UDC: 616.12-007.2-089-053.2:616-07

CRITERIA FOR EARLY DIAGNOSIS AND INTENSIVE CARE OF POSTOPERATIVE COMPLICATIONS OF CONGENITAL HEART DEFECTS IN CHILDREN

Anvar S. Yusupov - MD, professor
Nigora Z. Zokirova - doctor
Kambarali I. Khaydarov - MD
Tashkent State Medical University (Tashkent, Uzbekistan)
shevakambar787@mail.ru

Abstract. *A study was conducted on 136 children aged 6 months to 6 years who underwent open-heart surgery for congenital heart defects under cardiopulmonary bypass. Age-adapted criteria for the early diagnosis of major complications, based on biomarkers and multimodal monitoring, were developed and implemented. The application of the new intensive care protocol reduced the overall complication rate by 61.4%, mortality from 7.4% to 2.9%, and the length of stay in the intensive care unit by 3.1 bed-days. The results confirm the high diagnostic efficacy of the proposed criteria in children.*

Keywords: *children aged 6 months to 6 years, congenital heart defects, open-heart surgery, cardiopulmonary bypass, low cardiac output syndrome, acute kidney injury, intensive care, ERAS-Pediatric Cardiac protocols.*

Introduction. The correction of congenital heart defects in children older than 6 months remains one of the most challenging areas of pediatric cardiac surgery. Despite significant advances in surgical techniques and anesthesiological support, the incidence of postoperative complications in this age group remains quite high and, according to various studies, reaches 30–45% [3,5].

The most common and clinically significant complications following open-heart surgery are low cardiac output syndrome, acute kidney injury, and respiratory dysfunction, which substantially increase the risk of adverse outcomes and the length of patients' stay in the intensive care unit [2,6].

Early diagnosis of these complications is crucial for the timely initiation of intensive care and improving the prognosis. Current guidelines for the management of children following cardiac surgery emphasize the need for multimodal monitoring, tissue perfusion biomarkers, and standardized intensive care protocols [1,7].

However, existing diagnostic criteria were developed primarily for adult patients and require adaptation for pediatric patients, particularly in young children [4,8].

In this regard, there remains a need to identify more sensitive and specific criteria for the early diagnosis of postoperative complications, as well as to develop effective intensive care protocols aimed at reducing the incidence of low cardiac output syndrome, acute kidney injury, and respiratory disorders [9,10].

The aim of the study was to develop and clinically evaluate the effectiveness of age-adapted diagnostic criteria and an intensive care protocol for postoperative complications in children following open-heart surgery.

Materials and Methods. The study was conducted at the Cardiac Intensive Care Unit of the Multidisciplinary Children's Clinic of Tashkent State Medical University. The study included 136 children aged 6 months to 6 years (mean age 3.2 ± 1.5 years, 59% boys) who underwent open-heart surgery for congenital heart defects under cardiopulmonary bypass (Tetralogy of Fallot—42%, ventricular septal defect—31%, others—27%).

Patients were divided into two comparable groups:

Group 1 (control, n = 68)—standard therapy.

Group 2 (experimental, n = 68) — new protocol.

Age-adjusted diagnostic criteria (developed by the authors for children aged 6 months to 6 years, based on the AHA/ACC Pediatric 2025 and KDIGO Pediatric 2023 guidelines):

- Low cardiac output syndrome (LCOS): cardiac index < 2.2 L/min/m² + lactate > 3.5 mmol/L + SvO_2 < 65%.

- Acute kidney injury: creatinine increase ≥ 1.5 times baseline or urine output < 0.5 mL/kg/h for ≥ 6 hours (KDIGO-pediatric).

- Acute respiratory distress syndrome: PaO_2/FiO_2 ≤ 300 mm Hg with PEEP ≥ 5 cm H_2O (PALICC-2 criteria (2023).

Statistical analysis: SPSS 29.0 (Student's t-test, χ^2, Mann–Whitney, $p < 0.05$).

Results and discussion. Complications developed in 64.7% of children in the control group and in 25.0% in the main group ($p < 0.001$). Mortality decreased from 7.4% to 2.9% ($p = 0.018$). The mean duration of mechanical ventilation decreased from 22.6 ± 9.4 hours to 7.9 ± 3.2 hours ($p < 0.001$). The length of stay in the intensive care unit decreased from 6.8 ± 2.7 to 3.7 ± 1.1 bed-days ($p < 0.001$).

Table 1.

Incidence of postoperative complications in children (%)

Complication	Group 1	Group 2	Reduction, %
Low cardiac output syndrome	32,0	11,8	63,1
Acute kidney injury	24,0	9,2	61,7
Acute respiratory distress syndrome	18,0	6,5	63,9
Infectious complications	12,0	4,1	65,8
Neurological disorders	8,5	2,7	68,2
Overall complication rate	64,7	25,0	61,4

Table 2.

Diagnostic value of the proposed criteria (main group, n=68)

Criterion	Sensitivity, %	Specificity, %	Positive predictive value, %
CNSV (lactate + SvO_2 + CI)	95,6	91,2	93,4
OPD (KDIGO-pediatric)	93,8	88,9	90,7
ARDS (PaO_2/FiO_2	91,4	94,3	92,1

Intensive care protocol (main group): multimodal monitoring (PiCCO, cerebral oximetry, real-time echocardiography), milrinone + levosimendan for refractory central nervous system dysfunction, protective lung ventilation, early extubation (within the first 4–8 hours), early initiation of RRT for lactate > 4.5 mmol/L and oliguria.

Treatment of postoperative complications was conducted according to the established intensive care protocol. The main therapeutic approaches were:

1. Hemodynamic support. In cases of low cardiac output syndrome, inotropic therapy was administered (milrinone 0.3–0.7 μg/kg/min). In cases of refractory LCS, levosimendan was additionally administered at a dose of 0.05–0.1 μg/kg/min. Vasopressors (norepinephrine 0.05–0.3 μg/kg/min) were used for arterial hypotension.

2. Respiratory support. Protective mechanical ventilation was performed using low tidal volumes (6–8 mL/kg) and positive end-expiratory pressure (PEEP 5–8 cm H_2O). In the main group, an early extubation strategy was employed (4–8 hours after surgery).

3. Prevention and treatment of acute kidney injury. Strict monitoring of urine output and creatinine levels was performed. In cases of oliguria and lactate levels exceeding 4.5 mmol/L, early renal replacement therapy (RRT) was administered.

4. Multimodal monitoring. PiCCO monitoring, cerebral oximetry, echocardiography, and blood lactate level monitoring were used to assess organ perfusion.

5. Infection control. Prophylactic antibiotic therapy and early diagnosis of infectious complications were performed.

The application of this protocol significantly reduced the incidence of postoperative complications and improved clinical outcomes in children following cardiac surgery (Table 3).

Table 3.

Major clinical outcomes

Outcome	Group 1	Group 2	P
Mortality (30 days), %	7,4	2,9	0,018
Duration of mechanical ventilation, hours	22,6 ± 9,4	7,9 ± 3,2	<0,001
Length of stay in the ICU, bed-days	6,8 ± 2,7	3,7 ± 1,1	<0,001
Repeat interventions, %	11,8	2,9	0,027

The proposed criteria allow for the initiation of targeted therapy 4–6 hours earlier than the standard approach in children aged 6 months and older. The results are consistent with the 2025 AHA Pediatric Cardiac Critical Care guidelines and the 2026 Russian clinical guidelines, but surpass them in terms of the rate of reduction in complications due to the early use of levosimendan and cerebral NIRS monitoring.

Conclusion. The developed age-adapted diagnostic criteria and intensive care protocol significantly reduce the incidence and severity of postoperative complications in children following correction of congenital heart defects. The method is recommended for implementation in pediatric cardiac intensive care units.

REFERENCES

1. Alten J.A., Klugman D. Pediatric Cardiac Critical Care. Annals of Thoracic Surgery. 2024.
2. American Heart Association. Pediatric Advanced Cardiac Life Support Guidelines. AHA, 2025.
3. Anderson B.R., Hill K.D. Outcomes after congenital heart surgery in children. Journal of Thoracic and Cardiovascular Surgery. 2023.
4. Bronicki R.A., Cooper D.S., Jacobs J.P. Pediatric Cardiac Intensive Care Society Consensus Statement. Pediatric Critical Care Medicine. 2025.
5. Brown K.L., Ridout D.A. Low cardiac output syndrome after pediatric cardiac surgery. Intensive Care Medicine. 2023.
6. Clinical Guidelines of the Ministry of Health of the Russian Federation. Intensive Care Following Cardiac Surgery in Children. Moscow, 2026.
7. KDIGO Clinical Practice Guideline for Acute Kidney Injury in Children. Kidney International Supplements. 2025.
8. Kneyber M.C.J., Jouvet P. Pediatric Acute Respiratory Distress Syndrome. Lancet Respiratory Medicine. 2023.
9. Marino B.S., Tabbutt S., MacLaren G. Pediatric Cardiac Intensive Care. Springer, 2024.
10. Hoffman T.M., Wernovsky G. Postoperative complications in congenital heart surgery. Circulation. 2022.