JPSIM Journal of Pakistan Society of Internal Medicine

Original Article

Effect of Systemic Normothermia During CPB on Postoperative Neurological Function Following Coronary Artery Bypass Grafting

Usama Zahid,[1] Zafar Tufail,[1] Muhammad Madni,[1] Muhammad Saeed Afridi,[2] Amna Shafqat[1]

[1]Punjab Institute of Cardiology, Lahore, [2]Hameed Latif Hospital, Lahore

Abstract

Objective: Aim of this study is to compare the incidence of postoperative neurological dysfunction in patients undergoing CABG with systemic normothermia versus systemic hypothermia during CPB.

Methodology: This prospective cohort study was completed at the Department of cardiac surgery, Punjab Institute of Cardiology (PIC) Lahore. One hundred and twenty cases comprising 60 cases in each group (Group A: Normothermic, Group B: Hypothermic) were statistically calculated.

Results: Mean age and gender distribution were comparable between normothermic (Group A) and hypothermic (Group B) patients. CPB and cross-clamp times were significantly longer in Group B (110.37 ± 11.89 and 77.48 ± 10.19 minutes) than Group A (93.82 ± 5.93 and 63.33 ± 9.45 minutes; $p < 0.001$). Neurological outcomes, including stroke, delirium, and POCD, showed no statistically significant differences between groups ($p > 0.05$).

Conclusion: Normothermic and hypothermic cardiopulmonary bypass showed no significant difference in postoperative neurological dysfunction (stroke, delirium, or POCD; $p > 0.05$). Normothermia appears to be a safe and acceptable alternative for routine CABG, as no clear neurological benefit of mild hypothermia was demonstrated.

Keywords: Normothermic, Hypothermic, Cardiopulmonary Bypass, Postoperative Cognitive Dysfunction

How to cite this:

Zahid U, Tufail Z, Madni M, Afridi MS, Shafqat A. Effect of Systemic Normothermia During CPB on Postoperative Neurological Function Following Coronary Artery Bypass Grafting. J Pak Soc Intern Med. 2026;7(4): 315-320

Corresponding Author: Dr. Usama Zahid **Email:** usama_zahidjan@hotmail.com

Received: 23-07-2026 **Revised:** 17-09-2026 **Accepted:** 04-11-2026 **DOI:** https://doi.org/10.70302/jpsim.v7i4.2663

2709-8729/© 2026 The Author(s). Published by JPSIM on behalf of Pakistan Society of Internal Medicine, Lahore, Pakistan. This is an open access article under the CC BY 4.0 license https://creativecommons.org/licenses/by/4.0/

Introduction

One of the main causes of death and morbidity following Coronary Artery Bypass Grafting (CABG) is Cerebral damage. Stroke, Encephalopathy (including Delirium), and Postoperative Cognitive Dysfunction (POCD) are the three main categories of neurological problems after heart surgery. The major cause of Stroke which occurs in 3% of patients is due to the embolization of atheromatous debris during handling of the diseased aorta.[1] Microembolization of gaseous and particulate debris, primarily produced by cardiotomy suction, is the primary cause of cognitive impairment. Similar cognitive impairment in patients who underwent surgery without cardiopulmonary bypass (CPB) suggests the involvement of additional pathophysiological pathways, including hypoperfusion, anesthesia, and systemic temperature.

Over the past 10 years, the frequency of neurological damage in CABG patients has decreased due to advancements in medical, anesthetic, and surgical care.[2]

With our aging populations, cerebral impairment following heart surgery continues to be a severe complication. By minimizing manipulation of the Ascending Aorta and using surgical techniques like off-pump CABG may lower the likelihood of neurological problems following surgery.[3] There are no clear variances for POCD amongst on-pump and off-pump CABG, despite the fact that off-pump CABG is linked to a lower risk of stroke. Postoperative neurological research has recently turned its attention from CPB to patient-related variables.

Strategies for minimizing cerebral dysfunction may be improved by identifying changes in the brains of elderly patients having heart surgery.[5] In addition to being a major risk factor for stroke and POCD after heart surgery, advanced age is linked to many more undetected cases of cerebrovascular illness.[6]

A study conducted in Istanbul, Turkey found better neurological outcome in CABG patients with systemic normothermia during CPB.[7] Similarly,

there are many other studies in literature for the prevention of neurological dysfunction following CABG.[8-9]

An earlier study compared normothermic and moderately hypothermic CPB and assessed the prevalence of persisting postoperative neurological impairment following CABG. The hypothermic CPB group had a 4.1% incidence of chronic postoperative neurological impairment, while the normothermic CPB group had a 2.3% incidence. The two groups did not differ statistically significantly (P=NS). These findings imply that, in comparison to hypothermic CPB, normothermic CPB did not raise the incidence of chronic postoperative neurological impairment.[10]

A study comparing the effects of hypothermia and normothermia on cognitive functioning following CABG throughout the hospital stay was carried out by Ziyaeifard et al. in 2021. On the second (21.54% vs. 43.08% P=0.003), third (13.85% vs. 46.15% P=0.000), and fourth (13.85% vs. 35.38% P=0.023) postoperative days, the cognitive scores of the two groups differed significantly. On the second, third, and fourth days, 14 (21.54%) and 9 (13.85%) patients in the normothermic group experienced cognitive impairment, while 28, 30, and 23 patients in the hypothermic group experienced cognitive impairment.[11]

Martin et al. evaluated the neurologic risks and myocardial advantages of normothermic vs hypothermic cardiopulmonary bypass. The warm group had a much higher incidence of perioperative stroke (3.1% compared to 1.0%; p = 0.02) and total neurologic events (normothermic, 4.5%; hypothermic, 1.4%; p < 0.005). Perioperative stroke (normothermic 15 vs. hypothermic 5; p-value <0.02 for perioperative encephalopathy i.e. 1 cold and 2 warm patients while delayed stroke among 1 cold and 5 warm patients during in hospital stay of ≥3 days were documented. Upon discharge, each stroke patient exhibited a persistent neurological deficit. Consequently, substantial evidence from this large prospective, randomised study indicates that warm heart surgery is associated with a significantly elevated incidence of neurologic impairment.[12]

Postoperative neurological dysfunction has been studied in regional literature. But the role of systemic temperature during CPB has not been studied well in our part of the world. Hypothermic and normothermic CPB have resulted in apparently contradictory cardiac and neurologic outcomes. The aim of this research was to conduct a comprehensive analysis comparing outcomes for individuals who had CABG with normothermic vs hypothermic CPB temperatures. Therefore aim of this study is to compare the incidence of postoperative neurological dysfunction in patients undergoing CABG with systemic normothermia versus systemic hypothermia during CPB.

Methodology

The study was a randomised controlled trial undertaken in the Cardiac Surgery Department of Punjab Institute of cardiology, Lahore. A total of 120 cases (60 in each group) were determined using a 5% significance level and 80% research power, with anticipated population proportions of cognitive impairment at 21.54% for the normothermic group and 43.08% for the hypothermic group. [11] A non-probability sequential sampling method was used to recruit patients. Group A was named to Normo-thermic patients considering >34°C intraoperative temperature during PCB while Group B was considered for the patients having intraoperative body temperature of 28-34°C. Further patients having CABG with cardiopulmonary bypass, Aged 45-65 years, all genders and preoperative echocardiography with ejection fraction >40% were included. Patients having preoperative carotid artery disease, prior history of atrial fibrillation, neurological dysfunction, and arrhythmias, off pump CABG, emergency / Salvage surgery and redo operations were excluded from study.

Data was input into SPSS version 20.00. Quantitative factors such as age, height, weight, BMI, CPB time, cross-clamp time, and ejection fraction were provided as mean ± standard deviation. Qualitative characteristics such as gender, smoking status, diabetes mellitus, hypertension, hyperlipidaemia, familial history of coronary artery disease, neurological dysfunction, stroke, delirium, and postoperative cognitive loss were provided as frequency and percentage in both groups. Significance was calculated using chi-square testof the difference between the two groups (normothermia vs hypothermia). The data was categorised by age, gender, diabetes mellitus, hypertension, and neurological impairment. A P-value of < 0.05 is deemed significant.

Results

The mean age of the cases in group A was 56.62 ± 4.65 years while in group B mean age was 56.92 ± 5.96 years. There were 48 (80%) males and 12 (20%) females in Group A. Similarly, 52 (86.7%) males and 8 (13.3%) females were in Group B. The mean weight, height, BMI and EF was found insignificant in both groups i.e., P-value 0.316, 0.061, 0.812 and 0.399 respectively. However, the mean EF, NYHA class and EuroSCORE showed insignificant results 0.870, 0.531 and 0.708 respectively. (Table 1)

Table 1: *Descriptive statistics of Demographic and Clinical variables*

Type of Group		Normothermia (>34°C)	Hypothermia (28°C-34°C)	P-Value
Age (years)		56.62 ± 4.65	56.92 ± 5.96	0.759
Gender	Male	48 (80%)	52 (86.7%)	0.327
	Female	12 (20%)	8 (13.3%)	
Weight (kg) Mean±SD		73.33 ± 12.63	75.75 ± 13.63	0.316
Height (cm) Mean±SD		168.53 ± 9.84	165.45 ± 7.87	0.061
BMI Mean±SD		28.25 ± 18.41	27.66 ± 4.88	0.812
Ejection Fraction (EF%) Mean±SD		53.43 ± 7.80	52.20 ± 8.15	0.399

In this study 36 (60%) diabetic, 37 (61.7%) hypertensive, 46 (76.7%) patients with hyperlipidemia, 45 (75%) smokers and 28 (46.7%) patients with family history were found in Group A while 37 (61.7%) diabetic, 31 (51.7%) hypertensive, 41 (68.3%) patients with hyperlipidemia, 27 (45%) smokers and 20 (33.3%) patients with family history were found in Group B. The results for diabetes, hypertension, hyperlipedemia and family history were found insignificant (P-values 1.00, 0.357, 0.414 and 0.192.) However, smoking status showed significant P-value 0.001. (Table 2)

Table 2: *Descriptive statistics of risk factors*

Type of Group	Normothermia (>34°C)	Hypothermia (28°C-34°C)	P-Value
Diabetes	36 (60%)	37 (61.7%)	1.00
Hypertension	37 (61.7%)	31 (51.7%)	0.357
Hyperlipedemia	46 (76.7%)	41 (68.3%)	0.414
Smoking	45 (75%)	27 (45%)	0.001
Family History	28 (46.7%)	20 (33.3%)	0.192

The results of this study showed that the mean CPB and aortic cross clamp time in Group A was 93.82 ± 5.93 and 63.33 ± 9.45 minutes while in Group B mean CPB and cross clamp time was 110.37 ± 11.89 and 77.48 ± 10.19 minutes showing significant results (P-values < 0.001 respectively.) (Table 3)

Table 3: *Comparison of Intra and Post-Operative variables*

Type of Group	Normothermia (>34°C)	Hypothermia (28°C-34°C)	P-Value
CPB in Min	93.82 ± 5.93	110.37 ± 11.89	< 0.001
Aortic Cross Clamp (XCL)	63.33 ± 9.45	77.48 ± 10.19	< 0.001

In this study neurological dysfunction, stroke, delirium and POCD was observed in 24 (40%), 0 (0%), 12 (20%) and 12 (20%) cases in Group A, while 17 (28.3%), 0 (0%), 7 (11.7%) and 10 (16.7%) cases in Group B respectively. However, this difference was statistically insignificant (P-value 0.248, 0.317, and 0.814 respectively.) (Table 4)

Table 4: *Comparison of Post-Operative variables*

Type of Group		Normothermia (>34°C)	Hypothermia (28°C-34°C)	P-Value
Neurological Dysfunction	Yes	24 (40%)	17 (28.3%)	0.248
	No	36 (60%)	43 (71.7%)	
Stroke	Yes	0 (0%)	0 (0%)	NA
	No	60 (100%)	60 (100%)	
Delirium	Yes	12 (20%)	7 (11.7%)	0.317
	No	48 (80%	53 (88.3%)	
POCD	Yes	12 (20%)	10 (16.7%)	0.814
	No	48 (80%)	50 (83.3%)	

The results showed that male patients had a higher frequency of neurological dysfunction in both groups as compared to females, but gender did not significantly modify the outcome ($p > 0.05$). Similarly, neurological dysfunction was more frequent in patients ≤55 years in the normothermic group; however, age stratification did not show a statistically significant association ($p > 0.05$) (Table 5).

Diabetic patients showed a slightly higher frequency of neurological dysfunction, but diabetes did not act as an effect modifier ($p > 0.05$). Similarly, hypertension showed no statistically significant association with postoperative neurological dysfunction after stratification ($p > 0.05$). (Table 6)

Table 5: *Stratification of age, gender and neurological dysfunction*

Type of Group		Normothermia (>34°C)	Hypothermia (28°C-34°C)	P-Value
Male	Yes	17 (29.2%)	11 (21.2%)	0.368
	No	34 (70.8%)	41 (78.8%)	
Female	Yes	3 (25%)	1 (12.5%)	0.619
	No	9 (75%)	7 (87.5%)	
≤55	Yes	10 (34.5%)	4 (18.2%)	0.225
	No	19 (65.5%)	18 (81.8%)	
>55	Yes	7 (22.6%)	8 (21.1%)	1.00
	No	24 (77.4%)	30 (78.9%)	

Table 6: *Stratification of diabetes, hypertension and neurological dysfunction*

Type of Group	Neurological Dysfunction	Normothermia (>34°C)	Hypothermia (28°C-34°C)	P-Value
Diabetic	Yes	9 (25%)	8 (21.6%)	0.787
	No	27 (75%)	29 (78.4%)	
Non Diabetic	Yes	8 (33.3%)	4 (17.4%)	0.318
	No	16 (66.7%)	19 (82.6%)	
Hypertensive	Yes	9 (24.3%)	7 (22.6%)	0.549
	No	28 (75.7%)	24 (77.4%)	
Non Hypertensive	Yes	8 (34.8%)	5 (17.2%)	0.201
	No	15 (65.2%)	24 (82.8%)	

Discussion

Cardiopulmonary bypass, enabling modern cardiac surgery, is one of the twentieth century's most significant medical advances However, it is associated with other perioperative issues, including coagulopathy, cognitive decline, and renal dysfunction.[13] Despite these drawbacks, there is overwhelming support for employing hypothermic temperatures during CPB for myocardial and multiorgan protection against ischemic damage.[14] The optimal CPB temperature during cardiac surgery remains debated, with both mild hypothermia and normothermia advocated. Although mild hypothermia may preserve myocardial function and reduce postoperative neurological dysfunction, hypothermic CPB has been associated with perioperative complications, including coagulopathy, delayed post-anesthesia recovery, and impaired drug metabolism.[15] Moreover, moderate hypothermia during CPB has not demonstrated clear neuroprotective benefits over normothermia. This research aims to investigate the prevalence of neurological damage in individuals with systemic hypothermia and normothermia after CABG.

The mean age of the cases in Group A was 56.62 ± 4.65 years and in Group B mean age was 56.92 ± 5.96 years. There were 48 (80%) males and 12 (20%) females in Group A, similarly, 52 (86.7%) males and 8 (13.3%) females in Group B. In a previous study by Ziyaeifard et al, (2021), the mean ± SD age was 60.36 ± 7.80 years in the normothermic group and 60.60 ± 7.50 years in the hypothermic group. Females comprised the majority of participants, accounting for 44 (67.69%) and 45 (69.23%) in the normothermic and hypothermic groups, respectively.[11]

The results of our study showed that the mean CPB and cross clamp time in Group A was 93.82 ± 5.93 and 63.33 ± 9.45 minutes while in Group B mean CPB and cross clamp time was 110.37 ± 11.89 and 77.48 ± 10.19 minutes showing significant results (P-values < 0.001 respectively.) Similarly, in the study by Ziyaeifard et al, (2021) the mean CPB time in normothermia group was 71.16 ± 15.43 while in hypothermia group was 86.12 ± 26.98 with significant P-value <0.001. Likewise, the mean cross clamp time was 40.04 ± 1.28 and 47.23 ± 19.57 in normothermia and hypothermia groups, respectively.[11]

The present study demonstrated insignificant difference (p>0.05) in the frequency of postoperative neurological dysfunction between patients managed with systemic normothermia vs. hypothermia during cardiopulmonary bypass. Notably, no cases of postoperative stroke were observed in either group. Furthermore, the incidence of delirium and postoperative cognitive dysfunction was comparable between the two temperature strategies, indicating similar neurological safety profiles. In this study neurological dysfunction, stroke, delirium and POCD were observed in 24 (40%), 0 (0%), 12 (20%) and 12 (20%) cases in Group A while 17 (28.3%), 0 (0%), 7 (11.7%) and 10 (16.7%) cases in Group B, respectively. However, these differences were statistically insignificant P-value 0.248, 0.317, and 0.814, respectively. Maintaining normothermia during cardiopulmonary bypass is not linked to a higher risk of neurological problems, according to our findings. Although a smaller systemic review from 2001 suggested that hypothermia was linked to a decrease in non-fatal strokes[16] and it can, theoretically protect the central nervous system during times of cerebral ischemia, our results were unable to confirm this benefit. Poncelet et al. discovered that the normothermic approach was superior to the hypothermic approach for neurological status.[17]

One week after surgery, the hypothermia groups' cognitive abilities improved for Boodhwani et al.[18] A different study conducted in 2007 found no significant differences between normothermic and hypothermic methods at the time of discharge,[19] and in agreement with results of present study.

Hiraoka et al. assessed patients' cognitive abilities following aortic arch replacement surgery using the Mini Mental State Examination (MMSE) questionnaire. The hypothermic group experienced less severe cognitive damage three weeks and six months following surgery than the normothermic group. The type of operation, the timing of postoperative cognitive function assessment, and the use of deep hypothermia in their investigation could all be factors for this discrepancy.[20]

Conclusion

There was insignificant difference among normothermic and hypothermic cardiopulmonary bypass groups in terms of the incidence of postoperative neurological dysfunction (stroke, delirium, or POCD.) These findings suggest that systemic normothermia during cardiopulmonary bypass is a safe and acceptable strategy related to neurological dysfunction, even in patients who are traditionally managed with lower temperatures. Given the absence of clear neurological benefit and the potential risks associated with mild hypothermia, routine use of normothermia may be considered equally safe or a preferable approach in routine coronary artery bypass grafting. Further studies with larger sample sizes, studying the effects of normothermia on myocardial protection and other end-organs (e.g. kidneys) may be needed to affirm the results of this study.

Ethical Approval: The IRB/EC approved this study via letter no. RTPGME-Research-426 dated September 12, 2025.

Conflict of Interest: None

Funding Source: None

Authors' Contribution

UZ: Conception.

MSA: Design of the work.

ZF, MM, AS: Data acquisition, analysis, or interpretation.

ZF, MM, AS: Draft the work.

UZ, MSA: Review critically for important intellectual content.

All authors approve the version to be published.

All authors agree to be accountable for all aspects of the work

References

1. Kaplan M, Karaagac A, Can T, Yilmaz S, Yesilkaya MI, Olsun A, et al. Open heart surgery at patient's own temperature without active cooling. Heart Surg Forum. 2018;21(3):E132-8.
2. Caputo M, Pike K, Baos S, Sheehan K, Selway K, Ellis L, et al. Normothermic versus hypothermic cardiopulmonary bypass in low-risk paediatric heart surgery: a randomised controlled trial. Heart. 2019;105(6):455-64.
3. Baos S, Sheehan K, Culliford L, Pike K, Ellis L, Parry AJ, et al. Normothermic versus hypothermic cardiopulmonary bypass in children undergoing open heart surgery (thermic-2): study protocol for a randomized controlled trial. JMIR Res Protoc. 2015;4(2):e59.
4. Aydemir NA, Harmandar B, Karaci AR, Erdem A, Yurtseven N, Sasmazel A, et al. Randomized comparison between mild and moderate hypothermic cardiopulmonary bypass for neonatal arterial switch operation. Eur J Cardiothorac Surg. 2012;41(3):581-6.
5. Rasmussen BS, Sollid J, Rees SE, Kjaergaard S, Murley D, Toft E. Oxygenation within the first 120 h following coronary artery bypass grafting: influence of systemic hypothermia (32 degrees C) or normothermia (36 degrees C) during the cardiopulmonary bypass: a randomized clinical trial. Acta Anaesthesiol Scand. 2006;50(1):64-71.
6. Cakir H, Gur O, Ege T. Comparison of the efficacy of cardiac hypothermia and normothermia to myocardial damage in coronary artery bypass graft surgery with systemic normothermic cardiopulmonary bypass. J Cardiovasc Surg (Torino). 2013;54(3):397-401.
7. Grigore AM, Mathew J, Grocott HP, Reves JG, Blumenthal JA, White WD, et al. Prospective randomized trial of normothermic versus hypothermic cardiopulmonary bypass on cognitive function after coronary artery bypass graft surgery. Anesthesiology. 2001;95(5):1110-9.
8. Rees K, Beranek-Stanley M, Burke M, Ebrahim S. Hypothermia to reduce neurological damage following coronary artery bypass surgery. Cochrane Database Syst Rev. 2001;(1):CD002138.
9. Grimm M, Czerny M, Baumer H, Kilo J, Madl C, Kramer L, et al. Normothermic cardiopulmonary bypass is beneficial for cognitive brain function after coronary artery bypass grafting—a prospective randomized trial. Eur J Cardiothorac Surg. 2000;18(3):270-5.

10. Nandate K, Muranaka K, Shinohara K, et al. Normothermic cardiopulmonary bypass: effect on the incidence of persistent postoperative neurological dysfunction following coronary artery bypass graft surgery. J Anesth. 1997;11:117-20.
11. Ziyaeifard M, Ghavidel A, Moradi A, Fatahi M, Salehzadeh A, et al. Comparison of the effects of hypothermia and normothermia on cognitive functions after coronary artery bypass surgery. Multidiscip Cardiovasc Ann. 2021;12(2):e111442.
12. Martin TD, Craver JM, Gott JP, Weintraub WS, Ramsay J, Mora CT, et al. Prospective, randomized trial of retrograde warm blood cardioplegia: myocardial benefit and neurologic threat. Ann Thorac Surg. 1994;57(2):298-304.
13. Paparella D, Yau TM, Young E. Cardiopulmonary bypass induced inflammation: pathophysiology and treatment. An update. Eur J Cardiothorac Surg. 2002;21(2):232-44.
14. 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.
15. 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;7:230-42.
16. You JS, Kim JY, Yenari MA. Therapeutic hypothermia for stroke: unique challenges at the bedside. Front Neurol. 2022;13:951586.
17. Poncelet AJ, van Steenberghe M, Moniotte S, Detaille T, Beauloye C, Bertrand L, et al. Cardiac and neurological assessment of normothermia/warm blood cardioplegia vs hypothermia/cold crystalloid cardioplegia in pediatric cardiac surgery: insight from a prospective randomized trial. Eur J Cardiothorac Surg. 2011;40(6):1384-90.
18. Boodhwani M, Rubens FD, Wozny D, Rodriguez R, Alsefaou A, Hendry PJ, et al. Predictors of early neurocognitive deficits in low-risk patients undergoing on-pump coronary artery bypass surgery. Circulation. 2006;114(1 Suppl):I461-6.
19. Boodhwani M, Rubens F, Wozny D, Rodriguez R, Nathan HJ. Effects of sustained mild hypothermia on neurocognitive function after coronary artery bypass surgery: a randomized, double-blind study. J Thorac Cardiovasc Surg. 2007;134(6):1443-52.
20. Hiraoka K, Kawatsu S, Mori E, Saiki Y. Total aortic arch replacement using hypothermic circulatory arrest with antegrade selective cerebral perfusion: are there cerebral deficits other than frank stroke? Gen Thorac Cardiovasc Surg. 2012;60(6):345-9.