

EFFECTIVENESS OF INSPIRATORY MUSCLE TRAINING IN REDUCING DYSPNEA IN CARDIAC SURGERY PATIENTS

Original Research

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Acknowledgement: The authors thank all participants and staff involved in this study.

Conflict of Interest: None

Grant Support & Financial Support: None

ABSTRACT

Background: Postoperative dyspnea is a common complication following cardiac surgery, often attributed to respiratory muscle weakness and impaired pulmonary function. Inspiratory muscle training (IMT) has emerged as a non-invasive rehabilitation strategy to counteract these limitations, yet its efficacy in the immediate postoperative setting remains underexplored.

Objective: To determine whether postoperative inspiratory muscle training reduces dyspnea and improves respiratory function in patients undergoing cardiac surgery.

Methods: A randomized controlled trial was conducted at two tertiary cardiac centers in Pakistan over 12 months. A total of 148 patients undergoing elective coronary artery bypass grafting or valve replacement were randomized into an intervention group receiving structured IMT from postoperative day three, and a control group receiving standard care. Dyspnea was assessed using the Modified Borg Dyspnea Scale. Pulmonary function was evaluated via forced vital capacity (FVC), forced expiratory volume in one second (FEV₁), and maximal inspiratory pressure (MIP). Assessments were performed at baseline, post-intervention (day 14), and 1-month follow-up. Statistical analysis was conducted using independent and paired t-tests for normally distributed data.

Results: Patients in the intervention group showed significantly greater reductions in dyspnea scores at day 14 (2.9 ± 1.0) and at 1 month (1.8 ± 0.9) compared to controls (4.6 ± 1.1 and 3.9 ± 1.0 , respectively; $p < 0.001$). Significant improvements were also observed in FVC, FEV₁, and MIP among the IMT group ($p < 0.001$). Adverse events were minimal and self-limiting.

Conclusion: Postoperative inspiratory muscle training is an effective and safe intervention for reducing dyspnea and enhancing respiratory function in cardiac surgery patients, supporting its routine inclusion in early postoperative rehabilitation.

Keywords: Cardiac Surgical Procedures, Dyspnea, Inspiratory Muscle Training, Pakistan, Postoperative Care, Pulmonary Function Tests, Randomized Controlled Trial.

INTRODUCTION

Breathing difficulties are a common and distressing consequence for patients recovering from cardiac surgery. Dyspnea, or shortness of breath, not only impairs physical recovery but also significantly diminishes patients' quality of life in the early postoperative period. While advances in surgical and anesthetic techniques have enhanced overall survival rates, the issue of postoperative pulmonary complications—particularly dyspnea—remains a persistent clinical challenge (1). This breathing discomfort is often exacerbated by factors such as general anesthesia, use of cardiopulmonary bypass, postoperative pain, restricted chest wall mobility, and prolonged bed rest. These factors collectively weaken respiratory muscles, especially the inspiratory muscles, leading to reduced pulmonary function and prolonged hospital stays (2,3). Thus, finding effective, non-invasive interventions to mitigate dyspnea after cardiac surgery is of critical importance. Inspiratory muscle training (IMT), a form of targeted respiratory therapy aimed at strengthening the muscles involved in inhalation, has emerged as a promising adjunct in postoperative care (4). By applying graded resistance during inspiration, IMT seeks to enhance the endurance and strength of the diaphragm and intercostal muscles, thereby improving overall ventilatory capacity. The technique has gained attention particularly in the rehabilitation of patients with chronic obstructive pulmonary disease (COPD) and heart failure, where it has shown favorable outcomes in reducing dyspnea and increasing exercise tolerance (5,6). The rationale behind its application in cardiac surgery patients lies in its potential to reverse the deleterious effects of mechanical ventilation and immobility on respiratory musculature.

Several studies have pointed to the benefits of IMT in various clinical contexts. Research conducted on patients with heart failure has demonstrated significant improvements in dyspnea scores, inspiratory muscle strength, and exercise capacity following structured IMT protocols. Additionally, IMT has been associated with a reduction in postoperative pulmonary complications when implemented preoperatively in patients undergoing major surgery, suggesting a prophylactic benefit (7,8). However, despite its growing use, the evidence base for IMT's role specifically in the context of cardiac surgery remains limited and somewhat inconsistent. While some randomized controlled trials (RCTs) suggest meaningful improvements in postoperative respiratory outcomes, others report negligible effects, pointing to the need for more focused and methodologically sound investigations. Part of the ambiguity surrounding IMT's effectiveness in this population stems from variations in study design, sample size, timing of intervention (preoperative vs. postoperative), and the intensity and duration of training protocols (9,10). Moreover, the subjective nature of dyspnea assessment introduces an additional layer of complexity. Given that dyspnea is influenced by physiological, psychological, and environmental factors, a multidimensional approach is essential to accurately evaluate therapeutic interventions (11). Importantly, most existing research has emphasized either preoperative training or its use in chronic respiratory conditions, leaving a significant gap regarding the potential benefits of structured postoperative IMT in cardiac surgery patients—a group particularly vulnerable to inspiratory muscle weakness.

In light of these gaps, there is a compelling rationale to investigate the specific impact of postoperative IMT on dyspnea and respiratory function in cardiac surgery patients. Randomized controlled trials offer the highest level of evidence for clinical interventions, allowing for robust evaluation of both efficacy and safety. By focusing exclusively on the postoperative period—a time when patients are most debilitated—this study aims to isolate the direct effects of IMT on recovery trajectories. Furthermore, standardizing training protocols and employing validated dyspnea measurement tools may help provide more definitive insights into IMT's clinical value. This study, therefore, seeks to determine whether a structured inspiratory muscle training regimen can effectively reduce postoperative dyspnea and enhance respiratory function in patients recovering from cardiac surgery. By conducting a randomized controlled trial, the objective is to provide high-quality evidence that either supports or refutes the integration of IMT into routine postoperative care for this population.

METHODS

This randomized controlled trial was conducted over a period of 12 months at two tertiary care cardiac centers in Pakistan: the Cardiac Surgery Department of the National Institute of Cardiovascular Diseases (NICVD) Karachi and the Punjab Institute of Cardiology (PIC) Lahore. The objective was to determine whether inspiratory muscle training (IMT) effectively reduces postoperative dyspnea and improves respiratory function in patients undergoing elective cardiac surgery. The study was approved by the Institutional Review Board

(IRB) of both participating institutions. All participants provided written informed consent prior to enrollment, ensuring voluntary participation in accordance with the Declaration of Helsinki. Participants included adult patients aged 40–75 years scheduled for elective cardiac surgery, specifically coronary artery bypass grafting (CABG) or valve replacement procedures, via median sternotomy under general anesthesia. Inclusion criteria required patients to be hemodynamically stable, extubated within 24 hours postoperatively, and capable of participating in the IMT protocol. Exclusion criteria were pre-existing chronic respiratory diseases such as COPD or asthma, neuromuscular disorders, significant cognitive impairment, reoperation, intraoperative complications requiring prolonged ventilation, and refusal to consent. Using G*Power 3.1 software for a two-tailed test with a moderate effect size ($d = 0.5$), a power of 0.8, and alpha of 0.05, the calculated sample size was 128. Allowing for a 15% dropout rate, a total of 148 patients were enrolled and randomly allocated into intervention and control groups using a computer-generated randomization sequence in blocks of four.

The intervention group received inspiratory muscle training using a threshold IMT device (POWERbreathe® K3) starting on postoperative day three, once patients were clinically stable and able to perform the procedure. The training protocol consisted of twice-daily sessions for 14 consecutive days during hospitalization, with each session involving five sets of six breaths against a resistance initially set at 30% of the patient's maximal inspiratory pressure (MIP). This resistance was increased incrementally every third day based on tolerance and performance. Participants were supervised by physiotherapists trained in cardiopulmonary rehabilitation. The control group received standard postoperative care, including breathing exercises and mobilization, but did not receive device-based inspiratory training. Primary outcome was dyspnea severity, measured using the modified Borg Dyspnea Scale (mBDS), a validated 0–10 scale assessing perceived breathlessness. Assessments were conducted at baseline (post-extubation), post-intervention (day 14), and at 1-month follow-up (12,13). Secondary outcomes included respiratory function parameters—forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), and maximal inspiratory pressure (MIP)—measured using a portable spirometer (MIR Spirobank II®) and a respiratory pressure meter (MicroRPM®). All outcome assessments were performed by blinded assessors not involved in patient care or training.

Data was entered into SPSS version 26.0 for statistical analysis. Continuous variables were expressed as mean $\pm$ standard deviation, and categorical variables as frequencies and percentages. Independent sample t-tests were used to compare mean differences in respiratory parameters and dyspnea scores between groups, while paired t-tests were applied for within-group pre- and post-intervention comparisons. Chi-square tests were used for categorical outcomes. A p-value of less than 0.05 was considered statistically significant. Data distribution was verified using the Shapiro-Wilk test, confirming normality for all continuous variables, justifying the use of parametric tests. The trial was monitored periodically by a data safety monitoring board to ensure adherence to protocol and patient safety. Adverse events, such as respiratory fatigue, dizziness, or desaturation during IMT, were recorded and managed per standard clinical guidelines. The integrity of randomization, blinding of assessors, and consistency in intervention delivery were maintained throughout the study to ensure the reliability of results. By combining a structured IMT protocol with rigorous clinical monitoring and validated outcome measures, the study was designed to provide credible evidence regarding the role of inspiratory muscle training in mitigating postoperative dyspnea and restoring respiratory function in cardiac surgery patients.

RESULTS

Out of 148 patients randomized equally into intervention and control groups, baseline demographic characteristics were comparable. The mean age in the intervention group was 59.3 years, and 60.1 years in the control group. Both groups had similar distributions in gender, BMI, and comorbid conditions, suggesting successful randomization. Dyspnea severity, as assessed by the modified Borg Dyspnea Scale, showed significant improvement in the intervention group over time compared to controls. At baseline, mean dyspnea scores were similar between groups (5.8 ± 1.1 vs. 5.6 ± 1.2 ; $p = 0.42$). By postoperative day 14, the intervention group demonstrated a significantly lower mean score of 2.9 ± 1.0 , while the control group averaged 4.6 ± 1.1 ($p < 0.001$). At one-month follow-up, scores further declined to 1.8 ± 0.9 in the intervention group and 3.9 ± 1.0 in the control group ($p < 0.001$), indicating sustained benefit from inspiratory muscle training. Assessment of pulmonary function at baseline and one-month follow-up also revealed significant differences between the two groups. In the intervention group, forced vital capacity (FVC) increased from 2.5 ± 0.4 L to 3.1 ± 0.5 L, and forced expiratory volume in one second (FEV_1) rose from 2.0 ± 0.3 L to 2.6 ± 0.4 L. Comparatively, the control group showed more modest gains (FVC from 2.4 ± 0.5 L to 2.7 ± 0.6 L; FEV_1 from 1.9 ± 0.4 L to 2.2 ± 0.4 L), with all between-group differences achieving statistical significance ($p < 0.001$). Similarly, maximal inspiratory pressure (MIP), a direct indicator of inspiratory muscle strength, improved significantly in the intervention group from 61 ± 6 cmH₂O at baseline to 78 ± 5 cmH₂O at one month. In contrast, the control group's MIP improved from 59 ± 7 to 67 ± 6 cmH₂O ($p < 0.001$). Regarding safety, minor adverse events were observed in the intervention

group. Three participants (4.1%) experienced mild respiratory fatigue, two (2.7%) had transient oxygen desaturation below 90%, and one (1.4%) reported brief dizziness during training sessions. No adverse events were reported in the control group. All events in the intervention group were self-limiting and resolved with brief rest, without requiring discontinuation of the intervention.

Table 1: Participant Demographics

Variable	Intervention Group (n=74)	Control Group (n=74)
Age (years)	59.3	60.1
Male (%)	51 (68.9%)	49 (66.2%)
BMI (kg/m²)	27.5	28.1
Smokers (%)	32 (43.2%)	30 (40.5%)
Diabetics (%)	29 (39.2%)	31 (41.9%)
Hypertension (%)	34 (45.9%)	36 (48.6%)

Table 2: Dyspnea Scores (Modified Borg Scale)

Timepoint	Intervention Group (Mean ± SD)	Control Group (Mean ± SD)	p-value
Baseline	5.8 ± 1.1	5.6 ± 1.2	0.42
Post-intervention (Day 14)	2.9 ± 1.0	4.6 ± 1.1	<0.001
1-Month Follow-up	1.8 ± 0.9	3.9 ± 1.0	<0.001

Table 3: Respiratory Function Parameters

Parameter	Baseline (Intervention)	Baseline (Control)	1-Month (Intervention)	1-Month (Control)	p-value
FVC (L)	2.5 ± 0.4	2.4 ± 0.5	3.1 ± 0.5	2.7 ± 0.6	<0.001
FEV ₁ (L)	2.0 ± 0.3	1.9 ± 0.4	2.6 ± 0.4	2.2 ± 0.4	<0.001
MIP (cmH ₂ O)	61 ± 6	59 ± 7	78 ± 5	67 ± 6	<0.001

Table 4: Adverse Events

Event	Intervention Group (n=74)	Control Group (n=74)
Respiratory fatigue	3 (4.1%)	0 (0%)
Desaturation < 90%	2 (2.7%)	0 (0%)
Dizziness	1 (1.4%)	0 (0%)
None	68 (91.8%)	74 (100%)

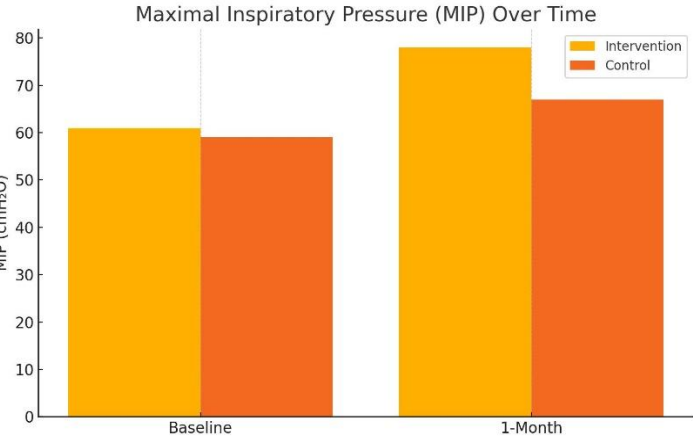


Figure 1 Maximal Inspiratory Pressure (MIP) Over Time

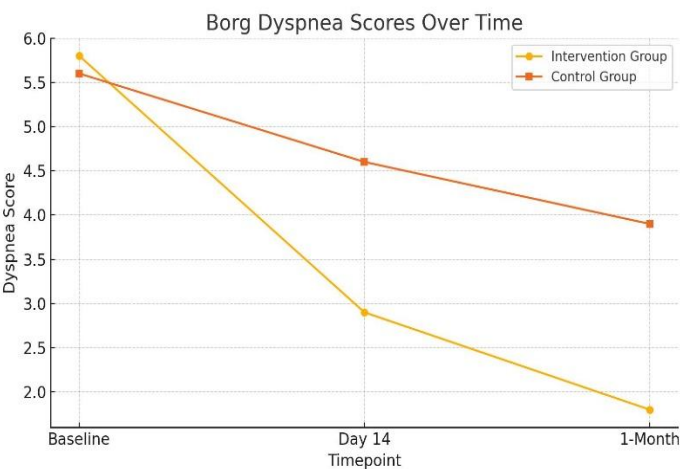


Figure 2 Borg Dyspnea Scores Over Time

DISCUSSION

The findings of this randomized controlled trial provide evidence that postoperative inspiratory muscle training (IMT) significantly reduces dyspnea and enhances respiratory function in patients recovering from cardiac surgery. This result supports a growing body of literature suggesting the therapeutic benefit of IMT in cardiothoracic populations. The improvement in Borg dyspnea scores observed in the intervention group aligns with previous meta-analytic data, which demonstrate that both preoperative and postoperative IMT can alleviate breathlessness and improve respiratory strength in surgical patients (13,14). Consistent with these results, the present study found that maximal inspiratory pressure (MIP) significantly improved in the intervention group, suggesting a direct training effect on inspiratory muscles. This is corroborated by recent findings which reported significant gains in pulmonary function and inspiratory strength following IMT protocols in cardiac surgery patients (15-17). Notably, this study focused exclusively on postoperative IMT initiated after extubation, highlighting its relevance during early inpatient recovery. While many previous trials have evaluated preoperative IMT, the present findings reinforce evidence from recent work indicating that IMT during postoperative rehabilitation can also yield significant respiratory benefits (18,19). Increased FVC and FEV₁ values in the intervention group suggest restored lung volume and airflow capacity, outcomes also reported in other postoperative IMT trials (20,21). These physiological improvements have practical implications, including potential reductions in hospital stay duration and enhanced physical activity tolerance, although these specific outcomes were not measured in the present study.

Strengths of this study include its randomized controlled design, use of validated measurement tools, and implementation in a real-world clinical setting across two tertiary cardiac centers in Pakistan. The standardized training protocol, blinded outcome assessment, and adherence monitoring further support the internal validity of the findings. However, several limitations must be acknowledged. The study did not include long-term follow-up beyond one month, limiting conclusions regarding sustained benefits or relapse of symptoms. Also, although dyspnea and pulmonary function improved, the impact on broader functional outcomes, such as exercise tolerance or quality of life, was not assessed. Additionally, while the sample size was adequately powered for the primary outcomes, subgroup analyses (e.g., valve vs. CABG patients) were not feasible. Variability in patient compliance, despite monitoring, could also have influenced the results. Another consideration is that the intervention was initiated postoperatively, while emerging evidence suggests that preoperative IMT may offer additional protective benefits against respiratory complications (16,22). Future studies may benefit from combining pre- and postoperative IMT strategies, examining optimal training intensities and durations, and integrating quality-of-life measures to provide a more holistic assessment of recovery. In conclusion, the findings of this trial underscore the clinical value of initiating inspiratory muscle training in the early postoperative period for cardiac surgery patients. By significantly reducing dyspnea and enhancing pulmonary function, IMT may serve as a practical, low-cost adjunct to conventional care in this vulnerable population.

CONCLUSION

This study demonstrated that postoperative inspiratory muscle training significantly reduces dyspnea and improves respiratory function in cardiac surgery patients. These findings support the integration of IMT into standard postoperative rehabilitation protocols, offering a simple, cost-effective intervention to enhance recovery. Broader implementation may improve patient outcomes and reduce respiratory complications.

AUTHOR CONTRIBUTION

Author	Contribution
Muhammad Majid Kanwar*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Hafzah Shah	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Farrukh Murtaza	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Muhammad Abdullah	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Sidra Asghar	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Bashir Ahmed	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

REFERENCES

- Eibel B, Marques JR, Dipp T, Waclawovsky G, Marschner RA, Boll LC, et al. Ventilatory Muscle Training for Early Cardiac Rehabilitation Improved Functional Capacity and Modulated Vascular Function of Individuals Undergoing Coronary Artery Bypass Grafting: Pilot Randomized Clinical Trial. *Int J Environ Res Public Health*. 2022;19(15).
- Keller SP, Whitman GJR, Grant MC. Temporary Mechanical Circulatory Support after Cardiac Surgery. *J Cardiothorac Vasc Anesth*. 2024;38(9):2080-8.
- Mayr B, Kido T, Holder S, Wallner M, Vodiskar J, Strbad M, et al. Single-centre outcome of extracorporeal membrane oxygenation after the neonatal Norwood procedure. *Eur J Cardiothorac Surg*. 2022;62(3).
- Shabbir H, Shafi MT, Mushtaq MH. Effects of Inspiratory Muscle Training on Respiratory Strength and Functional Capacity in Post-operative Patients with Scoliosis during Maximum Protection Phase. *The Healer Journal of Physiotherapy and Rehabilitation Sciences*. 2025 Jul 1;5(2):72-80.
- Corujo Rodriguez A, Richter E, Ibekwe SO, Shah T, Faloye AO. Postcardiotomy Shock Syndrome: A Narrative Review of Perioperative Diagnosis and Management. *J Cardiothorac Vasc Anesth*. 2023;37(12):2621-33.
- Bari G, Mariani S, van Bussel BCT, Ravaux J, Di Mauro M, Schaefer A, et al. Post-cardiotomy extracorporeal life support: A cohort of cannulation in the general ward. *Artif Organs*. 2024;48(11):1355-65.
- Wang Q, Peng Y, Xu S, Guo H, Chen Y, Lin L, et al. Perioperative respiratory muscle exercise in patients undergoing cardiac surgery: An evidence-based review. *Heart Lung*. 2025;70:73-81.
- Shaefi S, Shankar P, Mueller AL, O'Gara BP, Spear K, Khabbaz KR, et al. Intraoperative Oxygen Concentration and Neurocognition after Cardiac Surgery. *Anesthesiology*. 2021;134(2):189-201.
- Cordeiro ALL, Almeida de Brito J, Rodrigues Pereira L, Duarte Pascoal H, Correia Dos Santos VT, Raimundo Guimarães A, et al. Inspiratory muscle training on quality of life and functional capacity after hospital discharge in patients submitted to coronary artery bypass grafting: A controlled clinical trial. *J Bodyw Mov Ther*. 2023;35:202-7.
- Araújo CO, Araújo Alves CC, Dos Santos FRA, Cahalin LP, Cipriano GFB, Cipriano G. Inspiratory Muscle Training in Phase 1 and 2 Postoperative Cardiac Rehabilitation Following Coronary Artery Bypass Graft Surgery: Systematic Review With Meta-Analysis. *Phys Ther*. 2024;104(7).
- Cole SP, Martinez-Acero N, Peterson A, Von Homeyer P, Gebhardt B, Nicoara A. Imaging for Temporary Mechanical Circulatory Support Devices. *J Cardiothorac Vasc Anesth*. 2022;36(7):2114-31.
- Huang Y-T, Lin Y-J, Hung C, Cheng H-C, Yang H-L, Kuo Y-L, et al. The fully engaged inspiratory muscle training reduces postoperative pulmonary complications rate and increased respiratory muscle function in patients with upper abdominal surgery: a randomized controlled trial. *Annals of Medicine*. 2022;54:2222-32.

13. Straube T, Cheifetz IM, Jackson KW. Extracorporeal Membrane Oxygenation for Hemodynamic Support. *Clin Perinatol*. 2020;47(3):671-84.
14. Aquino TN, Prado JP, Crisafulli E, Clini EM, Galdino G. Efficacy of Respiratory Muscle Training in the Immediate Postoperative Period of Cardiac Surgery: A Systematic Review and Meta-Analysis. *Braz J Cardiovasc Surg*. 2024;39(1):e20220165.
15. Fortes J, Borges M, Marques M, Oliveira RL, Da Rocha LR, De Castro ÉM, et al. Effects of Inspiratory Muscle Training Using an Electronic Device on Patients Undergoing Cardiac Surgery: A Randomized Controlled Trial. *International Journal of Cardiovascular Sciences*. 2020.
16. Dsouza FV, Amaravadi S, Samuel S, Raghavan H, Ravishankar N. Effectiveness of Inspiratory Muscle Training on Respiratory Muscle Strength in Patients Undergoing Cardiac Surgeries: A Systematic Review With Meta-Analysis. *Annals of Rehabilitation Medicine*. 2021;45:264-73.
17. Hegazy FA, Mohamed Kamel SM, Abdelhamid AS, Aboelnasr EA, Elshazly M, Hassan AM. Effect of postoperative high load long duration inspiratory muscle training on pulmonary function and functional capacity after mitral valve replacement surgery: A randomized controlled trial with follow-up. *PLoS One*. 2021;16(8):e0256609.
18. Fang L, Cheng A, Zhu Z, Shao M, Wang G. Effect of Inspiratory Muscle Training on Outcomes After Cardiac Surgery: A Comprehensive Meta-Analysis of Randomized Controlled Trials. *J Cardiopulm Rehabil Prev*. 2024;44(5):324-32.
19. Evangelodimou A, Patsaki I, Andrikopoulos A, Chatzivasiloglou F, Dimopoulos S. Benefits from Implementing Low- to High-Intensity Inspiratory Muscle Training in Patients Undergoing Cardiac Surgery: A Systematic Review. *Journal of Cardiovascular Development and Disease*. 2024;11.
20. Marathe SP, Suna J, Betts KS, Merlo G, Konstantinov IE, Iyengar AJ, et al. The Australia and New Zealand Congenital Outcomes Registry for Surgery (ANZCORS): methodology and preliminary results. *ANZ J Surg*. 2022;92(12):3154-61.
21. Donatelli F, Miceli A, Glauber M, Cirri S, Maiello C, Coscioni E, et al. Adult cardiovascular surgery and the coronavirus disease 2019 (COVID-19) pandemic: the Italian experience. *Interact Cardiovasc Thorac Surg*. 2020;31(6):755-62.
22. Sanfilippo F, Palumbo GJ, Bignami E, Pavesi M, Ranucci M, Scolletta S, et al. Acute Respiratory Distress Syndrome in the Perioperative Period of Cardiac Surgery: Predictors, Diagnosis, Prognosis, Management Options, and Future Directions. *J Cardiothorac Vasc Anesth*. 2022;36(4):1169-79.