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CLINICAL EFFICACY OF BIS MONITORING IN THE PERIOPERATIVE PERIOD OF CONGENITAL HEART DEFECT CORRECTION IN CHILDREN

https://doi.org/10.5281/zenodo.18407600

Choriyev X.T
Khamraeva G.Sh
Shakhizirova I.D
Saidazizov X.B

Abstract: *Background: Bispectral index (BIS) monitoring represents a promising approach for optimizing anesthetic depth in pediatric cardiac surgery. This study evaluated the clinical efficacy of BIS monitoring during perioperative management of children undergoing congenital heart defect (CHD) correction.*

Methods*: A prospective comparative study was conducted at Ixlos Private Clinic, Tashkent, from 2024 to 2025, involving 86 pediatric patients aged 1-15 years. Patients were divided into two groups: Group 1 (main group, n=56) received BIS-guided anesthesia, while Group 2 (comparison group, n=30) received standard monitoring based on clinical signs and hemodynamic parameters.*

Reisults*: BIS monitoring demonstrated significant advantages in anesthetic management, including reduced anesthetic consumption ($p<0.05$), faster extubation times ($p<0.01$), shorter ICU stays ($p<0.05$), and improved hemodynamic stability. No cases of intraoperative awareness were recorded in either group.*

Conclusion*: BIS monitoring provides superior perioperative outcomes in pediatric cardiac surgery, enabling precise anesthetic titration and enhanced patient safety.*

Keywords*: BIS monitoring, congenital heart defects, pediatric cardiac surgery, anesthesia depth, perioperative management, bispectral index*

INTRODUCTION

Congenital heart defects remain one of the most prevalent birth anomalies worldwide, affecting approximately 8-9 per 1,000 live births globally. According to the World Health Organization, CHDs account for nearly 30% of all congenital anomalies and represent a leading cause of infant mortality, with an estimated 260,000 deaths annually. In developed countries, advances in surgical techniques and perioperative care have improved survival rates to over 90%, yet anesthetic management continues to pose significant challenges, particularly in maintaining optimal depth of anesthesia while preserving hemodynamic stability.

The perioperative period in pediatric cardiac surgery demands meticulous attention to anesthetic depth, as both inadequate and excessive anesthesia can lead to adverse outcomes. Traditional

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monitoring methods rely primarily on clinical signs and hemodynamic parameters, which may not accurately reflect the actual depth of anesthesia, especially in children with complex cardiac pathophysiology. Studies have shown that approximately 0.1-0.2% of pediatric patients experience intraoperative awareness, with potentially severe psychological consequences.

Bispectral Index (BIS) monitoring has emerged as an objective neurophysiological tool for assessing anesthetic depth through processed electroencephalographic analysis. The BIS value ranges from 0 (complete cortical suppression) to 100 (fully awake), with target values of 40-60 recommended for general anesthesia. Recent evidence suggests that BIS-guided anesthesia may reduce anesthetic consumption by 20-30%, decrease recovery time, and minimize postoperative complications in adult populations. However, data regarding its efficacy in pediatric cardiac surgery remains limited, with only 15-20% of pediatric cardiac centers worldwide routinely implementing BIS monitoring.

The unique physiological characteristics of children with CHDs, including altered cerebral perfusion, hypothermia during cardiopulmonary bypass, and developmental variations in brain electrical activity, necessitate specific investigation of BIS monitoring in this vulnerable population. Furthermore, the economic burden of prolonged ICU stays and complications associated with suboptimal anesthetic management underscores the need for evidence-based approaches to improve perioperative care.

Aim of the Study. The aim of this study was to evaluate the clinical efficacy of BIS monitoring compared to standard monitoring techniques in the perioperative management of children undergoing surgical correction of congenital heart defects, with particular focus on anesthetic consumption, hemodynamic stability, recovery parameters, and postoperative outcomes.

Materials and Methods. This prospective comparative study was conducted at the Ixlos Private Clinic in Tashkent, Uzbekistan, between January 2024 and December 2025. The study protocol was approved by the institutional ethics committee, and informed consent was obtained from parents or legal guardians of all participants.

A total of 86 pediatric patients aged 1 to 15 years scheduled for elective surgical correction of congenital heart defects were enrolled in the study. Patients were allocated into two groups: the main group (Group 1) consisted of 56 patients who received BIS-guided anesthetic management, while the comparison group (Group 2) included 30 patients managed with standard monitoring based on clinical assessment and conventional hemodynamic parameters. Exclusion criteria included emergency procedures, neurological disorders, documented developmental

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delays, and contraindications to BIS monitoring.

All patients underwent comprehensive preoperative evaluation including echocardiography, electrocardiography, chest radiography, and laboratory investigations. Anesthetic induction was performed using sevoflurane or propofol with fentanyl, followed by muscle relaxation with rocuronium or atracurium. Maintenance of anesthesia utilized sevoflurane in oxygen-air mixture or total intravenous anesthesia with propofol and fentanyl infusions.

In Group 1, BIS sensors were applied to the forehead following manufacturer guidelines, and anesthetic depth was maintained at BIS values between 40 and 60 throughout the procedure. Anesthetic agents were titrated based on BIS readings in conjunction with hemodynamic parameters. In Group 2, anesthetic depth was assessed using traditional clinical signs including heart rate, blood pressure, pupillary response, lacrimation, and movement, with anesthetic adjustments made accordingly.

Intraoperative monitoring in both groups included continuous electrocardiography, pulse oximetry, capnography, invasive arterial blood pressure, central venous pressure, temperature monitoring, and urine output measurement. For patients requiring cardiopulmonary bypass, additional monitoring included activated clotting time and blood gas analysis.

The following parameters were systematically recorded and compared between groups: total consumption of anesthetic agents (sevoflurane in MAC-hours and propofol in mg/kg), intraoperative hemodynamic stability assessed by episodes of hypotension or hypertension requiring intervention, time to extubation following surgery, duration of intensive care unit stay, postoperative pain scores using age-appropriate scales, incidence of postoperative delirium, and any adverse events or complications. Statistical analysis was performed using appropriate parametric and non-parametric tests, with p-values less than 0.05 considered statistically significant.

Results. The demographic and clinical characteristics of both groups were comparable, with no statistically significant differences in age distribution, gender ratio, body weight, types of congenital heart defects, or surgical complexity scores. The mean age in Group 1 was 6.8±3.2 years compared to 7.1±3.4 years in Group 2 ($p=0.67$). The most common cardiac defects in both groups included ventricular septal defects, atrial septal defects, tetralogy of Fallot, and atrioventricular septal defects.

Analysis of anesthetic consumption revealed significant differences between the two groups. Patients in the BIS-monitored group demonstrated substantially reduced requirements for anesthetic agents compared to the standard monitoring group, reflecting

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more precise titration of anesthesia depth (Table 1).

Table 1.

Anesthetic Consumption in Study Groups

Parameter	Group 1 (BIS, n=56)	Group 2 (Standard, n=30)	p-value
Sevoflurane (MAC-hours)	2.8±0.6	3.9±0.8	<0.001
Propofol (mg/kg/h)	8.2±1.4	11.6±2.1	<0.001
Fentanyl (μg/kg)	12.4±2.8	15.9±3.6	<0.01
Total anesthetic cost (USD)	284±52	398±67	<0.001

The reduction in anesthetic consumption in the BIS group was approximately 28% for sevoflurane, 29% for propofol, and 22% for fentanyl, translating to significant cost savings and potentially reduced drug-related adverse effects.

Hemodynamic stability throughout the perioperative period showed marked improvement in the BIS-monitored group. The incidence of hemodynamic interventions and deviations from target parameters was significantly lower in Group 1 (Table 2).

Table 2.

Hemodynamic Stability and Interventions

Parameter	Group 1 (BIS, n=56)	Group 2 (Standard, n=30)	p-value
Episodes of hypotension (n)	18 (32.1%)	17 (56.7%)	<0.05
Episodes of hypertension (n)	12 (21.4%)	14 (46.7%)	<0.05
Vasopressor use (n)	15 (26.8%)	16 (53.3%)	<0.05
Mean intraop HR variability (%)	12.4±4.2	18.7±5.8	<0.01
Mean intraop MAP variability (%)	14.6±3.9	22.3±6.1	<0.001

The BIS-monitored group demonstrated superior hemodynamic stability with fewer episodes requiring intervention, suggesting that precise control of anesthetic depth contributes to cardiovascular stability in this vulnerable population.

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Recovery parameters and postoperative outcomes revealed significant advantages for BIS-guided anesthesia. Patients in Group 1 experienced faster emergence from anesthesia, earlier extubation, and reduced intensive care unit length of stay (Table 3).

Table 3.

Recovery Parameters and Postoperative Outcomes

Parameter	Group 1 (BIS, n=56)	Group 2 (Standard, n=30)	p-value
Time to extubation (hours)	4.2±1.8	6.8±2.4	<0.01
ICU length of stay (hours)	28.6±8.4	42.3±12.6	<0.05
Time to first oral intake (hours)	8.4±2.6	11.7±3.8	<0.05
Postoperative delirium (n)	4 (7.1%)	8 (26.7%)	<0.05
Hospital length of stay (days)	6.8±1.9	8.4±2.6	<0.05

The accelerated recovery profile in the BIS group resulted in reduced ICU and hospital stays, with potential implications for healthcare resource utilization and patient comfort.

Postoperative complications and adverse events were systematically monitored in both groups. The overall complication rate was lower in the BIS-monitored group, though some differences did not reach statistical significance due to the relatively small sample size (Table 4).

Table 4.

Postoperative Complications and Adverse Events

Complication	Group 1 (BIS, n=56)	Group 2 (Standard, n=30)	p-value
Respiratory complications (n)	3 (5.4%)	5 (16.7%)	<0.05
Neurological complications (n)	2 (3.6%)	4 (13.3%)	0.08
Postoperative nausea/vomiting (n)	8 (14.3%)	11 (36.7%)	<0.05
Intraoperative awareness (n)	0 (0%)	0 (0%)	-
Reoperation requirement (n)	1 (1.8%)	2 (6.7%)	0.24

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Notably, no cases of intraoperative awareness were documented in either group, suggesting adequate anesthetic depth was maintained regardless of monitoring technique. However, the BIS group showed reduced incidence of respiratory complications and postoperative nausea and vomiting, likely related to reduced anesthetic exposure.

Conclusion. This prospective comparative study demonstrates that BIS monitoring provides significant clinical advantages in the perioperative management of children undergoing congenital heart defect correction. The implementation of BIS-guided anesthesia resulted in approximately 25-30% reduction in anesthetic agent consumption, enhanced hemodynamic stability with fewer interventions required, accelerated recovery with earlier extubation times, shortened intensive care unit and hospital stays, and reduced incidence of postoperative complications including delirium and respiratory events.

The findings suggest that BIS monitoring enables more precise titration of anesthetic depth, avoiding both inadequate anesthesia and excessive drug administration. This is particularly relevant in pediatric cardiac surgery, where patients present unique physiological challenges and heightened vulnerability to anesthetic-related complications. The improved hemodynamic stability observed in the BIS group likely reflects the avoidance of anesthetic overdosing, which can depress cardiovascular function in children with already compromised cardiac reserve.

The economic implications of BIS monitoring are noteworthy, with reduced anesthetic consumption translating to direct cost savings, while shorter ICU and hospital stays contribute to decreased overall healthcare expenditure. Furthermore, the improved recovery profile and reduced complication rates enhance patient safety and family satisfaction.

Based on these results, we conclude that BIS monitoring should be considered a valuable adjunct in the anesthetic management of pediatric patients undergoing cardiac surgery for congenital heart defects. The technology provides objective, real-time assessment of anesthetic depth that complements traditional monitoring methods and enables individualized anesthetic management. Future research should explore long-term neurodevelopmental outcomes and cost-effectiveness analysis in larger multicenter populations.

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