42 (13.0%)	$\chi^2 = 2.83, p = 0.092$
Chronic tonsillitis / Хронический тонзиллит	5 (6.5%)	16 (5.6%)	$\chi^2 = 0.05, p = 0.816$
Pathology of the respiratory system / Патология дыхательной системы	3 (3.9%)	7 (2.4%)	$\chi^2 = 0.11, p = 0.745$
Injuries / Перенесенные травмы	5 (6.5%)	4 (1.4%)	$\chi^2 = 2.91, p = 0.088$
Varicose disease / Варикозная болезнь	5 (6.5%)	33 (11.5%)	$\chi^2 = 1.08, p = 0.284$
Vision pathology / Патология зрения	14 (18.2%)	33 (11.5%)	$\chi^2 = 1.48, p = 0.223$
Anemia / Анемия	1 (1.3%)	2 (0.70%)	$\chi^2 = 0.25, p = 0.621$
Obesity / Ожирение			
• first degree / первой степени	4 (5.2%)	7 (2.4%)	$\chi^2 = 0.92, p = 0.646$
• second degree / второй степени	3 (3.9%)	7 (2.4%)	
Pathology of the thyroid gland / Патология щитовидной железы	16 (20.8%)	21 (7.7%)	$\chi^2 = 7.59, p = 0.007$
Diabetes mellitus / Сахарный диабет	–	1 (0.4%)	–
Hypercoagulation, APS, hereditary thrombophilia / Гиперкоагуляция, антифосфолипидный синдром, наследственная тромбофилия	3 (3.9%)	7 (2.4%)	$\chi^2 = 0.11, p = 0.745$
Thrombocytopenia, thrombocytopenia / Тромбоцитопения, тромбоцитопатия	3 (3.9%)	7 (2.4%)	$\chi^2 = 0.75, p = 0.387$
Skin diseases / Заболевания кожи	3 (3.9%)	4 (1.4%)	$\chi^2 = 0.52, p = 0.482$

The number of pregnancies and childbirths, history of miscarriages, missed miscarriages, and ectopic pregnancies, abortions in primiparas, preterm births, and perinatal losses in the study groups were registered equally frequently. Two or more abortions in multiparous women, history of placental insufficiency in a previous pregnancy, and previous delivery by cesarean section were statistically significantly more common in mothers of deceased newborns (Table 6).

Pregnancy as a result of assisted reproductive technologies, namely, in vitro fertilization and in-

tracytoplasmic sperm injection, infectious lesions of the genital tract caused by *Trichomonas vaginalis* and *Chlamydia trachomatis*, mycoplasma and ureaplasma infections, presence of opportunistic microflora in the cervical canal, gestational diabetes mellitus, moderate and severe preeclampsia, cholestatic hepatosis, thrombocytopenia, isthmic-cervical insufficiency (including its correction with the installation of an obstetric unloading pessary), placenta previa, premature detachment of a normally located placenta were noted with an equal frequency in the study groups. Threatened abortion

Table 5 / Таблица 5

Gynecological morbidity of mothers of newborns of the studied groups

Гинекологическая заболеваемость матерей новорожденных исследуемых групп

Indicator / Показатель	Deceased / Погибшие (n = 77)	Survived / Выжившие (n = 287)	Statistical significance / Статистическая значимость
Uterine fibroids / Миома матки	3 (3.9%)	7 (2.4%)	$\chi^2 = 0.09, p = 0.771$
Primary infertility / Бесплодие первичное	3 (3.9%)	21 (7.7%)	$\chi^2 = 1.72, p = 0.199$
Secondary infertility / Бесплодие вторичное	4 (5.2%)	13 (4.5%)	$\chi^2 = 0.01, p = 0.973$
Congenital malformations of the genitals / Врожденные пороки развития полового аппарата	1 (1.3%)	—	—
Menstrual irregularities / Нарушения менструального цикла	3 (3.9%)	—	—
Endometriosis / Эндометриоз	1 (1.3%)	—	—
Ovarian tumors / Опухоли яичника	1 (1.3%)	—	—
Chronic inflammatory of the pelvic organs / Хронический воспалительный процесс органов малого таза	5 (6.5%)	4 (1.4%)	$\chi^2 = 2.81, p = 0.094$
Chronic inflammation of the organs of the lower floor of the genital tract / Хроническое воспаление органов нижнего этажа полового тракта	8 (10.4%)	4 (1.4%)	$\chi^2 = 8.22, p = 0.005$
Ectopia of the cervix / Эктопия шейки матки	8 (10.4%)	2 (0.7%)	$\chi^2 = 10.48, p = 0.001$
Ureaplasmosis / Уреаплазмоз	5 (6.5%)	—	—
Chlamydial infection / Хламидиоз	3 (3.9%)	—	—
Transferred operations / Операции в анамнезе	3 (3.9%)	—	—

Table 6 / Таблица 6

Features of the obstetric anamnesis of mothers of newborns of the studied groups

Особенности акушерского анамнеза матерей новорожденных исследуемых групп

Indicator / Показатель	Deceased / Погибшие (n = 77)	Survived / Выжившие (n = 287)	Statistical significance / Статистическая значимость
Pregnancy by account (max–min) / Беременность по счету	2.747 ± 2.075 (1–11)	2.389 ± 1.56 (1–9)	$p = 0.109$
Childbirth by account (max–min) / Роды по счету	1.845 ± 1.023 (1–6)	1.789 ± 0.946 (1–5)	$p = 0.662$
Miscarriages / Выкидыши, замершие беременности	7 (9.1 %)	30 (10.5 %)	$\chi^2 = 9.67, p = 0.085$
Miscarriages (number) / Выкидыши, замершие беременности (количество)	0.239 ± 0.917	0.122 ± 0.388	$p = 0.101$
A history of abortion in a nulliparous / Аборт в анамнезе у первородящей	3 (3.9%)	12 (4.2%)	$\chi^2 = 0.00, p = 0.978$
Two or more abortions in a multiparous / Два и более аборт у повторнородящей	14 (18.2%)	18 (6.3%)	$\chi^2 = 8.37, p = 0.004$
Placental insufficiency / Плацентарная недостаточность	2 (2.6%)	—	—
Ectopic pregnancy / Эктопическая беременность	1 (1.3%)	8 (2.5%)	$\chi^2 = 0.34, p = 0.558$
Caesarean section / Кесарево сечение	6 (7.8%)	5 (1.7%)	$\chi^2 = 5.62, p = 0.017$
Preterm birth / Преждевременные роды	2 (2.6%)	9 (3.1%)	$\chi^2 = 0.03, p = 0.860$
Perinatal losses / Перинатальные потери	1 (1.3%)	—	—

(both single, double, and multiple), acute respiratory viral infections during pregnancy, exacerbations of chronic infectious diseases, inflammatory diseases of the lower genital tract, early toxicosis, carriage of *Cytomegalovirus* and *Herpes simplex* types 1 and 2, asymptomatic bacteriuria, and anemia of pregnancy were registered statistically significantly more often in mothers of deceased newborns (Table 7).

Ultrasound data during pregnancy were analyzed. Diagnosed pathological conditions and structural aspects of the placenta are presented in Table 8.

The rates of increased thickness of the collar space, a single umbilical artery, and prenatally diagnosed fetal edema were not statistically significantly different. In the deceased group, the pathological conditions of the placental complex, namely, chronic placental insufficiency, circulatory failure (stages IA and B, II, and III), fetal hypotrophy, oligohydramnios, and polyhydramnios, were diagnosed statistically significantly more often.

As regards the characteristics of delivery (Table 9), the duration of stages 1, 2, and 3 of labor, frequency of amniotomy, and perineotomy were not statistically significantly different in the groups. In the group of deceased newborns, vaginal delivery was statistically significantly more common. Operative vaginal delivery was not used in the study groups.

Amniotic fluid discharges were analyzed. The duration from rupture to delivery and childbirth with a whole fetal bladder was not statistically significantly different. In the survived group, the normal color of the amniotic fluid was statistically significantly more common, whereas meconium-stained and blood-tinged amniotic fluid were statistically significantly more common in the main group. Moreover, the diagnosis of intrauterine fetal hypoxia during childbirth was established in the study groups with approximately equal frequency, and no statistically significant differences were detected. In the deceased group, deliveries were statistically significantly more frequent with breech presentation.

No statistically significant differences in the gestational age, weight and height of newborns, and weight and height of full-term newborns were noted. The 1-min and 5-min Apgar scores were statistically significantly lower in the deceased group (Table 10).

In the analysis of the histological structure of the placenta, stage 3 ascending infection and chlamydial choriodecidualitis were statistically significantly more common in the deceased group. Meanwhile,

hematogenous infection (mycoplasma, herpetic, and RNA-viral) and placental insufficiency, both chronic and acute, were not statistically significant different between the groups (Table 11).

Thus, the unfavorable prognostic risk factors for neonatal death after surgery performed in the early neonatal period are as follows:

- Multiple CMs and congenital heart diseases in the child
- Lack of prenatal diagnosis of the malformation
- Chronic nicotine intoxication, hypertension and arterial hypertension, chronic serum hepatitis B and C, urinary system and thyroid gland pathologies, cervical ectropion, chronic inflammation of the lower genital tract organs (vaginitis and bacterial vaginosis), two or more abortions in multiparous women, history of placental insufficiency in a previous pregnancy, previous delivery by cesarean section
- Threatened abortion (both single, double, and multiple), acute respiratory viral infections during pregnancy, exacerbations of chronic infectious diseases, inflammatory diseases of the lower genital tract, early toxicosis, carriage of *Cytomegalovirus* and *Herpes simplex* types 1 and 2, asymptomatic bacteriuria, and anemia in the current pregnancy
- Circulatory inefficiency, small-for-gestational-age fetus, abnormal amniotic fluid volume diagnosed by ultrasound in the third trimester of pregnancy
- Breech presentation of the fetus and meconium staining of amniotic fluid
- Stage 3 ascending infection of the placenta and chlamydial choriodecidualitis

DISCUSSION OF RESULTS

Modern surgery in the early neonatal period has undergone significant changes in recent years. Thanks to the development of prenatal diagnostics, most CMs can now be detected even before birth. According to Appendix No. 1 of the Order of the Ministry of Health of the Russian Federation No. 1130n², "If, according to the conclusion of a case conference, surgical correction of fetal malformations in the neonatal period is possible, pregnant women are referred for delivery to obstetric hospitals that have departments (wards) of resuscitation and intensive care for newborns and the possibility of providing medical care in Pediatric Surgery." A similar procedure for providing medical care in prenatal diagnostics of CMs allows for performing timely surgical treatment to reduce postoperative losses.

² Order of the Ministry of Health of Russia dated October 20, 2020 No. 1130n "On approval of the procedure for providing medical care in the field of obstetrics and gynecology."

Table 7 / Таблица 7

Features of the course of pregnancy in the study groups

Особенности течения беременности в исследуемых группах

Indicator / Показатель	Deceased / Погибшие (n = 77)	Survived / Выжившие (n = 287)	Statistical significance / Статистическая значимость
Pregnancy as a result of ART / Беременность в результате вспомогательных репродуктивных технологий			
• IVF / экстракорпоральное оплодотворение	10 (13.0%)	38 (13.2%)	$\chi^2 = 0.01, p = 0.914$
• ICSI / интрацитоплазматическая инъекция сперматозоида	—	4 (1.4 %)	—
Early toxicosis / Ранний токсикоз	4 (5.2%)	—	—
Inflammatory diseases of the lower genital tract / Воспалительные заболевания нижнего отдела полового тракта	16 (20.8%)	5 (1.8%)	$\chi^2 = 18.51, p = 0.000$
Trichomoniasis / Трихомониаз	1 (1.3%)	—	—
<i>Chlamydia trachomatis</i>	1 (1.3%)	—	—
<i>Cytomegalovirus</i>	7 (9.1%)	—	—
<i>Herpes simplex</i> 1, 2	3 (3.9%)	—	—
<i>Mycoplasma</i> / <i>Ureaplasma</i>	3 (3.9%)	—	—
Genital opportunistic microflora / Условно-патогенная микрофлора	3 (3.9%)	—	—
Threat of abortion / Угроза прерывания беременности			
• single / однократная	12 (15.6%)	4 (1.4%)	$\chi^2 = 45.87, p = 0.000$
• double / двукратная	6 (7.8%)	2 (0.7%)	$\chi^2 = 20.50, p = 0.000$
• multiple / многократная	8 (10.4%)	—	—
Gestational diabetes mellitus / Гестационный сахарный диабет	10 (13.0%)	15 (5.2%)	$\chi^2 = 3.46, p = 0.068$
Истмико-цервикальная недостаточность / Isthmic-cervical insufficiency	2 (2.6%)	12 (4.2%)	$\chi^2 = 0.26, p = 0.611$
Obstetric unloading pessary / Акушерский разгружающий пессарий	1 (1.3%)	2 (0.7%)	$\chi^2 = 0.13, p = 0.72$
Moderate preeclampsia / Умеренная преэклампсия	3 (3.9%)	28 (9.8%)	$\chi^2 = 2.71, p = 0.174$
Severe preeclampsia / Тяжелая преэклампсия	7 (9.1%)	10 (3.5%)	$\chi^2 = 2.23, p = 0.142$
Cholestatic hepatitis / Холестатический гепатоз	4 (5.2%)	2 (0.7%)	$\chi^2 = 3.95, p = 0.05$
Thrombocytopenia / Тромбоцитопения	1 (1.3%)	—	—
SARS during pregnancy / Острая респираторная вирусная инфекция во время беременности	16 (20.8%)	3 (1.1%)	$\chi^2 = 25.39, p = 0.000$
Exacerbations of chronic infections / Обострения хронических инфекций	7 (9.1%)	2 (0.7%)	$\chi^2 = 7.19, p = 0.007$
Asymptomatic bacteriuria / Бессимптомная бактериурия	4 (5.2%)	—	—
Placenta previa / Предлежание плаценты	7 (9.1%)	15 (5.2%)	$\chi^2 = 0.83, p = 0.370$
Premature detachment of a normally located placenta /Преждевременная отслойка нормально расположенной плаценты	9 (11.7%)	24 (8.4%)	$\chi^2 = 0.42, p = 0.522$
Anemia in pregnancy / Анемия беременных			
• mild degree / легкой степени	17 (22.1%)	11 (3.8%)	$\chi^2 = 28.42, p = 0.000$
• medium degree / средней степени	1 (1.3%)	—	—

Table 8 / Таблица 8

Ultrasound data in the study groups

Данные ультразвукового исследования в группах

Indicator / Показатель	Deceased / Погибшие (n = 77)	Survived / Выжившие (n = 287)	Statistical significance / Статистическая значимость
Increased NT / Увеличение толщины воротникового пространства	1 (1.3%)	–	–
Chronic placental insufficiency / Хроническая плацентарная недостаточность	11 (14.3%)	–	–
Circulatory failure / Недостаточность кровообращения	7 (9.1%)	2 (0.7%)	$\chi^2 = 18.06, p = 0.002$
Fetal hypotrophy / Гипотрофия плода	9 (11.7%)	2 (0.7%)	$\chi^2 = 20.86, p = 0.000$
Polyhydramnios / Многоводие	11 (14.3%)	17 (5.9%)	$\chi^2 = 4.55, p = 0.033$
Oligohydramnios / Маловодие	5 (6.5%)	4 (1.4%)	$\chi^2 = 4.29, p = 0.038$
The only artery of the umbilical cord / Единственная артерия пуповины	1 (1.3%)	2 (0.7%)	$\chi^2 = 0.25, p = 0.628$
Immune and non-immune fetal edema / Иммунный и неиммунный отек плода	–	2 (0.7%)	–

Table 9 / Таблица 9

Features of delivery in the studied groups

Особенности родоразрешения в исследуемых группах

Indicator / Показатель	Deceased / Погибшие (n = 77)	Survived / Выжившие (n = 287)	Statistical significance / Статистическая значимость
Duration of the first stage of labor, minutes / Длительность первого периода родов, мин	295.250 ± 178.103	333.000 ± 137.264	$p = 0.308$
Duration of the second stage of labor, minutes / Длительность второго периода родов, мин	14.611 ± 13.342	12.986 ± 8.227	$p = 0.514$
Duration of the third stage of labor, minutes / Длительность третьего периода родов, мин	9.375 ± 3.096	10.274 ± 3.216	$p = 0.311$
Caesarean section, including / Кесарево сечение, в том числе	39 (50.7%)	211 (73.5%)	$\chi^2 = 14.76, p = 0.000$
• emergency / экстренное	29 (74.4%)	140 (66.4%)	$\chi^2 = 2.03, p = 0.152$
• planned / плановое	10 (25.6%)	71 (33.6%)	$\chi^2 = 4.26, p = 0.119$
Perineotomy / Перинеотомия	4 (5.2%)	14 (4.9%)	$\chi^2 = 0.01, p = 0.909$
Amniotomy / Амниотомия	2 (2.6%)	2 (0.7%)	$\chi^2 = 1.64, p = 0.200$
Manual examination of the uterine cavity / Ручное обследование полости матки	–	9 (3.1%)	–
The duration of the waterless period / Длительность безводного промежутка	292.650 ± 277.343	1409.638 ± 5616950	$p = 0.377$
Delivery with whole amniotic sac / Родоразрешение с целым плодным пузырем	30 (39.0%)	127 (44.3%)	$\chi^2 = 0.84, p = 0.658$
Amniotic fluid is light / Околоплодные воды светлые	56 (72.7%)	272 (94.8%)	$\chi^2 = 23.57, p = 0.000$
Meconium staining of amniotic fluid / Мекониальная окраска околоплодных вод	6 (7.8%)	11 (3.8%)	$\chi^2 = 6.19, p = 0.013$
Intrauterine fetal hypoxia / Внутриутробная гипоксия плода	6 (7.8%)	30 (10.5%)	$\chi^2 = 0.49, p = 0.487$
Breech presentation / Тазовое предлежание	5 (6.5%)	3 (1.1%)	$\chi^2 = 6.56, p = 0.010$
Transverse position of the fetus / Поперечное положение плода	1 (1.3%)	–	$\chi^2 = 3.12, p = 0.078$

Table 10 / Таблица 10

Massometric indicators and Apgar score in children of the studied groups at birth

Массометрические показатели и оценка по шкале Апгар у детей исследуемых групп при рождении

Indicator / Показатель	Deceased / Погибшие (n = 77)	Survived / Выжившие (n = 287)	Statistical significance / Статистическая значимость
Pregnancy duration, weeks (max–min) / Срок беременности, недель (max–min)	35.442 ± 5.310 (23–40)	36.582 ± 5.194 (22–40)	p = 0.436
Weight of newborns, g (max–min) / Масса новорожденных, г (max–min)	2516.04 ± 1019.99 (400–4460)	2684.82 ± 1015.99 (400–5740)	p = 0.200
Weight of full-term newborns, g (max–min) / Масса доношенных новорожденных, г (max–min)	3085.57 ± 599.20 (1870–4460)	3221.36 ± 548.62 (1880–5740)	p = 0.147
Height of newborns, cm (max–min) / Рост новорожденных, см (max–min)	45.686 ± 7.482 (23–56)	46.739 ± 7.267 (24–57)	p = 0.200
Growth of full-term newborns, cm (max–min) / Рост доношенных новорожденных, см (max–min)	49.897 ± 3.235 (43–56)	50.616 ± 2.575 (42–57)	p = 0.132
Apgar score at 1 st minute (max–min) / Оценка по шкале Апгар на 1-й минуте (max–min)	5.471 ± 2.452 (1–8)	6.515 ± 2.092 (2–9)	p = 0.000
Apgar score at 5 th minutes (max–min) / Оценка по шкале Апгар на 5-й минуте (max–min)	6.618 ± 2.130 (1–8)	7.695 ± 1.848 (2–9)	p = 0.000

Table 11 / Таблица 11

Features of the structure of the placenta of newborns of the studied groups

Особенности строения плаценты новорожденных исследуемых групп

Indicator / Показатель	Deceased / Погибшие (n = 77)	Survived / Выжившие (n = 287)	Statistical significance / Статистическая значимость
Ascending infection / Восходящее инфицирование			
• the first stage / первой стадии	11 (14.3%)	82 (28.6%)	$\chi^2 = 5.51, p = 0.018$
• the second stage / второй стадии	11 (14.3%)	21 (7.3%)	$\chi^2 = 2.85, p = 0.267$
• the third stage / третьей стадии	12 (15.6%)	16 (5.7%)	$\chi^2 = 6.71, p = 0.010$
Chlamydial choriodecidualitis / Хламидийный хориодецидуит	12 (15.6%)	11 (3.8%)	$\chi^2 = 11.47, p = 0.001$
Mycoplasma choriodecidualitis / Микоплазменный хориодецидуит	21 (27.3%)	108 (37.6%)	$\chi^2 = 2.01, p = 0.156$
RNA viral choriodecidualitis / РНК-вирусный хориодецидуит	17 (22.1%)	90 (31.4%)	$\chi^2 = 2.09, p = 0.149$
Herpetic choriodecidualitis / Герпетический хориодецидуит	42 (54.5%)	165 (57.5%)	$\chi^2 = 0.12, p = 0.723$
Hematogenous infection, unspecified / Гематогенное инфицирование	1 (1.3%)	5 (1.7%)	$\chi^2 = 0.01, p = 0.914$
TORCH infection / TORCH-инфекция	1 (1.3%)	2 (0.7%)	$\chi^2 = 0.62, p = 0.429$
Total hematogenous infection / Всего гематогенное инфицирование	52 (67.5%)	216 (75.3%)	$\chi^2 = 1.91, p = 0.591$
Chronic placental insufficiency / Хроническая плацентарная недостаточность			
• compensated / компенсированная	25 (32.5%)	161 (56.1%)	$\chi^2 = 4.15, p = 0.041$
• subcompensated / субкомпенсированная	32 (41.6%)	75 (26.1%)	$\chi^2 = 4.54, p = 0.033$
• decompensated / декомпенсированная	1 (1.3%)	1 (0.4%)	$\chi^2 = 1.35, p = 0.246$
Acute placental insufficiency / Острая плацентарная недостаточность	2 (2.6%)	12 (4.3%)	$\chi^2 = 0.68, p = 0.410$

A few studies are investigating risk factors for neonatal death after surgeries performed in the first days after birth. In the literature, congenital heart defects are one of the main causes of death of children after surgeries performed in the early neonatal period [2, 3, 5, 39, 40], which is consistent with the data obtained in this study. According to the literature, the main fields of the search for measures to reduce postoperative mortality can be the development of methods of surgical interventions [2, 3, 35, 39, 42, 44], improvement of anesthesia [12], clarification of indications, contraindications, and schemes for the use of pharmacological drugs [33, 43], and development of care methods for newborns [25, 26, 31, 37, 47] in the postoperative period [17].

It was not possible to find studies investigating studying microbial damage to the organs and systems of the newborn, condition of the placenta, and postoperative outcomes; however, an association between postoperative complications and levels of markers of the systemic inflammatory response (thrombocytopenia, C-reactive protein, and procalcitonin) was reported [23, 28, 30]. The factors that increase the risk of postoperative complications in the neonatal period include gestational anemia [26, 33], arterial hypertension [46], chronic placental insufficiency, circulatory failure according to dopplerometry [28], and low Apgar scores at birth [25], which is consistent with the data obtained in the study.

Many authors have indicated factors in increasing postoperative mortality such as low gestational age and low birthweight [23, 30, 36, 41, 48]; however, the data obtained in our work are consistent with the opposite opinion, where no statistically significant differences in gestational age and birthweight were registered [7].

Studies have noted the need for improving the complicated course of the neonatal period, which may require surgical interventions (necrotizing ulcerative colitis and spontaneous intestinal perforation) [11, 38, 41, 48]. Moreover, one of the risk factors is chorioamnionitis during childbirth [36]. Some authors have indicated the presence of certain pathogenic microflora in children who underwent surgical interventions in the neonatal period, without specifying their role in the development of complications or lethal outcomes [15].

CONCLUSIONS AND PRACTICAL RECOMMENDATIONS

The results of this study on risk factors for postoperative mortality of newborns, who underwent

surgical treatment within the first 7 days of extra-uterine life, such as chronic inflammation of lower genital tract organs (vaginitis and bacterial vaginosis), exacerbations of chronic infectious diseases, asymptomatic bacteriuria, and stage 3 ascending infection of the placenta, indicate a significant role of bacterial infection. In pregnant women with prenatally diagnosed fetal CMs, bacteriological studies and an emergency histological examination of the placenta must be performed to identify possible microbial lesions, as well as timely examination and treatment of newborns with an upcoming surgery or after it.

ADDITIONAL INFORMATION

Author contribution. Thereby, 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.

Funding source. This study was not supported by any external sources of funding.

REFERENCES

1. Averin VI, Korostelev OYu, Dardynskiy AV, Zapolianski AV. One-stage radical correction of persistent cloaca. *Surgery Eastern Europe*. 2012;(1):83–87. (In Russ.)
2. Averin VI, Podgaysky VN, Nesteruk LN, et al. First experience of graft revascularization at esophagoplasty in children in non-standard cases. *Surgery news*. 2012;20(1):80–84. (In Russ.)
3. Bokeriya LA, Alekhan BG, Pursanov MG, et al. Gibrindnye operatsii pri sindrome gipoplazii levogo serdtsa i kriticheskikh obstrukivnykh porazheniyakh voshodyashchei aorty. *The bulletin of Bakoulev center. Cardiovascular diseases*. 2010;11(S3):4. (In Russ.)
4. Govorukhina OA, Prokopenya NS, Kharitonchik VA, Khomich VM. Diagnostics and surgical treatment of hirsprung disease in newborns and patients in the first months of life. *Meditinskii zhurnal*. 2022;(2):4–11. (In Russ.)
5. Gorbatiy KV, Totolin IS, Karpov EA, et al. Treatment of congenital heart defects with a combination of interrupted aortic arch, operational technology. *Medical science and education of Ural*. 2018;19(2):6–9. (In Russ.)
6. Dzehtyarou YuG. Congenital anorectal anomalies: diagnosis, treatment. *Meditinskii zhurnal*. 2014;(2):53–59. (In Russ.)
7. Efimochkin GA, Barbukhatti KO, Karakhalis NB, et al. Transposition complex with aortic arch obstruction:

- outcomes after one-stage repair in newborn period. *Innovative Medicine of Kuban*. 2017;7(3):6–13. (In Russ.)
8. Karavaeva SA. Khirurgicheskoe lechenie nekroticheskogo ehnterokolita [dissertation abstract]. Saint Petersburg, 2002. (In Russ.)
 9. Kozlov YuA, Bregel LV, Rasputin AA, et al. Laparoscopic Santulli intestinal anastomosis in an infant with cystic fibrosis. *Pediatrics. Journal named after G.N. Speransky*. 2021;100(60):187–191. (In Russ.) DOI: 10.24110/0031-403X-2021-100-6-187-191
 10. Kozlov YuA, Koval'kov KA, Chubko DM, et al. Intestinal strictures in newborn babies after necrotizing enterocolitis (post-NEC intestinal strictures). *Russian Journal of Pediatric Surgery*. 2016;20(5):228–234. (In Russ.)
 11. Kozlov YuA, Novozhilov VA, Koval'kov KA, et al. Results of the treatment of spontaneous intestinal perforation in preterm children. *Russian Journal of Pediatric Surgery*. 2017;21(6):284–290. (In Russ.)
 12. Kucheroval IYu, Kryuchko DS, Movsesyan RR. Opyt anesteziologicheskogo posobiya u nedonoshennykh detei vo vremya operatsii klipirovaniya otkrytogo arterial'nogo protoka. *The Peer-reviewed Scientific and Practical Journal. The Bulletin of Bakoulev Center. Cardiovascular Diseases*. 2008;9(S6):225. (In Russ.)
 13. Maksimenko AV, Shipov DO, Motrechko AA, et al. Opyt ballonnoi val'vuloplastiki u patsientov s atreziei legochnoi arterii i intaktnoi mezhheludochkovoi peregorodkoj. *Pediatrica i detskaya khirurgiya*. 2018;(2):30–35. (In Russ.)
 14. Orlov YuO, Shaversky AV, Marushchenko LL, Zyabchenko VI. Intracranial tumors in newborns. *Ukrainskii nevrologicheskii zhurnal*. 2014;(2):63–68. (In Russ.)
 15. Ostreykov IF, Mel'nikova NI, Babaev BD, Shtatnov MK. Fungal infections in children with surgical disease in the ICU. *Russian Journal of Anaesthesiology and Reanimatology*. 2017;62(4):310–315. (In Russ.)
 16. Prokopenya NS, Govorukhina OA, Averin VI. Lechenie kresttsovo-kopchikovyx teratom u detei. *Surgery Eastern Europe*. 2012;(3):232–233. (In Russ.)
 17. Protasevich TS, Bontsevich NS, Svirskaya AA. Analiz sluchaev vrozhdennogo pilorostenozha u detei. Proceeding of the international science and practice conferences with international participation "Aktual'nye voprosy pediatrii"; 2017 Apr 8; Perm. Perm: Knizhnyi format, 2017. P. 191–194. (In Russ.)
 18. Razumovsky AY, Mokrushina OG, Shumikhin VS, et al. Pediatric surgeons choose endosurgery. *Russian journal of thoracic and cardiovascular surgery*. 2016;21(1–2):52–59. (In Russ.)
 19. Sadykova AZh, Boranbaeva RZ, Kusainov AZ, et al. Analiz chastoty i prichin ostrogo povrezhdeniya pochk u novorozhdennykh s vrozhdennymi porokami razvitiya. *Farmatsiya Kazakhstana*. 2022;(3):89–96. (In Russ.) DOI: 10.53511/pharmkaz.2022.74.15.015
 20. Sadykova AZh, Boranbaeva RZ, Sarsenbaeva GI, et al. Chastota i faktory riska ostrogo povrezhdeniya pochk v neonatal'noi kardiokhirurgii. *Farmatsiya Kazakhstana*. 2022;(1):28–36. (In Russ.) DOI: 10.53511/pharmkaz.2022.64.56.006
 21. Svirsky AA, Sevkovsky IA, Averin VI, et al. Necrotizing enterocolitis of newborns – pressing issues and factors prognosticating treatment outcome. *Russian Journal of Pediatric Surgery, Anesthesia and Intensive Care*. 2016;6(3):19–26. (In Russ.)
 22. Truba IP, Lazoryshynets VV, Sekelyk RI, et al. Aortic arch hypoplasia in combination with other congenital heart defects in infants: results of a one-stage repair. *Cardiology in Belarus*. 2021;13(6):885–894. (In Russ.) DOI: 10.34883/PI.2021.13.6.003
 23. Trunina II. Gipotrofiya, vnutritrobnnye infektsii i sindromal'naya patologiya kak faktory riska neonatal'noi kardiokhirurgii. *Children's Heart and Vascular Diseases*. 2012;(3):23–30. (In Russ.)
 24. Kholostova VV, Dronov AF, Smirnov AN, et al. Surgical treatment of Hirschprung's disease total form in children. *Pirogov Russian Journal of Surgery*. 2014;(7):44–54. (In Russ.)
 25. Aggarwal A, Kumar P, Chowdhary G, et al. Evaluation of renal functions in asphyxiated newborns. *J Trop Pediatr*. 2005;51(5):295–299. DOI: 10.1093/tropej/fmi017
 26. Alten JA, Cooper DS, Blinder JJ, et al. Neonatal and Pediatric Heart and Renal Outcomes Network (NEPHRON) investigators. Epidemiology of acute kidney injury after neonatal cardiac surgery: a report from the multicenter neonatal and pediatric heart and renal outcomes network. *Crit Care Med*. 2021;49(10):941–951. DOI: 10.1097/CCM.0000000000005165
 27. Bell EF. Preventing necrotizing enterocolitis: what works and how safe? *Pediatrics*. 2005;115(1):173–175. DOI: 10.1542/peds.2004-2360
 28. Mol BWJ, Roberts CT, Thangaratnam S, et al. Pre-eclampsia. *Lancet*. 2016;387(10022):999–1011. DOI: 10.1016/S0140-6736(15)00070-7
 29. Bhatia J. Strategies to prevent necrotizing enterocolitis. *Chin Med J*. 2010;123(20):2759–2765.
 30. Brennan KG, Parravicini E, Lorenz JM, Bateman DA. Patterns of urinary neutrophil gelatinase-associated lipocalin and acute kidney injury in neonates receiving cardiopulmonary bypass. *Children (Basel)*. 2020;7(9):132. DOI: 10.3390/children7090132
 31. Clyman R, Wickremasinghe A, Jhaveri N, et al. Enteral feeding during indomethacin and ibuprofen treatment of a patent ductus arteriosus. *J Pediatr*. 2013;163(2):406–411. DOI: 10.1016/j.jpeds.2013.01.057
 32. Gaudin A, Farnoux C, Bonnard A, et al. Necrotizing Enterocolitis (NEC) and the risk of intestinal stricture: The value of C-reactive protein. *PLoS One*. 2013;8:e76858. DOI: 10.1371/journal.pone.0076858

33. Gist KM, Blinder JJ, Bailly D, et al. Neonatal and Paediatric Heart and Renal Outcomes Network: design of a multi-centre retrospective cohort study. *Cardiol Young*. 2019;29(4):511–518. DOI: 10.1017/S1047951119000210
34. Gordon PV. Understanding intestinal vulnerability to perforation in the extremely low birth weight infant. *Pediatr Res*. 2009;65:138–144. DOI: 10.1203/PDR.0b013e31818c7920
35. Greenberg JH, Zappitelli M, Jia Y, et al. Biomarkers of AKI progression after pediatric cardiac surgery. *J Am Soc Nephrol*. 2018;29(5):1549–1556. DOI: 10.1681/ASN.2017090989
36. Kai K, Sameshima H, Ikeda T, Ikenoue T. Severe variable deceleration is associated with intestinal perforation in infants born at 22–27 weeks' gestation. *J Matern Fetal Neonatal Med*. 2009;22(3):259–264. DOI: 10.1080/14767050802379049
37. Karagianni P, Briana DD, Mitsiakos G, et al. Early versus delayed minimal enteral feeding and risk for necrotizing enterocolitis in preterm growth-restricted infants with abnormal antenatal Doppler results. *Am J Perinatol*. 2010;27(5):367–373. DOI: 10.1055/s-0029-1243310
38. Kelleher J, Salas AA, Bhat B, et al. Prophylactic indomethacin and intestinal perforation in extremely low birth weight infants. *Pediatrics*. 2014;134(5):1369–1377. DOI: 10.1542/peds.2014-0183
39. Leaf A, Dorling J, Kempley S, et al. Early or delayed enteral feeding for preterm growth-restricted infants: a randomized trial. *Pediatrics*. 2012;129(5):1260–1268. DOI: 10.1542/peds.2011-2379
40. Marelli AJ, Mackie AS, Ionescu-Iltu R, et al. Congenital heart disease in the general population: changing prevalence and age distribution. *Circulation*. 2007;115(2):163–172. DOI: 10.1161/CIRCULATIONAHA.106.627224
41. Nakajima Y, Masaoka N, Yamamoto T. Obstetrical risk factors for focal intestinal perforation in very low birth weight infants. *J Perinat Med*. 2011;39(2):179–184. DOI: 10.1515/jpm.2010.129
42. Phad N, Trivedi A, Todd D, Lakkundi A. Intestinal strictures postnecrotizing enterocolitis: Clinical profile and risk factors. *J Neonatal Surg*. 2014;3(4):44. DOI: 10.47338/jns.v3.134
43. Pumberger W, Mayr M, Kohlhauser C, Weninger M. Spontaneous localized intestinal perforation in very-low-birth-weight infants: a distinct clinical entity different from necrotizing enterocolitis. *J Am Coll Surg*. 2002;195(6):796–803. DOI: 10.1016/S1072-7515(02)01344-3
44. Rao SC, Basani L, Simmer K, et al. Peritoneal drainage versus laparotomy as initial surgical treatment for perforated necrotizing enterocolitis or spontaneous intestinal perforation in preterm low birth weight infants. *Cochrane Database Syst Rev*. 2011;(6):CD006182. DOI: 10.1002/14651858.CD006182.pub2
45. Raval MR, Hall NJ, Pierro A, Moss RL. Evidence-based prevention and surgical treatment of necrotizing enterocolitis – A review of randomized controlled trials. *Semin Pediatr Surg*. 2013;22(2):117–121. DOI: 10.1053/j.sempedsurg.2013.01.009
46. Selewski DT, Jordan BK, Askenazi DJ, et al. Acute kidney injury in asphyxiated newborns treated with therapeutic hypothermia. *J Pediatr*. 2013;162(4):725–729. DOI: 10.1016/j.jpeds.2012.10.002
47. Wadhawan R, Oh W, Vohr BR, et al. Spontaneous intestinal perforation in extremely low birth weight infants: association with indomethacin therapy and effects on Jones and Fisher 6 neurodevelopmental outcomes at 18–22 months corrected age. *Arch Dis Child*. 2013;98:127–132. DOI: 10.1136/archdischild-2011-300659
48. Guner YS, Chokshi N, Petrosyan M, et al. Necrotizing enterocolitis – bench to bedside: novel and emerging strategies. *Semin Pediatr Surg*. 2008;17(4):255–265. DOI: 10.1053/j.sempedsurg.2008.07.004
49. Yoneyama F, Okamura T, Takigiku K, Yasukouchi S. Novel urinary biomarkers for acute kidney injury and prediction of clinical outcomes after pediatric cardiac surgery. *Pediatr Cardiol*. 2020;41(4):695–702. DOI: 10.1007/s00246-019-02280-3

СПИСОК ЛИТЕРАТУРЫ

1. Аверин В.И., Коростелев О.Ю., Дардынский А.В., Заполянский А.В. Радикальная одномоментная коррекция сохранившейся клоаки // Хирургия. Восточная Европа. 2012. № 1. С. 83–87.
2. Аверин В.И., Подгайский В.Н., Нестерук Л.Н., и др. Первый опыт реваскуляризации трансплантата при пластике пищевода у детей в нестандартных ситуациях // Новости хирургии. 2012. Т. 20, № 1. С. 80–84.
3. Бокерия Л.А., Алесян Б.Г., Пурсанов М.Г., и др. Гибридные операции при синдроме гипоплазии левого сердца и критических обструктивных поражениях восходящей аорты // Бюллетень НЦССХ им. А.Н. Бакулева РАМН. Сердечно-сосудистые заболевания. 2010. Т. 11, № 53. С. 4.
4. Говорухина О.А., Прокопеня Н.С., Харитончик В.А., Хомич В.М. Диагностика и хирургическое лечение болезни Гиршпрунга у новорожденных и пациентов первых месяцев жизни // Медицинский журнал. 2022. № 2. С. 4–11.
5. Горбатов К.В., Тотолин И.С., Карпов Е.А., и др. Лечение врожденных пороков сердца с сочетанием перерыва дуги аорты, оперативная техника // Медицинская наука и образование Урала. 2018. Т. 19, № 2. С. 6–9.

6. Дегтярев Ю.Г. Врожденные аноректальные аномалии: диагностика, лечение // Медицинский журнал. 2014. № 2. С. 53–59.
7. Ефимочкин Г.А., Барбухатти К.О., Карахалис Н.Б., и др. Результаты одномоментной коррекции транспозиции магистральных сосудов и обструкции дуги аорты в периоде новорожденности // Инновационная медицина Кубани. 2017. № 3. С. 6–13.
8. Караваева С.А. Хирургическое лечение некротического энтероколита: автореф. дис. ... д-ра мед. наук. Санкт-Петербург, 2002.
9. Козлов Ю.А., Брегель Л.В., Распутин А.А., и др. Лапароскопический межкишечный анастомоз Santulli у младенца с муковисцидозом // Педиатрия. Журнал им. Г.Н. Сперанского. 2021. Т. 100, № 6. С. 187–191. DOI: 10.24110/0031-403X-2021-100-6-187-191
10. Козлов Ю.А., Ковальков К.А., Чубко Д.М., и др. Стриктуры кишечника у новорожденных после некротизирующего энтероколита (пост-НЭК стриктуры кишечника) // Детская хирургия. 2016. Т. 20, № 5. С. 228–234.
11. Козлов Ю.А., Новожилов В.А., Ковальков К.А., и др. Результаты лечения спонтанной перфорации кишечника у недоношенных детей // Детская хирургия. 2017. Т. 21, № 6. С. 284–290.
12. Кучерова И.Ю., Крючко Д.С., Мовсесян Р.Р. Опыт анестезиологического пособия у недоношенных детей во время операции клипирования открытого артериального протока // Бюллетень НЦССХ им. А.Н. Бакулева РАМН. Сердечно-сосудистые заболевания. 2008. Т. 9, № 56. С. 225.
13. Максименко А.В., Шипов Д.О., Мотречко А.А., и др. Опыт баллонной вальвулопластики у пациентов с атрезией легочной артерии и интактной межжелудочковой перегородкой // Педиатрия и детская хирургия. 2018. № 2. С. 30–35.
14. Орлов Ю.А., Шаверский А.В., Марущенко Л.Л., Зябченко В.И. Интракраниальные опухоли у новорожденных // Украинский неврологический журнал. 2014. № 2. С. 63–68.
15. Острейков И.Ф., Мельникова Н.И., Бабаев Б.Д., Штатнов М.К. Грибковая инфекция у детей с хирургическими заболеваниями в ОИТ // Анестезиология и реаниматология. 2017. Т. 62, № 4. С. 310–315.
16. Прокопеня Н.С., Говорухина О.А., Аверин В.И. Лечение крестцово-копчиковых тератом у детей // Хирургия. Восточная Европа. 2012. № 3. С. 232–233.
17. Протасевич Т.С., Бонцевич Н.С., Свиркова А.А. Анализ случаев врожденного пилоростеноза у детей // Материалы межрегиональной научно-практической конференции с международным участием: «Актуальные вопросы педиатрии»; Апрель 8, 2017; Пермь. Пермь: Книжный формат, 2017. С. 191–194.
18. Разумовский А.Ю., Мокрушина О.Г., Шумихин В.С., и др. Детские хирурги выбирают эндохимию // Анналы хирургии. 2016. Т. 21, № 1–2. С. 52–59.
19. Садыкова А.Ж., Боранбаева Р.З., Кусаинов А.З., и др. Анализ частоты и причин острого повреждения почек у новорожденных с врожденными пороками развития // Фармация Казахстана. 2022. № 3. С. 89–96. DOI: 10.53511/pharmkaz.2022.74.15.015
20. Садыкова А.Ж., Боранбаева Р.З., Сарсенбаева Г.И., и др. Частота и факторы риска острого повреждения почек в неонатальной кардиохирургии // Фармация Казахстана. 2022. № 1. С. 28–36. DOI: 10.53511/pharmkaz.2022.64.56.006
21. Свирский А.А., Севковский И.А., Аверин В.И., и др. Некротизирующий энтероколит у новорожденных // Российский вестник детской хирургии, анестезиологии и реаниматологии. 2016. Т. 6, № 3. С. 19–26.
22. Труба Я.П., Лазоришинец В.В., Секель Р.И., и др. Гипоплазия дуги аорты в сочетании с другими врожденными пороками сердца у младенцев: результаты одноэтапного лечения // Кардиология в Беларуси. 2021. Т. 13, № 6. С. 885–894. DOI: 10.34883/PI.2021.13.6.003
23. Трунина И.И. Гипотрофия, внутриутробные инфекции и синдромальная патология как факторы риска неонатальной кардиохирургии // Детские болезни сердца и сосудов. 2012. № 3. С. 23–30.
24. Холостова В.В., Дронов А.Ф., Смирнов А.Н., и др. Хирургическое лечение тотальной формы болезни Гишпрунга у детей // Хирургия. Журнал им. Н.И. Пирогова. 2014. № 7. С. 44–54.
25. Aggarwal A., Kumar P., Chowdhary G., et al. Evaluation of renal functions in asphyxiated newborns // J Trop Pediatr. 2005. Vol. 51, No. 5. P. 295–299. DOI: 10.1093/tropej/fmi017
26. Alten J.A., Cooper D.S., Blinder J.J., et al. Neonatal and Pediatric Heart and Renal Outcomes Network (NEPHRON) Investigators. Epidemiology of acute kidney injury after neonatal cardiac surgery: a report from the multicenter neonatal and pediatric heart and renal outcomes network // Crit Care Med. 2021. Vol. 49, No. 10. P. 941–951. DOI: 10.1097/CCM.00000000000005165
27. Bell E.F. Preventing necrotizing enterocolitis: what works and how safe? // Pediatrics. 2005. Vol. 115, No. 1. P. 173–175. DOI: 10.1542/peds.2004-2360
28. Mol B.W.J., Roberts C.T., Thangaratinam S., et al. Pre-eclampsia // Lancet. 2016. Vol. 387, No. 10022. P. 999–1011. DOI: 10.1016/S0140-6736(15)00070-7
29. Bhatia J. Strategies to prevent necrotising enterocolitis // Chin Med J. 2010. Vol. 123, No. 20. P. 2759–2765.
30. Brennan K.G., Parravicini E., Lorenz J.M., Bateman D.A. Patterns of urinary neutrophil gelatinase-associated lipocalin and acute kidney injury in neonates recei-

- ving cardiopulmonary bypass // *Children (Basel)*. 2020. Vol. 7, No. 9. ID132. DOI: 10.3390/children7090132
31. Clyman R., Wickremasinghe A., Jhaveri N., et al. Enteral feeding during indomethacin and ibuprofen treatment of a patent ductus arteriosus // *J Pediatr*. 2013. Vol. 163, No. 2. P. 406–411. DOI: 10.1016/j.jpeds.2013.01.057
 32. Gaudin A., Farnoux C., Bonnard A., et al. Necrotizing Enterocolitis (NEC) and the risk of intestinal stricture: The value of C-reactive protein // *PLoS One*. 2013. Vol. 8. ID e76858. DOI: 10.1371/journal.pone.0076858
 33. Gist K.M., Blinder J.J., Bailly D., et al. Neonatal and Paediatric Heart and Renal Outcomes Network: design of a multi-centre retrospective cohort study // *Cardiol Young*. 2019. Vol. 29, No. 4. P. 511–518. DOI: 10.1017/S1047951119000210
 34. Gordon P.V. Understanding intestinal vulnerability to perforation in the extremely low birth weight infant // *Pediatr Res*. 2009. Vol. 65. P. 138–144. DOI: 10.1203/PDR.0b013e31818c7920
 35. Greenberg J.H., Zappitelli M., Jia Y., et al. Biomarkers of AKI progression after pediatric cardiac surgery // *J Am Soc Nephrol*. 2018. Vol. 29, No. 5. P. 1549–1556. DOI: 10.1681/ASN.2017090989
 36. Kai K., Sameshima H., Ikeda T., Ikenoue T. Severe variable deceleration is associated with intestinal perforation in infants born at 22–27 weeks' gestation // *J Matern Fetal Neonatal Med*. 2009. Vol. 22, No. 3. P. 259–264. DOI: 10.1080/14767050802379049
 37. Karagianni P., Briana D.D., Mitsiakos G., et al. Early versus delayed minimal enteral feeding and risk for necrotizing enterocolitis in preterm growth-restricted infants with abnormal antenatal Doppler results // *Am J Perinatol*. 2010. Vol. 27, No. 5. P. 367–373. DOI: 10.1055/s-0029-1243310
 38. Kelleher J., Salas A.A., Bhat B., et al. Prophylactic indomethacin and intestinal perforation in extremely low birth weight infants // *Pediatrics*. 2014. Vol. 134, No. 5. P. 1369–1377. DOI: 10.1542/peds.2014-0183
 39. Leaf A., Dorling J., Kempley S., et al. Early or delayed enteral feeding for preterm growth-restricted infants: a randomized trial // *Pediatrics*. 2012. Vol. 129, No. 5. P. 1260–1268. DOI: 10.1542/peds.2011-2379
 40. Marelli A.J., Mackie A.S., Ionescu-Iltu R., et al. Congenital heart disease in the general population: changing prevalence and age distribution // *Circulation*. 2007. Vol. 115, No. 2. P. 163–172. DOI: 10.1161/CIRCULATIONAHA.106.627224
 41. Nakajima Y., Masaoka N., Yamamoto T. Obstetrical risk factors for focal intestinal perforation in very low birth weight infants // *J Perinat Med*. 2011. Vol. 39, No. 2. P. 179–184. DOI: 10.1515/jpm.2010.129
 42. Phad N., Trivedi A., Todd D., Lakkundi A. Intestinal strictures postnecrotizing enterocolitis: Clinical profile and risk factors // *J Neonatal Surg*. 2014. Vol. 3, No. 4. P. 44. DOI: 10.47338/jns.v3.134
 43. Pumberger W., Mayr M., Kohlhauser C., Weninger M. Spontaneous localized intestinal perforation in very-low-birth-weight infants: a distinct clinical entity different from necrotizing enterocolitis // *J Am Coll Surg*. 2002. Vol. 195, No. 6. P. 796–803. DOI: 10.1016/S1072-7515(02)01344-3
 44. Rao S.C., Basani L., Simmer K., et al. Peritoneal drainage versus laparotomy as initial surgical treatment for perforated necrotizing enterocolitis or spontaneous intestinal perforation in preterm low birth weight infants // *Cochrane Database Syst Rev*. 2011. No. 6. ID CD006182. DOI: 10.1002/14651858.CD006182.pub2
 45. Raval M.R., Hall N.J., Pierro A., Moss R.L. Evidence-based prevention and surgical treatment of necrotizing enterocolitis – A review of randomized controlled trials // *Semin Pediatr Surg*. 2013. Vol. 22, No. 2. P. 117–121. DOI: 10.1053/j.sempedsurg.2013.01.009
 46. Selewski D.T., Jordan B.K., Askenazi D.J., et al. Acute kidney injury in asphyxiated newborns treated with therapeutic hypothermia // *J Pediatr*. 2013. Vol. 162, No. 4. P. 725–729. DOI: 10.1016/j.jpeds.2012.10.002
 47. Wadhawan R., Oh W., Vohr B.R., et al. Spontaneous intestinal perforation in extremely low birth weight infants: association with indomethacin therapy and effects on Jones and Fisher 6 neurodevelopmental outcomes at 18–22 months corrected age // *Arch Dis Child*. 2013. Vol. 98. P. 127–132. DOI: 10.1136/archdischild-2011-300659
 48. Guner Y.S., Chokshi N., Petrosyan M., et al. Necrotizing enterocolitis – bench to bedside: novel and emerging strategies // *Semin Pediatr Surg*. 2008. Vol. 17, No. 4. P. 255–265. DOI: 10.1053/j.sempedsurg.2008.07.004
 49. Yoneyama F., Okamura T., Takigiku K., Yasukouchi S. Novel urinary biomarkers for acute kidney injury and prediction of clinical outcomes after pediatric cardiac surgery // *Pediatr Cardiol*. 2020. Vol. 41, No. 4. P. 695–702. DOI: 10.1007/s00246-019-02280-3

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