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COMPARATIVE EVALUATION OF DIFFERENT TYPES OF ANESTHESIA IN SURGICAL TREATMENT OF CHILDREN WITH CONGENITAL DEFECTS

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Absrtact. Comparative evaluation of different types of anesthesia in surgical treatment of children with congenital defects. Vlasov O.O. *In pediatric anesthesiology in surgical interventions various methods of combined anesthesia with a combination of inhalation, regional, and intravenous anesthesia are used. The provision of high-quality anesthetic support in newborns and infants during surgical treatment of congenital defects is complicated by risk factors, concomitant diseases and different pathology conditions. The study of risk factors and their influence on the functional indices of the child's vital activity in prescribing anesthesia at all stages of the surgical intervention will help prevent complications and deaths in children. Aim – to conduct a comparative assessment of various types of anesthesia for surgical correction of congenital defects in children and create a predictive model of the association of risk factors and deaths in the selected methods of anesthetic support. The retrospective study included 150 newborns and infants with congenital defects of the surgical profile depending on anesthesia (inhalation + regional anesthesia; inhalation + intravenous anesthesia and total intravenous). After identifying and evaluating prognostic variables by simple logistic regression with calculating the odds ratio, stepwise multiple logistic regression analysis was performed and a predictive model of the association of risk factors and deaths with various types of anesthetic management was created. In thoracic operations a combined anesthesia with sevoran and fentanyl was most often used – 20.4%. In abdominal operations, in total anesthetic support with sevoran and regional anesthesia was used– 69.4%, while in urological operations combined total intravenous anesthesia with 2 drugs – 18.4% ranked first. No significant differences were found between the types of anesthesia in various surgical interventions for congenital pathologies, between the types of surgery and deaths (p=0.863). To prevent fatalities in various types of surgical intervention and options for anesthetic support of newborns and infants with congenital defects, it is advisable to more closely monitor the cerebral and peripheral oximetry indicators at all stages of treatment and timely correct the impaired condition of the child.*

Реферат. Сравнительная оценка различных видов анестезии при хирургическом лечении детей с врожденными пороками. Власов А.А. *В детской анестезиологии при хирургических вмешательствах используются различные методы комбинированной анестезии с сочетанием ингаляционного, регионального, внутривенного обезболивания. Предоставление качественного анестезиологического сопровождения при хирургической коррекции врожденных пороков внутренних органов у новорожденных и младенцев осложняется факторами риска, сопутствующими заболеваниями и фоновыми состояниями. Изучение факторов риска и их влияние на функциональные показатели жизнедеятельности ребенка при назначении анестезии на всех этапах операционного вмешательства помогут предотвратить реализацию осложнений и случаев смерти детей. Цель работы – провести сравнительную оценку различных видов анестезии при хирургической коррекции врожденных пороков развития у детей и создать прогностическую модель ассоциации факторов риска и*

смертельных случаев при выбранных методах анестезиологического сопровождения. В ретроспективное исследование были включены 150 новорожденных и младенцев с врожденными пороками развития хирургического профиля в зависимости от анестезии (ингаляционное + региональное обезболивание; ингаляционное + внутривенное обезболивание и тотальное внутривенное). После идентификации и оценки прогностических переменных методом простой логистической регрессии с расчетом отношения шансов проведен пошаговый множественный логистический регрессионный анализ и создана прогностическая модель ассоциации факторов риска и смертельных случаев при различных видах анестезиологического сопровождения. При торакальных операциях чаще всего использовали комбинированную анестезию севораном и фентанилом – 20,4%. При абдоминальных операциях чаще всего применяли анестезиологическое сопровождение севораном и региональным обезболиванием – 69,4%, тогда как при урологических операциях на первом месте была комбинированная тотальная внутривенная анестезия 2 препаратами – 18,4%. Достоверных различий между видами анестезии при различных оперативных вмешательствах по поводу врожденных патологий, между видами операции и смертельными случаями не обнаружили (р=0,863). Для предотвращения смертельных случаев при различных видах оперативного вмешательства и вариантах анестезиологического сопровождения новорожденных и младенцев с врожденными пороками целесообразно более тщательно контролировать показатели церебральной, периферической оксиметрии на всех этапах лечения и своевременно корректировать нарушенное состояние ребенка.

Given the unfavorable demographic situation in Ukraine, congenital defects (CD) and hereditary diseases in newborns deserve special attention, the level of which in the country remains high with a negative trend – 23.05-25.99 3 [3, 4]. This problem is not excluded in the Dnipropetrovsk region. Thus, in 2019, 812 children with congenital anomalies (36.71) were born in the Dnipropetrovsk region, of which 11.2% were children with defects of the intestines, digestive organs, and urogenital system. Given this, neonatal surgery is considered a priority in the field of pediatric surgery [2].

No surgery is possible without modern methods of anesthesia, which are effective and safe for the patient. The main task of anesthesia is the maximum control of the body's stress response to surgical aggression to improve treatment outcomes in the future.

Providing high-quality anesthesia support for surgical correction of congenital malformations of the internal organs and the postoperative period in newborns and infants is complicated by certain risk factors (perinatal period, childbirth, early neonatal period, etc.), comorbidities and background conditions.

Among the diseases that complicate anesthesia and are characteristic of newborns with CD in the early neonatal period, signs of intrauterine infection, perinatal lesions of the central nervous system of posthypoxic origin, cardiovascular and respiratory failure are the most common [10]. All these conditions significantly affect the processes of metabolism, gas exchange, homeostasis, cerebral, peripheral hemodynamics and others in the child before, during and after surgery.

Stressful effect on the body of a child with CD in severe concomitant and background pathology, which is surgical trauma and anesthesia, causes activation of the neuroendocrine system, which seeks to match metabolism, homeostasis with altered living conditions. Hormonal and metabolic changes can cause changes in systemic hemodynamics, cerebral circulation, cerebral oxygenation, and so on. The complex neurohumoral response of the body to stress is not always absolute and optimal, so it requires direct control and timely correction at all stages of anesthesia. Therefore, the study of risk factors and their impact on the functional parameters of the body when prescribing anesthesia at all stages of surgery will help prevent complications and lethal outcomes in children.

Congenital anomalies make a significant contribution to neonatal mortality. A number of studies have been devoted to identifying risk factors for death in children with CD [5, 6]. Meanwhile, there are practically no data on risk factors for death in various types of anesthesia for surgical correction of CD in newborns and infants.

The aim is to make a comparative assessment of different types of anesthesia in the surgical correction of congenital malformations in children and to create a prognostic model of the association of risk factors for death in selected methods of anesthesia.

MATERIALS AND METHODS OF RESEARCH

The retrospective study included newborns and infants under 6 months of age with CD, who received phased surgical treatment in ME "Dnepropetrovsk Specialized Clinical Center for Mother and Child named after prof. M.F. Rudnev "DRC" during 2015-2019. Exclusion criteria: children with urgent surgical pathology (bleeding, rupture of parenchymal organs, etc.), limited duration of

preoperative preparation according to the patient's condition which did not allow to conduct the examination in full. According to the nature of CD, the study involved 150 children with the following pathology: esophageal defects – 14 (9.3%), intestinal obstruction – 36 (24%), embryonic hernia – 7 (21.3%), gastroschisis – 9 (6%), tumors of different localization – 32 (21.3%), intestinal defects – 14 (9.3%), anorectal defects – 17 (11.3%), lung defects – 21 (14%) .

The distribution of patients by groups was carried out depending on the type of combined anesthesia: Group I (50 children) – inhalation (sevoran) + regional anesthesia; Group II (50 children) – inhalation (sevoran) + intravenous anesthesia (fentanyl); Group III (50 children) – total intravenous anesthesia with 2 drugs: analgesic (fentanyl) and medical sleep on the background of intravenous injection of hypnotics (20% sodium oxybutyrate). In addition, the analysis was performed depending on the type of surgery: thoracic – 27 (18%), urological – 23 (15%), abdominal – 100 (67%).

The study consisted of five stages: Stage I – before surgery and anesthesia, Stage II – general anesthesia, Stage III – the most painful stage of surgery, Stage IV – postoperative period (within 1 hour after transporting the child in the intensive care unit), Stage V – 24 hours after surgery.

Clinical and laboratory examination, using standard clinical methods, included gestational age, physical examination, monitoring of heart rate, respiratory rate, blood pressure, hourly diuresis, clinical blood test, biochemical methods: blood glucose, blood lactate, acid-base state, blood electrolytes. Instrumental methods of examination – BIS-monitoring, echocardiography with Doppler, neurosonography with Doppler (except for the II and III stage of the examination), spectroscopy of the brain in the near infrared region – NIRS). Echocardiography with Doppler allowed to determine the indicators of central hemodynamics, neurosonography with Doppler – to assess cerebral arterial blood flow, spectroscopy in the near infrared region (NIRS) – cerebral oxygenation (rSO_2).

Normal ranges of selected indicators were taken into account in the range: NIRS – rSO_2 – for newborns and infants – from 75 to 95% [7]; for SpO_2 – 95-100%; blood pressure – for newborns: systolic – 60-96 mm Hg.; diastolic – 40-65 mm Hg.; for infants: systolic – 90-112 mm Hg.; diastolic – 50-75 mm Hg.

At the II-V stages of the survey, the state of gas transport was monitored, which included a pulse-oximetry, a study of the gas composition of venous and arterial blood using a gas analyzer Easy Blood Gas (Medica, USA) [8, 9]. The partial tension of oxygen in arterial blood (PaO_2), the partial tension of oxygen in venous blood (PvO_2), the partial tension of carbon dioxide in arterial blood ($PaCO_2$), the saturation of arterial blood (SaO_2), and the saturation of venous blood (SvO_2) were determined.

Determination of risk factors for fatalities was performed by the method of simple logistic regression with the calculation of the odds ratio (OR), 95% confidence interval (95% CI) [1]. The short-term consequence of the surgical intervention was chosen as the dependent variable: survival or death. The following variables were independent after a preventive, thorough analysis:

1. Functional indicators of vital activity of the body according to a research stage: SpO_2, rSO_2.

2. Biological: gestational age.

3. Medical: blood pressure.

Statistical processing of the results was performed using the software product STATISTICA 6.1® (StatSoft Inc., serial No. AGAR909E415822FA).

RESULTS AND DISCUSSION

The type of anesthesia depending on the nature of surgery for CD is presented in Table 1.

The results presented in Table 2 show that in thoracic surgeries, type II combined anesthesia was most often used and variant III was used the least. In abdominal surgeries, the first variant of anesthesiological support was used the most, while in urological surgeries, type III anesthesia ranked first. Probable differences between types of anesthesia in different surgical interventions for congenital pathologies were not found (p=0.863).

On determining the associations between types of surgery and fatalities, no dependencies were found. The data are presented in Table 2.

Therefore, the next area of research was to identify significant risk factors that would affect death during surgery in children with different types of combined anesthesia to create a prognostic model of the association of risk factors with death.

To identify risk factors, 41 prognostic variables were considered, which are related to the determination of risk factors for death.

In our study, among the most significant functional indicators of the body at the stages of anesthesia support in a simple logistic regression analysis, the chance of death increases with deviations from the norm (Table 3).

The nature of surgical interventions for CD in groups of examined patients, n (%)

Type of surgical interventions	Groups of subjects			χ	p
	I	II	III		
Thoracic n=27	9 (18.4)	10 (20.4)	8 (14.3)	1.290	0.863
Abdominal n=100	35 (69.4)	32 (63.3)	33 (67.3)		
Urological n=23	6 (12.2)	8 (16.3)	9 (18.4)		
Total	50 (100%)	50 (100%)	50 (100%)		

In a simple logistic regression analysis, the chance of death decreases if the indicators are reduced by 20% of the norm at the third stage of the operation – rSO_2 of the right hemisphere of the child's brain (OR 0.833 [95% CI 0.748-0.928]) $p \leq 0.001$; rSO_2 of the left hemisphere of the child's brain (OR 0.810 [95% CI 0.715-0.918]) $p \leq 0.001$.

Associations between types of surgical interventions and consequences in the examined patients, n (%) are defined

Type of surgery	Consequences		Odds ratio (CI 95%)	P
	died	survived		
Thoracic	2 (6.3)	24 (93.8)	1.037 (0.211-5.240)	0.614
Urological and abdominal	9 (8.5)	112 (91.5)		
Urological	0 (0.0)	23 (100.0)	1.097 (1.039-1.159)	0.143
Thoracic and abdominal	11 (8.9)	113 (91.1)		
Abdominal	9 (9.2)	89 (90.8)	2.376(0.493-11.450)	0.224
Urological and thoracic	2 (4.1)	47 (95.9)		

In determining the association between blood pressure and death, no dependencies were found.

Taking into account the obtained data, the ones that are significant in a simple logistic equation were

introduced into the forecasting model, namely: SpO_2 (I-IV stages); rSO_2 of the right hemisphere (stage II); rSO_2 of the left hemisphere (stage II); rSO_2 of the right hemisphere (stage IV); rSO_2 of the left hemisphere (stage IV); rSO_2 of the right hemisphere (stage III); rSO_2 of the left hemisphere (stage III). After the assessment, the most significant in this model are the predictors that increase the risk of death in children:

• SpO_2 – the chances of a lethal outcome increase by 2.7 times if the patient has a reduced level of initial SpO2 in anesthesia of types I and III) – Exp. (β)=2.704 [95% CI 1.10-8.733] p=0.02;

• SpO_2 – the chances of a lethal outcome increase by 7.2 times if the patient has a reduced level of SpO_2 at the stage of induction of anesthesia in all types of it – Exp. (β)=7.246 [95% CI 4.81-15.621] p=0.03;

• SpO_2 – the chances of a lethal outcome increase by 4.6 times at low levels of SpO_2 at the stage of maximum surgical trauma in all types of anesthesia – Exp. (β)=4.563 [95% CI 7.89-19.827] p=0.03;

• rSO_2 of the left hemisphere of the brain – the chances of a lethal outcome increase by 2.4 times with a decrease in the rate of induction of anesthesia in all types of it – Exp. (β)=2.386 [95% CI 2,896-12,021] p=0.04;

• rSO_2 of the right hemisphere of the brain – the chances of a lethal outcome increase by 1.8 times with a decrease in the rate of induction of anesthesia in all types of it – Exp. (β)=1.807 [95% CI 1.364-8.435] p=0.02;

• rSO_2 of the right hemisphere of the brain – the chances of a lethal outcome increase by 4.1 times with a significant decrease in the rate at the stage of maximum operative trauma – Exp. (β)=4.128 [95% CI 1.368-8.528] p=0.006.

Other indicators turned out to be confounding (from the Latin confundere – to mix together), i.e. they distort the influence of factors on the outcome of surgery – lethal outcome.

The results of the created prognostic model of fatal outcome are presented in Table 4. The sensitivity of the logistic regression model is 79.20%, specificity – 84.80%.

Table 3

Categorical indicators involved in modeling, depending on the presence of lethal outcome

Indicator	OR (95 % CI)	p<
SpO_2 (stage I of the survey)	15.120 (3.919-8.339)	0.001
SpO_2 (stage II of the survey)	11.759 (3.786-16.086)	0.001
SpO_2 (stage III of the survey)	8.40 (2.31-13.547)	0.002
SpO_2 (stage IV of the survey)	8.804 (1.827-12.439)	0.002
rSO_2 of the right hemisphere (stage II of the survey)	3.889 (1.096-13.793)	0.04
rSO_2 of the left hemisphere (stage II the survey)	9.470 (2.486-36.069)	0.003
rSO_2 of the right hemisphere (stage IV of the survey)	42.667 (9.454-19.251)	0.001
rSO_2 of the left hemisphere (stage IV of the survey)	37.630 (8.487-16.834)	0.001

Note. When comparing frequencies of using χ^2-test or Fisher's exact test

**Prognostic model for I, II, III groups associated with risk factors
of functional indicators of the body and lethal outcomes**

Predictors	B	Standard error	Wald	Exp (β)	95% CI for Exp. (β)		p
					lower	upper	
SpO₂ (I)	1.545	1.231	0.968	2.704	1. 10	8.733	0.02
SpO₂ (II)	1.963	1.586	1.752	7.246	4.81	15.621	0.03
SpO₂ (III)	2.79	2.31	1.962	4.563	7.89	19.827	0.03
SpO₂ (IV)	0.904	1.239	0.969	1.986	0.614	13.458	0.590
rSO₂ left. (II)	0.921	1.384	1.864	2.386	2.896	12.021	0.04
rSO₂ rights. (II)	1.936	0.968	1.421	1.807	1.364	8.435	0.02
rSO₂ rights. (III)	1.764	3.425	1.83	4.128	1.368	8.528	0.006
rSO₂ left. (III)	0.830	1.367	0.844	1.230	0.64	28.038-	0.07
rSO₂ rights. (IV)	0.430	1.269	0.365	1.383	0.95	4.203	0.201
rSO₂ left. (IV)	1.536	1.269	1.432	1.182	0.258	7.252	0.40

CONCLUSIONS

1. Probable differences between types of anesthesia in different surgical interventions for congenital pathologies were not found (p=0.863). In addition, in determining the associations between the types of surgery and lethal outcomes, dependencies were also not identified.

2. After a simple logistic regression analysis, the identified risk factors that increased and/or reduced the chance of lethal outcome were introduced into the prognostic model. Therefore, to prevent deaths in various types of surgery and options for anesthesia of newborns and infants with CD, it is advisable to more carefully monitor the indicators of cerebral, peripheral oximetry at all stages of treatment and timely correct the disturbed condition of the child.

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

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