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ABSTRACT
to the dissertation work of Suieubekov Bekzat Yerkinbekuly
on the topic:
“Intensive therapy of acute kidney injury in newborns with critical congenital heart defects after cardiac surgery”,
submitted for the degree of Doctor of Philosophy (PhD) in the specialty
8D10141 – “Medicine”

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Relevance of the study

Acute kidney injury (AKI) in newborns remains one of the most serious complications of cardiac surgery performed under cardiopulmonary bypass (CPB). According to international and national studies, the incidence of cardiac surgery–associated acute kidney injury (CSA-AKI) in neonates ranges from 20% to 60%, and in patients with obstructive aortic arch defects reaches 62–64%. In severe cases, mortality exceeds 80%.

The high prevalence of AKI in neonates is due to the combination of risk factors such as nephrogenic immaturity, low glomerular filtration rate, increased vascular permeability, and limited renal compensatory capacity. Significant contributors include prolonged CPB, aortic cross-clamping, massive transfusions, and the use of vasopressors and nephrotoxic agents.

Clinical diagnosis of AKI in neonates is challenging because of the subtle course of the disease and the low sensitivity of standard markers (serum creatinine and urine output). In premature infants, a significant rise in creatinine often appears only on days 7–10 of life, making early diagnosis impossible. Therefore, the search for new biomarkers such as NGAL, cystatin C, KIM-1, and IL-18 is of increasing importance.

According to the multicenter international AWAKEN study (over 4,000 neonates), AKI was diagnosed in 30% of infants in intensive care units. Russian and Kazakhstani data similarly indicate a high incidence - between 20% and 45% among patients with congenital heart defects. However, to date, unified protocols for the early diagnosis and management of CSA-AKI in newborns are lacking, leading to wide variability in outcomes.

Current treatment approaches include renal replacement therapy (RRT), with peritoneal dialysis (PD) being the preferred, most physiological, and accessible method in neonatal practice. Yet the issues of timely PD initiation, risk stratification, and optimization of dialysate composition remain unresolved.

With in the framework of this study, an integrated algorithm of intensive therapy for CSA-AKI in neonates was developed and tested, including:

- a risk assessment scale for timely indication of early RRT initiation;
- a modified hyperosmolar dialysis solution for accelerated correction of water–electrolyte disorders;
- and a comprehensive perioperative PD protocol.

The obtained results demonstrated that the use of the risk scale and modified dialysate significantly reduced complications, normalized biochemical indicators (creatinine, urea, electrolytes) faster, shortened the duration of mechanical

ventilation, inotropic support, and ICU stay, and decreased mortality from 16.7% to 2.8%.

Thus, the high frequency of CSA-AKI, the unfavorable prognosis in delayed diagnosis, and the insufficiently developed risk-stratification and management methods determine the need to improve intensive care approaches for neonates after cardiac surgery.

Purpose of the study - to improve the methods of intensive therapy for acute kidney injury in newborns with critical congenital heart defects after cardiac surgery.

Research objectives:

1. To characterize the risk factors and clinical-laboratory indicators of acute kidney injury in newborns with critical congenital heart defects after cardiac surgery under cardiopulmonary bypass.
2. To develop and validate a risk-assessment scale for early initiation of renal replacement therapy.
3. To identify specific morphological characteristics of the kidneys in cardiac surgery – associated acute kidney injury in newborns.
4. To conduct a comprehensive evaluation of the effectiveness of peritoneal dialysis during the perioperative period in cardiac surgery for critical congenital heart defects.
5. To develop an adapted algorithm for performing peritoneal dialysis in newborns with critical congenital heart defects after cardiac surgery.

Research methods

The study was conducted at the Perinatal and Pediatric Cardiac Surgery Center in the Department of Anesthesiology, Resuscitation, and Intensive Care for Cardiac Surgery from 2021 to 2024. Written informed consent was obtained from parents or legal representatives before enrollment. The study adhered strictly to the Helsinki Declaration (2013) and was approved by the local ethics committee of the Kazakh Medical University “School of Public Health” No. 11, dated 17.06.2025.

The research had a combined (retrospective-prospective) design and included clinical-laboratory, morphological, and functional evaluation of neonates with CS-AKI.

The study design included three stages:

1. Retrospective analysis of medical records of neonates who underwent cardiac surgery under CPB to identify incidence, risk factors, and clinical-laboratory features of AKI.
2. Prospective clinical observation to test the developed risk scale and modified PD regimens.
3. Pathomorphological examination of kidney tissue to identify structural changes characteristic of CS-AKI.

At the initial stage of the study, the risk factors for the development of cardiac surgery-associated acute kidney injury (CI-AKI) were analyzed. The analysis

included anthropometric and clinical-laboratory parameters such as neonatal age, body weight, baseline levels of urea, creatinine, and glomerular filtration rate (GFR), as well as intraoperative indicators, including cardiopulmonary bypass (CPB) duration, aortic cross-clamp time, the presence of anuria and macroscopic hematuria, the surgical risk category according to the RACHS-1 scale, and the inotropic support index. Additionally, the dynamics of biochemical markers were evaluated in comparison with uNGAL concentrations. Laboratory monitoring was conducted preoperatively and on postoperative days 1, 3, 5, and 7. Based on a comprehensive analysis of these factors, a scoring system for early initiation of peritoneal dialysis (PD) was developed to stratify risk and optimize the management of neonates following cardiac surgery. The final score of the developed scale was compared with existing AKI severity assessment tools (KDIGO, AKIN, and pRIFLE) to verify the diagnosis.

Following confirmation of the diagnostic efficacy of the developed scale, neonates included in the prospective study group (n = 72) were enrolled and divided into two subgroups:

- **Main group** - 36 neonates who received early peritoneal dialysis using a modified hyperosmolar solution (Physionil-40, 2.27%);
- **Control group** - 36 neonates receiving the standard dialysis solution.

In neonates enrolled in the prospective study, a peritoneal catheter was placed intraoperatively after completion of the primary cardiac surgical stage via an infraumbilical approach. A 32-cm Tenckhoff catheter with two cuffs, equipped with a reinforced extension tube, was used as the drainage system. Renal replacement therapy was initiated immediately after patient transfer to the intensive care unit (ICU). The starting volume of dialysis solution was 10 mL/kg body weight. Dwell time ranged from 20 to 40 minutes, and dialysis fluid was drained passively over 20 minutes. The total number of daily dialysis cycles ranged from 20 to 24.

Comprehensive monitoring of clinical, laboratory, and instrumental parameters was performed, including: urea and creatinine concentrations, GFR, serum electrolytes (potassium, chloride, sodium), and acid-base balance parameters (pCO_2, pO_2, pH, bicarbonate concentration, and lactate levels). Instrumental parameters included central venous pressure (CVP), left ventricular ejection fraction (LVEF), renal resistive index (RI), and renal arcuate artery diameter. Clinical parameters assessed included inotropic support index, rate of diuresis recovery, and duration of mechanical ventilation (MV) and ICU stay.

Histopathological examination of renal tissue was performed using a combination of staining techniques (hematoxylin-eosin, Van Gieson, PAS) and immunohistochemistry (Ki-67, CD31). The analysis allowed assessment of tubular injury, interstitial fibrosis, microcirculatory disturbances, and cellular proliferative activity. Morphological evaluation included:

- Macroscopic assessment of the kidneys (color, consistency, corticomedullary differentiation, presence of hemorrhages);
- Microscopic assessment of glomerular, tubular, and interstitial components of renal parenchyma.

For quantitative and objective evaluation of injury severity, the following indices were used:

- Tubular Injury Score (TIS);
- Interstitial Injury Score (IIS).

Statistical analysis was performed using SPSS Statistics v.26.0 (IBM, USA) and MedCalc v.20.218 (Belgium). Prior to analysis, the distribution of variables was assessed for normality using the Shapiro–Wilk test. Normally distributed data were presented as mean ± standard deviation (M ± SD); non-normally distributed data were reported as median and interquartile range (Me [Q25 – Q75]).

To evaluate the significance of differences between two independent samples:

- Student's t-test was used for parametric data;
- Mann–Whitney U test was applied for non-parametric data.

Frequency comparisons were conducted using Pearson's χ^2 test. Correlation between the total score on the developed scale and uNGAL concentration was assessed using Pearson's correlation analysis.

Receiver operating characteristic (ROC) analysis was applied to evaluate the prognostic accuracy and diagnostic significance of the developed scale, including area under the curve (AUC), sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). The optimal cut-off point was determined according to the Youden index (J). Agreement between predicted outcomes according to the scale and actual clinical outcomes was assessed using Cohen's kappa (κ), with values >0.80 considered indicative of near-perfect agreement.

In all cases, differences were considered statistically significant at $p < 0.05$. For specific calculations, 95% confidence intervals (CI) were reported.

Study object

The study population consisted of neonates with critical congenital heart defects who underwent cardiac surgery under cardiopulmonary bypass and subsequently developed acute kidney injury (AKI) of varying severity.

The investigation included both a retrospective cohort of patients (n = 112) treated in intensive care and resuscitation units, and a prospective group of neonates (n = 72) in whom risk assessment and management were conducted using the developed diagnostic and therapeutic approaches. For histopathological analysis, autopsy materials were obtained from 19 deceased neonates with cardiac surgery-associated AKI (CS-AKI) and from 10 neonates with sepsis-associated AKI, which served as a comparison group.

Subject of the study

The subject of the study included the clinical-laboratory, morphological, and pathogenetic characteristics of cardiac surgery–associated acute kidney injury (CSA-AKI) in newborns, as well as the methods for its early diagnosis, risk stratification, and optimization of renal replacement therapy using improved peritoneal dialysis regimens.

Special attention was given to the validation of the early peritoneal dialysis initiation scale, the analysis of its prognostic effectiveness, and the comparison of clinical outcomes between standard and modified approaches to dialysis therapy.

Key findings submitted for defense

1. In neonates with critical congenital heart defects, the development of cardiac surgery–associated acute kidney injury (CSA-AKI) is determined by the combined influence of multiple factors. The predominant among these are the level of surgical risk, a high inotropic support index, the presence of macrohematuria and anuria during the perioperative period, elevated concentrations of blood urea and creatinine, decreased glomerular filtration rate, as well as low gestational age and body weight at the time of surgery.
2. Cardiac surgery–associated acute kidney injury in neonates is characterized by specific morphological alterations of the renal parenchyma, manifested by ischemic and dystrophic lesions of the tubular apparatus, interstitial tissue, and vascular bed, presenting as tubular necrosis, glomerulosclerosis, and vascular collapse followed by sclerosis.
3. The developed scoring system for assessing the criteria of early initiation of peritoneal dialysis in neonates with critical congenital heart defects represents a reliable instrument for risk stratification. Its application ensures the timely initiation of renal replacement therapy and contributes to a significant improvement in clinical outcomes.
4. The early application of peritoneal dialysis using a modified hyperosmolar solution constitutes an effective postoperative management strategy in neonates, facilitating rapid normalization of biochemical parameters, optimization of metabolic processes, and a reduction in the duration of stay in the intensive care unit. Consequently, it exerts a positive influence on clinical prognosis and reduces the risk of postoperative complications.
5. The developed adapted algorithm for peritoneal dialysis in neonates with cardiac surgery–associated acute kidney injury (CSA-AKI) represents a comprehensive strategy integrating the morphofunctional characteristics of the kidneys, the degree of surgical risk, and intraoperative factors. Its implementation contributes to a reduction in mortality and postoperative complication rates, rationalization and optimization of intensive care unit resources, and overall enhancement of the efficacy and safety of postoperative management in this patient population.

Description of the main research results

The comprehensive study provided a thorough characterization of the clinical, laboratory, instrumental, and morphological features of cardiac surgery–associated acute kidney injury (CSA-AKI) in neonates who underwent cardiopulmonary bypass procedures.

Analysis of the retrospective cohort (n = 112) revealed that the leading risk factors for the development of CSA-AKI in neonates with critical congenital heart defects were:

- age less than 7 days (OR = 1.08; CI 1.01–1.16; p = 0.032);
- body weight less than 3 kg (OR = 1.10; CI 0.46–2.66; p = 0.003);
- surgical risk category according to RACHS-1 ≥ 4 (OR = 4.79; CI 0.93–274.40; p = 0.037);
- cardiopulmonary bypass duration exceeding 120 minutes (OR = 1.08; CI 1.01–1.16; p = 0.030);
- aortic cross-clamp time exceeding 40 minutes (OR = 1.09; CI 1.01–1.19; p = 0.082);
- absence of urine output for more than 12 hours preoperatively (OR = 2.48; CI 1.12–5.03; p = 0.027);
- elevation of serum urea 2.5–3 times above baseline (OR = 2.12; CI 1.17–3.42; p = 0.034);
- increase in serum creatinine more than twofold (OR = 1.87; CI 1.19–3.01; p = 0.016);
- reduction in glomerular filtration rate by more than 75% (OR = 1.59; CI 1.41–2.59; p = 0.020);
- presence of macroscopic hematuria (OR = 1.38; CI 1.11–1.85; p = 0.047);
- requirement for high-dose inotropic support VIS >10 (OR = 2.30; CI 1.03–4.89; p = 0.041).

In 67.9% of cases with fatal outcomes, these parameters served as key predictors of severe CSA-AKI, defining an unfavorable prognosis for neonates following cardiac surgery.

The prospective part of the study (n = 72) focused on the validation of a newly developed scoring system for early initiation of peritoneal dialysis (PD), as well as the evaluation of a modified dialysis protocol. Using the scoring system, patients were stratified into three risk groups: low (<12 points), medium (12–22 points), and high (>22 points). The majority of neonates (72.2%) were classified as high-risk, confirming the high prevalence of the need for early renal replacement therapy.

ROC analysis demonstrated significant diagnostic value of the developed scoring system: the area under the curve (AUC = 0.97) indicated high accuracy and reliability. The optimal cutoff, determined by the Youden index (J = 0.88), ensured maximal sensitivity (96.3%) and specificity (98.0%), with a high agreement coefficient ($\kappa = 0.92$), reflecting complete concordance between predicted scores and actual clinical necessity for renal replacement therapy. Correlation analysis revealed a strong direct association between the cumulative score and uNGAL concentration ($r = 0.87$; $p < 0.001$), indicating high concordance between clinical and biochemical markers of renal dysfunction.

Comparison of standard and modified PD regimens in the intervention group showed substantial improvements in clinical, laboratory, and functional parameters. Within 24 hours of therapy initiation, notable changes were observed:

- reduction of serum urea from 15.8 ± 1.2 to 9.3 ± 0.8 mmol/L ($p < 0.01$);

- reduction of serum creatinine from 142.6 ± 6.4 to 98.4 ± 5.1 μmol/L ($p < 0.01$);
- increase in GFR from 22.4 ± 3.1 to 38.7 ± 4.2 mL/min/1.73 m² ($p < 0.001$);
- acceleration of urine output to 2.1 ± 0.4 mL/kg/h (1.8-fold higher than in the retrospective cohort, $p < 0.001$);
- reduction in lactate levels from 5.6 ± 0.9 to 2.8 ± 0.6 mmol/L ($p < 0.01$);
- normalization of pH = 7.36 ± 0.04 (vs. 7.29 ± 0.05 in the control group; $p < 0.05$);
- increase in left ventricular ejection fraction from 52.3 ± 4.5% to 64.1 ± 3.8% ($p < 0.01$);
- decrease in pulmonary artery pressure from 48.6 ± 6.2 to 36.9 ± 4.8 mmHg ($p < 0.01$);
- reduction of renal resistive index (RI) by day 7 to 0.66 ± 0.03 (vs. 0.69 ± 0.05 in controls), indicating improved renal perfusion and vascular response under the proposed protocol.

Histopathological analysis revealed characteristic CSA-AKI changes: ischemic–degenerative injury of tubular structures, interstitial and vascular damage, including tubular necrosis (100%), glomerulosclerosis (68.4%), and vascular collapse and sclerosis (63.2%). The mean tubular injury score (TIS = 3.43 ± 0.52) significantly exceeded that observed in sepsis-associated AKI (2.60 ± 0.70; $p = 0.004$), while the interstitial injury score (IIS = 1.47 ± 0.52) was lower than in septic forms (2.10 ± 0.57; $p = 0.016$), reflecting the predominance of ischemic rather than inflammatory injury. Signs of tubulointerstitial fibrosis were present in 22.4% of patients, and nephron hypoplasia in 27.6%.

Implementation of the adapted early PD algorithm allowed integration of the scoring system into clinical decision-making and ensured timely initiation of renal replacement therapy. Its application resulted in:

- reduction of mortality to 2.8% (vs. 16.7% in the comparison group, $p = 0.047$, and 67.9% in the retrospective cohort, $p < 0.001$);
- shortening of inotropic support to 4.17 ± 0.65 days;
- reduction of mechanical ventilation duration to 6.00 ± 0.79 days;
- decrease in ICU stay to 7.03 ± 0.77 days ($p < 0.001$ for all parameters).

Thus, the study results confirmed the high clinical and prognostic value of the developed scoring system and algorithm, enabling a personalized, predictive, and pathogenetically grounded approach to the management of CSA-AKI in neonates.

Justification of scientific novelty

1. For the first time, the risk factors contributing to the development of cardiac surgery–associated acute kidney injury (CSA-AKI) in neonates have been identified and characterized as prognostically significant predictors of its onset. Based on the studied factors, a scoring scale for assessing the criteria for early initiation of renal replacement therapy has been developed and validated. This scale is adapted to the morphofunctional and clinical characteristics of the neonatal

cardiac surgery population, thereby enhancing patient management efficiency and improving clinical outcomes.

2. For the first time, a comprehensive pathomorphological examination of renal tissue was conducted in neonates with acute kidney injury that developed following cardiac surgical interventions involving cardiopulmonary bypass. Morphological features specific to cardiac surgery–associated AKI were identified, including signs of ischemic–interstitial injury and tubulointerstitial fibrosis.

3. For the first time, an improved composition of the peritoneal dialysis solution has been proposed and clinically tested, demonstrating higher efficacy and safety in neonates compared to standard protocols.

4. For the first time, an original clinical experience of effective peritoneal dialysis application in the perioperative period among neonates with critical congenital heart defects has been presented. Its effectiveness was confirmed by clinical, laboratory, and instrumental data.

5. For the first time, an adapted algorithm for performing peritoneal dialysis has been developed and implemented into clinical practice. This algorithm integrates the use of a risk assessment scale and a modified dialysis solution, ensuring the optimization of intensive care, improving survival rates, and enhancing the overall efficacy and safety of treatment in neonates with CSA-AKI.

Practical significance of the obtained results

The practical significance of the study lies in the development and implementation of an intensive care algorithm for newborns with cardiac surgery–associated acute kidney injury (CSA-AKI), based on the integration of an objective risk assessment scale and a modified dialysate composition. The application of the developed scale allows for timely identification of high-risk patients and early initiation of renal replacement therapy (RRT) before the development of pronounced azotemia and complications, thereby reducing mortality and improving clinical outcomes.

The modified dialysate composition provides accelerated correction of fluid-electrolyte and acid-base imbalances, promotes earlier recovery of diuresis and hemodynamic stabilization, thus enhancing the safety and efficacy of peritoneal dialysis in newborns.

Implementation of the adapted management algorithm for patients with CSA-AKI in clinical practice enables standardization of treatment tactics, shortening of mechanical ventilation duration, reduction of inotropic support requirements, and decrease in ICU stay length.

The study results have practical value for neonatology, pediatric cardiac surgery, and anesthesiology – critical care, as they establish a foundation for a personalized approach to the treatment of newborns with critical congenital heart defects. The developed algorithm can be recommended for broad implementation in tertiary-level healthcare facilities providing high-technology neonatal cardiac surgical care.

Personal contribution of the doctoral candidate

The personal contribution of the doctoral candidate lies in the comprehensive and independent execution of all stages of the research. The candidate developed and scientifically substantiated the theoretical and methodological framework of the study, including the definition of its aim, objectives, hypotheses, structure, and directions of analysis. The candidate conducted a thorough search, analysis, and systematization of contemporary scientific literature concerning the pathogenetic mechanisms, risk factors, and diagnostic criteria of cardiac surgery–associated acute kidney injury (CSA-AKI) in neonates.

Under the candidate's guidance, the clinical component of the study was organized and coordinated, including patient selection, collection of primary clinical and biological data, verification of protocol adherence, and compliance with ethical standards. The candidate was responsible for the creation and structuring of the research database, as well as the processing of clinical and laboratory parameters using modern biostatistical methods.

The candidate independently performed the interpretation and critical evaluation of the results, comparing them with domestic and international studies, which allowed identification of novel patterns and the establishment of the diagnostic significance of the developed methodological approaches.

All sections of the dissertation were prepared by the candidate, including the introduction, literature review, materials and methods, results, and discussion. The candidate formulated the principal scientific contributions for defense, as well as conclusions and practical recommendations, highlighting both the theoretical and applied significance of the conducted research.

Conclusions

1. The identified risk factors in neonates with critical congenital heart defects (CHD) - including body weight less than 3 kg (OR = 1.10; CI 0.46–2.66; p = 0.003), a RACHS-1 surgical risk category ≥ 4 (OR = 4.79; CI 0.93–274.40; p = 0.037), cardiopulmonary bypass duration exceeding 120 minutes (OR = 1.08; CI 1.01–1.16; p = 0.030), and aortic cross-clamping time exceeding 40 minutes (OR = 1.09; CI 1.01–1.19; p = 0.082)—serve as significant predictors of the development of cardiac surgery–associated acute kidney injury (CSA-AKI). In 67.9% of fatal cases, the combination of these parameters formed a key determinant complex contributing to the progression of severe forms of CSA-AKI and defining an unfavorable clinical outcome.

2. The developed scoring system for evaluating the criteria of early initiation of peritoneal dialysis can be regarded as a reliable prognostic tool, demonstrating high diagnostic sensitivity (96.3%), specificity (98%), and overall accuracy (95.5%) in predicting the risk of CSA-AKI in neonates with critical CHD. The application of this scale enables timely and evidence-based initiation of renal replacement therapy.

3. The detected morphological alterations - tubular necrosis (100%), glomerulosclerosis (68.4%), and vascular collapse with sclerosis (63.2%) - represent

specific histopathological hallmarks of CSA-AKI, distinguishing it from sepsis-associated AKI, and confirm the ischemic genesis of renal tissue injury.

4. Early implementation of peritoneal dialysis using a modified hyperosmolar solution in neonates with CSA-AKI is an effective renal replacement therapy approach that significantly improves clinical, biochemical, and functional parameters. Within less than three days from the initiation of therapy, urea levels decreased from 15.8 ± 1.2 to 9.3 ± 0.8 mmol/L ($p < 0.01$), creatinine levels declined from 142.6 ± 6.4 to 98.4 ± 5.1 μmol/L ($p < 0.01$), and urine output increased to 2.1 ± 0.4 mL/kg/h, 1.8 times higher than in the retrospective group ($p < 0.001$). By day 7, the renal arterial resistive index (RI) was 0.66 ± 0.03 in the main group versus 0.69 ± 0.05 in the control group ($p < 0.01$).

5. The results of clinical implementation of the adapted peritoneal dialysis algorithm in neonates convincingly confirm its high prognostic significance, clinical efficacy, and potential for standardized application in neonatal intensive care practice. This approach has been shown to reduce mortality rates by more than threefold.

Approbation of the dissertation results

The main results of the dissertation were presented and discussed at the following scientific forums and conferences:

1. Scientific and Practical Conference with International Participation “New Technologies in Pediatric Anesthesiology, Resuscitation, and Intensive Care”, presentation: “Features of Renal Replacement Therapy for Acute Kidney Injury in Newborns after Cardiac Surgery” (Tashkent, June 10, 2022);
2. Scientific and Practical Conference with International Participation “Modern Technologies in Anesthesiology, Resuscitation, and Intensive Therapy”, presentation: “Modern Approach to Intensive Care of the Cardiac Surgery – Associated Acute Kidney Injury in Newborns” (Kyiv, December 21, 2022);
3. Regional Scientific and Educational Forum “Ana men bala”, presentation: “Modern Approach to Intensive Therapy of Cardiac Surgery–Associated Acute Kidney Injury in Newborns” (Shymkent, November 4, 2022);
4. International Scientific and Practical Conference “Салауатты ұрпақ - Қазақстанның болашағы” (Healthy Generation - the Future of Kazakhstan), presentation: “Application of Peritoneal Dialysis in Cardiac Surgery–Associated Acute Kidney Injury” (Kazakhstan, June 14, 2024);
5. III Conference of the Kazakhstan Society of Pediatric Cardiac Specialists theme: “Conquering the Summits of Pediatric Cardiac Surgery and Cardiology – A Challenging Path in Medicine” presentation title: “Scoring Scale for Evaluating Criteria of Early Initiation of Peritoneal Dialysis in Neonates After Cardiac Surgery” (Kazakhstan, October 23–24, 2025).

Publications

A total of 8 scientific works have been published on the topic of the dissertation, including:

2 articles in journals recommended by the Committee for Quality Assurance in the Sphere of Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan;

2 articles in journals indexed in the Scopus database, including:

1 article in a journal with Scopus CiteScore 3.1, 63rd percentile - Electronic Journal of General Medicine (2023);

1 article in a journal with Scopus CiteScore 0.8, 48th percentile - Salud, Ciencia y Tecnología (2024);

2 conference abstracts published in the proceedings of international scientific conferences;

2 patents for inventions:

Patent No. 27507 (June 27, 2022) - “Scoring Scale for Early Peritoneal Dialysis Criteria”;

Patent No. 29562 (October 19, 2022) - “Early Application of Peritoneal Dialysis in Newborns with Cardiac Surgery – Associated Acute Kidney Injury”.

Volume and structure of the dissertation

The dissertation is prepared in accordance with established academic requirements and consists of an introduction, a literature review, materials and methods, a chapter presenting the results of the author’s own research, a conclusion, and a list of references comprising 150 sources.

The dissertation is presented on 140 pages of computer-typed text formatted according to the required standards and includes 50 tables and 17 figures.