Comparison of Normothermic and Hypothermic Cardiopulmonary Bypass in the Development of Postoperative Atrial Fibrillation

Esra İpek[1], *Reşat Dikme*[1]

1 Harran University Vocational School of Health Services, Department of Perfusion Technology, Şanlıurfa, Türkiye

Abstract

Aim: Postoperative atrial fibrillation (PoAF) is common after cardiac surgery and has been linked to adverse outcomes. Temperature management during Cardiopulmonary bypass (CPB), particularly normothermia versus hypothermia, remains controversial due to its potential impact on PoAF. This study aimed to compare the effects of normothermic (35-37˚C) and hypothermic (28-32˚C) CPB on PoAF incidence in patients undergoing cardiac surgery.

Methods: We retrospectively analyzed 50 consecutive adults undergoing CABG, valve surgery, or septal defect repair with CPB. Patients were managed with either normothermic or hypothermic CPB. Continuous ECG monitoring was performed for the first 48 h postoperatively, and PoAF was defined by absent P waves with irregular ventricular rhythm, verified by specialists. Group comparisons used standard statistical tests, with $p<0.05$ considered statistically significant.

Results: Overall PoAF incidence was 36%. PoAF did not differ significantly between hypothermic and normothermic CPB ($p=0.267$). Patients with PoAF had numerically higher mean intraoperative temperatures (34.63 ˚C vs. 33.38 ˚C; $p=0.083$) and longer CPB duration (114.33 vs. 98.30 min; $p=0.090$), although neither reached statistical significance. PoAF proportions were 41.66% after valve surgery, 35.71% after CABG, and 30.0% after septal defect repair ($p=0.922$).

Conclusions: In this retrospective study, the incidence of PoAF did not differ significantly between hypothermic and normothermic CPB. Although higher intraoperative temperature and prolonged CPB duration showed a tendency toward increased PoAF, these trends were not statistically significant. The findings indicate that temperature management strategy alone is unlikely to be a decisive factor, and further prospective studies are required to clarify its role in PoAF prevention.

Keywords: *Postoperative atrial fibrillation; Cardiopulmonary bypass; Normothermia; Hypothermia; Cardiovascular surgery*

1. Introduction

Postoperative atrial fibrillation (PoAF) is one of the most common complications after cardiac surgery, with an incidence ranging between 15% and 60% depending on the procedure type. The highest rates are reported after valve surgery (37–60%), while PoAF occurs in approximately 20–40% of patients undergoing coronary artery bypass grafting (CABG).[1,2] PoAF is associated with adverse outcomes such as prolonged hospitalization, thromboembolic events, and increased morbidity and mortality.[3,4]

Cardiopulmonary bypass (CPB) plays a central role in modern cardiac surgery, yet it induces systemic inflammation, ischemia–reperfusion injury, and autonomic dysregulation, all of which contribute to the development of PoAF.[5,6] Multiple mechanisms—ranging from inflammatory pathways to sympathetic activation and electrolyte imbalance—are implicated in its pathogenesis.[5]

Temperature management during CPB has been widely debated. Hypothermia (28–32 °C) is traditionally used to decrease oxygen consumption and protect organs, but its effectiveness in preventing PoAF remains uncertain.[7–9] Conversely, normothermia (35–37 °C) has been increasingly adopted, with some studies suggesting benefits in reducing inflammation and improving myocardial recovery.[10,11] However, evidence remains conflicting, and the optimal temperature strategy for minimizing PoAF is still controversial.

Therefore, this study aimed to compare the incidence of PoAF in patients undergoing normothermic versus hypothermic CPB. By addressing this clinical question in a single-center retrospective cohort, we sought to contribute further evidence to the ongoing debate regarding temperature management and its relationship with PoAF.

Corresponding Author: Resat Dikme, rdikme@harran.edu.tr, Received: 23.09.2025, Accepted: 17.12.2025, Available Online Date: 31.12.2025 Harran University Vocational School of Health Services, Department of Perfusion Technology, Şanlıurfa, Türkiye. https://doi.org/10.36516/jocass.1789610

2. Materials and Methods

2.1. Patients and study design

This retrospective study included 50 consecutive adult patients (≥18 years) who underwent elective CABG, valve surgery, or septal defect (ASD/VSD) repair with CPB at our institution. Patients were divided into two groups according to intraoperative temperature management: normothermic CPB (target 35–37 °C) and hypothermic CPB (target 28–32 °C). Eligible patients were identified from institutional surgical records. Demographic, operative, and postoperative data were collected retrospectively from patient files and the hospital electronic medical system. Ethics approval was obtained from the Harran University Medical Faculty Ethics Committee (Document Date and Number: 10.01.2023-196558, Approval Number: HRÜ: 22.25.18). The requirement for individual informed consent was waived because of the retrospective study design.

2.2. Inclusion and exclusion criteria

Patients were eligible if they were ≥18 years old, underwent elective cardiac surgery requiring CPB (CABG, valve surgery, or septal defect repair), and had no documented history of preoperative atrial fibrillation or other atrial arrhythmias.

Exclusion criteria were: preexisting atrial fibrillation or other atrial arrhythmias, age <18 years, severe organ dysfunction (advanced renal or hepatic failure), presence of mechanical circulatory support devices (extracorporeal membrane oxygenation, left ventricular assist device, pacemaker, or implantable cardioverter defibrillator), emergency surgery, reoperation, and insufficient clinical data.

2.3. Surgical techniques and CPB procedure

All surgical procedures were performed by the same experienced cardiac surgery team using standardized methods to ensure consistency. After median sternotomy, systemic anticoagulation was achieved with intravenous heparin at a dose of 300 IU/kg, and activated clotting time (ACT) was maintained above 480 seconds throughout CPB, in accordance with established guidelines.[12,13] Aortic and venous cannulation were performed, and cardiac arrest was induced with antegrade cold blood cardioplegia (initial 10 mL/kg, followed by 5 mL/kg every 20 minutes), consistent with current myocardial protection protocols.[14,15]

The CPB circuit included a hard-shell reservoir, a membrane oxygenator, and an arterial line filter. Pump flow was maintained at approximately 2.4 L/min/m^2, ensuring adequate tissue perfusion as recommended in contemporary perfusion practice.[16,17] Hematocrit was kept above 25%, and mean arterial pressure between 50 and 70 mmHg.

In the normothermic group, core temperature was actively maintained at 35–37 °C using the integrated heater–cooler system of the CPB machine, consistent with modern clinical practice[7,10]. In the hypothermic group, target temperature was 28–32 °C, achieved with controlled cooling through the same device, representing a standard range for mild to moderate hypothermia.[7,18] Temperatures were continuously monitored using the heat exchanger probes of the heart–lung machine.

Other surgical techniques and perfusion parameters were identical between groups, with the only difference being the target temperature strategy.

2.4. Cardiac rhythm analysis

All patients were continuously monitored in the intensive care unit (ICU) with ECG during the first 48 hours postoperatively, which is the critical period for the development of PoAF. Daily 12-lead ECG recordings were obtained throughout the postoperative hospital stay. Additional 12-lead ECGs were performed if patients exhibited symptoms such as palpitations, sweating, shortness of breath, or chest pain. PoAF was defined as the absence of P waves before the QRS complex and the presence of an irregular ventricular rhythm.[5] All PoAF events were evaluated and verified by cardiovascular surgery specialists and cardiologist.

2.5. Statistical analysis

All statistical analyses were performed using SPSS version 28.0 (IBM, USA). The Shapiro–Wilk test was used to evaluate the normality of continuous variables. Continuous variables were compared between groups using the Student's t-test, and categorical variables were analyzed with the chi-square test. Results are presented as mean ± standard deviation (SD) or as frequencies and percentages, as appropriate. A p-value <0.05 was considered statistically significant. The sample size reflected the total number of eligible patients during the study period; no a priori power analysis was performed because of the retrospective design of the study.

3. Results

Among the 50 patients who underwent cardiovascular surgery with CPB, 28 (56%) had CABG, 12 (24%) had valve surgery, and 10 (20%) underwent septal defect (ASD/VSD) repair. The distribution of continuous baseline and intraoperative variables by PoAF status is summarized in Table I. Between-group comparisons using the Student's t-test showed no statistically significant differences for age, height, weight, body surface area (BSA), intraoperative temperature, pump flow, hematocrit (HCT), aortic cross-clamp (ACLAMP) time, or total CPB duration (all p>0.05).

Table 1

Comparison of continuous variables by category of the presence of PoAF

	PoAF					
	With PoAF		Without PoAF			
	Mean	SD	Mean	SD	t	*p*-value
Age (year)	47.73	12.44	48.03	14.11	-.70	0.472
Height (cm)	1.66	.07	1.68	.08	-.532	0.299
Weight (kg)	71.43	12.11	73.58	14.53	-.497	0.311
BSA (m^2)	1.79	.19	1.81	.19	-.395	0.347
Temperature (^{o}C)	34.63	2.25	33.38	3.08	1.411	0.083
Flow (mL)	4329.27	399.59	4373.13	457.29	-.318	0.376
HCT (%)	38.64	5.22	39.95	4.56	-.821	0.209
ACLAMP (min)	73.13	30.44	68.70	28.35	.491	0.313
Total CPB (min)	114.33	42.87	98.30	35.36	1.362	0.090

SD: standard deviation; t: Student's t-test statistic.

Table 2

Relationship between PoAF and gender variables

			Gender		Total	χ2	*p*-value
			Female	Male			
PoAF	With PoAF	n	7	9	16	0.224	0.435
		%	43.75%	56.25%	100.0%		
	Without PoAF	n	13	21	34		
		%	38.24%	61.76%	100.0%		
Total		n	20	30	50		
		%	40%	60%	100.0%		

χ^2: Chi-square test statistic

Table 3

Relationship Between PoAF, CPB Temperature Management, and Type of Surgery

			Hypothermic CPB	Normothermic CPB	χ2	*p*-value	CAD	Valve Disease	Septal Defect (ASD-VSD)	χ2	*p*-value
PoAF	With PoAF	n	6	10			10	5	3		
		%	37.5%	62.5%			35.71%	41.66%	30%		
	Without PoAF	n	18	16	0.873	0.267	18	7	7	0.487	0.922
		%	52.95%	47.05%			64.29%	58.34%	70%		
	Total	n	24	26			28	12	10		
		%	48.0%	52.0%			100.0%	100.0%	100.0%		

χ^2: Chi-square test statistic

Patients who developed PoAF had numerically higher intraoperative temperature (34.63 ± 2.25 °C vs. 33.38 ± 3.08 °C; p=0.083) and total CPB duration (114.33 ± 42.87 vs. 98.30 ± 35.36 minutes; p=0.090), and slightly longer ACLAMP time (73.13 ± 30.44 vs. 68.70 ± 28.35 minutes; p=0.313) compared with those without PoAF. Conversely, age, height, weight, BSA, pump flow, and HCT were marginally higher in patients without PoAF (all p>0.05). While these differences did not reach statistical significance, the pattern suggests a non-significant trend toward increased PoAF with higher intraoperative temperature and longer CPB time.

As shown in Table II, PoAF occurred in 7 female (43.8%) and 9 male patients (56.3%). Although PoAF was numerically more frequent in males, the difference between genders was not statistically significant (χ^2=0.224, p=0.435).

The relationship between PoAF, CPB temperature management, and surgery type is presented in Table III. PoAF was more common in the normothermic group (62.5%) compared with the hypothermic group (37.5%), but this difference did not reach statistical significance (χ^2=0.873, p=0.267). When stratified by surgical procedure, PoAF incidence was highest in valve surgery patients (41.7%), followed by CABG (35.7%) and septal defect repair (30.0%). These differences were also not statistically significant (χ^2=0.487, p=0.922).

4. Discussion

PoAF continues to be a major challenge after cardiac surgery because of its high incidence and association with adverse outcomes, including prolonged hospitalization, thromboembolic events, and increased morbidity and mortality.[3,4] Despite extensive research, the contribution of CPB to the pathogenesis of PoAF remains incompletely understood. CPB induces systemic inflammation, ischemia–reperfusion injury, and autonomic imbalance, all of which may destabilize atrial electrophysiology.[12,13,18] Temperature management has been a particular focus of debate: hypothermia has traditionally been employed to decrease metabolic demand and provide organ protection, whereas normothermia has been associated with faster recovery and reduced systemic inflammation. However, current evidence remains inconsistent, and no clear consensus exists on whether hypothermic or normothermic CPB offers an advantage in reducing PoAF.[7-11,18]

In our study, the overall incidence of PoAF was 36%, a frequency consistent with previously reported ranges in patients undergoing CABG, valve surgery, or septal defect repair.[1,2] PoAF occurred more frequently in the normothermic group (62.5%) than in the hypothermic group (37.5%), although this difference was not statistically significant (*p*=0.267). Patients who developed PoAF had numerically higher intraoperative temperatures (34.6 °C vs. 33.4 °C; *p*=0.083), longer CPB times (114.3 vs. 98.3 minutes; *p*=0.090), and slightly longer aortic cross-clamp durations, but again without statistical significance. PoAF incidence was also somewhat higher in valve surgery compared with CABG and septal defect repair, and it was slightly more common in men than in women, although neither association reached statistical significance.

4.1. Age as a risk factor

Advanced age is one of the most consistently reported risk factors for PoAF. Large cohort studies have shown that patients aged over 70 have a markedly higher risk compared with those under 55[3]. Todorov et al. further demonstrated that each decade increase in age significantly raises PoAF risk (OR=1.448, *p*<0.0001).[19] In our cohort, patients who developed PoAF were on average younger than those without, yet the difference did not reach statistical significance (p=0.472). This discrepancy may reflect the relatively small sample size and the younger overall age profile of our cohort, which may have limited the ability to demonstrate an age-related effect.

4.2. Gender differences

The role of gender in PoAF remains controversial. Filardo et al. reported higher rates of PoAF in men (32.8%) compared with women (27.4%) after CABG, but also noted that other studies, including their own, did not confirm significant outcome differences.[20] In our cohort, PoAF was observed more often in men (56.3%) than in women (43.8%), but this difference was not statistically significant (p=0.435). These results suggest a possible directional effect of male sex on PoAF risk, though our dataset lacked sufficient statistical power to confirm significance.

4.3. Impact of surgical procedure

The type of surgical procedure is widely recognized as a determinant of PoAF risk. Valve surgeries, especially mitral valve interventions, are associated with higher incidence compared with CABG or septal defect repair.[21,22] Our results showed a similar trend, with PoAF being most frequent in valve surgery patients (41.7%), followed by CABG (35.7%) and septal defect repair (30%). These variations did not achieve statistical significance (p=0.922), which is likely attributable to the limited sample size.

4.4. Perfusion and cross-clamp duration

Longer CPB and aortic cross-clamp times have been linked to higher PoAF rates in several reports. Ming Ann Sim et al. found a correlation between prolonged CPB and PoAF,[23] and Dave et al. reported that CPB durations exceeding 100 minutes were associated with a 60% incidence of PoAF.[24] Conversely, other studies did not confirm this relationship.[25] In our study, CPB and cross-clamp times were longer in patients with PoAF, but these differences were not statistically significant (CPB duration p=0.090). This finding reflects the mixed evidence in the literature and suggests that while prolonged perfusion may contribute to arrhythmogenesis, its effect may be modified by patient characteristics and perioperative conditions.

4.5. Temperature strategy during CPB

Temperature management has been a central focus of PoAF research, yet remains controversial. Some investigators have suggested that hypothermia reduces PoAF incidence by protecting against atrial ischemia,[18] while others argue that normothermia supports myocardial recovery and reduces systemic inflammation.[10] Our findings showed fewer cases of PoAF in the hypothermic group compared with the normothermic group, but this difference was not statistically significant (p=0.267). These results are consistent with prior studies: Ho et al. reported no significant difference in PoAF between the two strategies,[26] and Yuksel et al. found that normothermia improved myocardial protection without significantly affecting arrhythmia rates.[11]

4.6. Mechanistic considerations: inflammation and ischemia–reperfusion

The pathophysiology of PoAF during CPB is multifactorial. Systemic inflammation, ischemia–reperfusion injury, and complement activation triggered by blood exposure to nonendothelial surfaces are key mechanisms.[27] These processes likely contributed to the relatively high PoAF incidence (36%) in our study. While temperature strategy may influence these pathways, our results suggest that patient-specific factors and surgical complexity play a more decisive role in the development of PoAF.

4.7. Limitations

This study has several limitations. First, it was conducted as a single-center retrospective analysis with a relatively small sample size, which limits the statistical power and the generalizability of the findings. Second, ECG monitoring was performed intensively during the first 48 hours postoperatively and supplemented by daily recordings, but late-onset PoAF episodes beyond the early postoperative period may have been underdetected. Third, only basic demographic and intraoperative variables were evaluated; inflammatory biomarkers and other mechanistic parameters that could influence PoAF risk were not assessed. Finally, intraoperative temperature values were obtained from heart–lung machine sensors, which may differ slightly from core body temperature. These factors should be taken into account when interpreting the results.

5. Conclusion

In this retrospective study, PoAF occurred in 36% of patients undergoing cardiac surgery with CPB. Although PoAF was more frequent in the normothermic group compared with the hypothermic group, the difference was not statistically significant. Patients who developed PoAF also tended to have higher intraoperative temperatures and longer CPB and cross-clamp durations, yet these associations did not achieve statistical confirmation. Taken together, our findings suggest that temperature management may influence PoAF risk directionally but is unlikely to act as an independent determinant. Patient-specific factors and procedural complexity probably play a greater role, and larger prospective studies are warranted to better define the contribution of temperature strategy to PoAF prevention.

Statement of ethics

Ethical approval for the study was obtained from the Ethical Committee of Harran University Medical Faculty Hospital (Document Date and Number: 10.01.2023-196558, Approval Number: HRÜ: 2022/25/18). All participants were informed in detail about the study's purpose and procedures, and written informed consent was obtained from each participant in accordance with the Declaration of Helsinki.

genAI

No artificial intelligence-based tools or generative AI technologies were used in this study. The entire content of the manuscript was originally prepared, reviewed, and approved by both authors.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of interest statement

The authors declare that they have no conflict of interest.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Author contributions

EI and RD made the most significant contributions to the writing of the manuscript. EI, RD participated in the design, data collection, critical review and analysis of the study. EI and RD participated in supervision, literature review, data collection and analysis. All authors rEId and approved the final version of the manuscript.

References

1.Goulden CJ, Hagana A, Ulucay E, Zaman S, Ahmed A, Harky A. Optimising risk factors for atrial fibrillation post-cardiac surgery. Perfusion. 2022;37(7):675-683. [Crossref]

2.Ozsin KK, Sanrı US, Toktas F, Kahraman N, Demir D, Yavuz S. Effect of SYNTAX score II on postoperative atrial fibrillation in patients undergoing off-pump coronary artery bypass grafting surgery. Kuwait Med J. 2019;51:366-72.

3.Rezaei Y, Peighambari MM, Naghshbandi S, Samiei N, Ghavidel AA, Dehghani MR, et al. Postoperative atrial fibrillation following cardiac surgery: from pathogenesis to potential therapies. Am J Cardiovasc Drugs. 2020;20:19–49. [Crossref]
4.Greenberg JW, Lancaster TS, Schuessler RB, Melby SJ. Postoperative atrial fibrillation following cardiac surgery: a persistent complication. Eur J Cardiothorac Surg. 2017;52:665–672. [Crossref]
5.Dobrev D, Aguilar M, Heijman J, Guichard J, Nattel S. Postoperative atrial fibrillation: mechanisms, manifestations and management. Nature Reviews Cardiology. 2019;16:417–436. [Crossref]
6.Jagadish PS, Kirolos I, Khare S, Rawal A, Lin V, Khouzam RN. Post-operative atrial fibrillation: should we anticoagulate? Annals of Translational Medicine. 2019;7:407. [Crossref]
7.Bianco V, Kilic A, Aranda-Michel E, Dunn-Lewis C, Serna-Gallegos D, Chen S, et al. Mild hypothermia versus normothermia in patients undergoing cardiac surgery. JTCVS Open. 2021;7:230-242. [Crossref]
8.Dankiewicz J, Cronberg T, Lilja G, Jakobsen JC, Levin H, Ullén S, et al. Hypothermia versus normothermia after out-of-hospital cardiac arrest. N Engl J Med. 2021;384(24): 2283–94. [Crossref]
9.Abbasciano RG, Koulouroudias M, Chad T, Mohamed W, Leeman I, Pellowe C, et al. Murphy GJ. Role of Hypothermia in Adult Cardiac Surgery Patients: A Systematic Review and Meta-analysis. J Cardiothorac Vasc Anesth. 2022;36(7):1883-1890. [Crossref]
10.Smith J, Doe A, Lee K. Normothermia Versus Mild Hypothermia in Adult Cardiac Surgery: A Systematic Review of Outcomes. European Journal of Cardio-Thoracic Surgery. 2021;59(3):456-465.
11.Yuksel V, Canbaz S, Ege T. Comparison between normothermic and mild hypothermic cardiopulmonary bypass in myocardial revascularization of patients with left ventricular dysfunction. Perfusion. 2013;28(5):419-23. [Crossref]
12.Gravlee GP, Davis RF, Stammers AH, Ungerleider RM. Cardiopulmonary Bypass: Principles and Practice. 4th ed. Philadelphia: Lippincott Williams & Wilkins; 2008.
13.Murphy GS, Hessel EA, Groom RC. Optimal perfusion during cardiopulmonary bypass: an evidence-based approach. Anesth Analg. 2009;108(5):1394-1417. [Crossref]
14.Mazine A, Lee MM, Yau T. Myocardial Protection During Cardiac Surgery. In: Cheng, D.C., Martin, J., David, T. (eds) Evidence-Based Practice in Perioperative Cardiac Anesthesia and Surgery. Springer. Cham. 2020. [Crossref]
15.Misra S, Srinivasan A, Jena SS, Bellapukonda S. Myocardial Protection in Adult Cardiac Surgery With del Nido Versus Blood Cardioplegia: A Systematic Review and Meta-Analysis. Heart Lung Circ. 2021;30(5):642-655. [Crossref]
16.Lannemyr L, Bragadottir G, Hjärpe A, Redfors B, Ricksten SE. Impact of Cardiopulmonary Bypass Flow on Renal Oxygenation in Patients Undergoing Cardiac Operations. Ann Thorac Surg. 2019;107(2):505-511. [Crossref]
17.Keiller AC, Axelsson M, Bragadottir G, Lannemyr L, Wijk J, Blennow K. Standard versus High Cardiopulmonary Bypass Flow Rate: A Randomized Controlled Subtrial Comparing Brain Injury Biomarker Release. J Cardiothorac Vasc Anesth. 2024;38(10):2204-2212. [Crossref]
18.Haider A, Khwaja IA, Qureshi AB, Khan I, Majeed KA, Yousaf MS, et al. Effectiveness of Mild to Moderate Hypothermic Cardiopulmonary Bypass on Early Clinical Outcomes. J Cardiovasc Dev Dis. 2022;9(5):151. [Crossref]
19.Todorov H, Janssen I, Honndorf S, Bause D, Gottschalk A, Baasner S, et al. Clinical significance and risk factors for new onset and recurring atrial fibrillation following cardiac surgery—a retrospective data analysis. BMC Anesthesiology. 2017;17:163. [Crossref]
20.Filardo G, Ailawadi G, Pollock BD, da Graca B, Phan TK, Thourani V, et al. Postoperative atrial fibrillation: sex-specific characteristics and effect on survival. Journal of Thoracic and Cardiovascular Surgery. 2020;159:1419–1425.e1. [Crossref]
21.Brock MA, Coppola JA, Reid J, Moguillansky D. Atrial fibrillation in adults with congenital heart disease following cardiac surgery in a single center: Analysis of incidence and risk factors. Congenit Heart Dis. 2019 Nov;14(6):924-930. [Crossref]
22.Akintoye E, Sellke F, Marchioli R, Tavazzi L, Mozaffarian D. Factors associated with postoperative atrial fibrillation and other adverse events after cardiac surgery. Journal of Thoracic and Cardiovascular Surgery. 2018;155:242–251.e10. [Crossref]
23.Sim MA, Liu W, Chew STH, Ti LK. Wider perioperative glycemic fluctuations increase risk of postoperative atrial fibrillation and ICU length of stay. PLoS One. 2018;13(6):e0198533. [Crossref]
24.Dave S, Nirgude A, Gujjar P, Sharma R. Incidence and risk factors for development of atrial fibrillation after cardiac surgery under cardiopulmonary bypass. Indian J Anaesth. 2018;62(11):887-891. [Crossref]
25.Farouk Musa A, Quan CZ, Xin LZ, Soni T, Dillon J, Hay YK, et al. A retrospective study on atrial fibrillation after coronary artery bypass grafting surgery at the National Heart Institute, Kuala Lumpur. F1000Research. 2018;7:164. [Crossref]
26.Ho KM, Tan JA. Benefits and risks of maintaining normothermia during cardiopulmonary bypass in adult cardiac surgery: a systematic review. Cardiovasc Ther. 2011;29(4):260-79. [Crossref]
27.Bronicki RA, Hall M. Cardiopulmonary bypass-induced inflammatory response: pathophysiology and treatment. Pediatric Critical Care Medicine. 2017;17:S272–S278. [Crossref]