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Original Article

Comparison of Balanced Anaesthesia and Total Intravenous Anaesthesia in Cardiac Surgery: Effects on Inflammation and Recover

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ABSTRACT

Background: Having heart surgery with a heart-lung machine causes a reaction in the body that can affect how quickly someone gets better after the operation. Objective: To see how using medicines for anesthesia compares to using medicines that go into the veins for anesthesia. The comparison is about how each affects the bodys response to inflammation the way the heart and blood pressure work and how quickly people get better after the surgery. The surgery in question is when a patient has an artery bypass graft with a heart-lung machine. Methods: This study had 80 people aged between 45 and 70 years. They were assigned to one of two groups in a 1 to 1 ratio. One group had a mix of medicines and some other drugs. The other group had medicines that go into the vein. The study looked at two substances in the blood called IL-6 and TNF-alpha before the surgery after the heart-lung machine was stopped and 24 hours later. Other things looked at were blood pressure, heart rate how long it took for the patient to breathe on their own after the operation. How long they stayed in the intensive care unit. The final results had 76 people with 38 in each group. Results: After the heart-lung machine was stopped the group with medicines had less IL-6 in their blood than the group with medicines in the veins (142.5±22.4 vs 168.3±26.1 pg/mL; average difference −25.8 95% CI −36.8 to −14.8; p<0.001) as well as less TNF-alpha (32.4±5.1 vs 38.9±6.3 pg/mL; average difference −6.5, 95% CI −9.1 to −3.9; p<0.001). There was a difference in how the two groups responded over time for IL-6 and TNF-alpha. The group with medicines had shorter time to breathing on their own (5.8±1.2 vs 7.4±1.6 hours; p<0.001) and spent less time in the intensive care unit (2.1±0.4 vs 2.6±0.6 days; p<0.001). The highest level of IL-6 after the operation was linked to how the patient needed a breathing machine (r=0.64; p<0.001). In this study using medicines for anesthesia was linked with lower levels of IL-6 and TNF-alpha after the operation and shorter time to get better than using medicines in the veins. These results suggest that using medicines might help with how the body deals with inflammation and how quickly someone gets better after the surgery. However the small number of people, in the study and the ones who were not included after randomization need to be considered. Keywords: Anesthesia, Intravenous; Anesthetics, Inhalation; Cardiopulmonary Bypass; Interleukin-6; Tumor Necrosis Factor-alpha; Coronary Artery Bypass; Intensive Care Units; Postoperative Recovery

INTRODUCTION

Cardiac surgery that uses a heart-lung machine is linked to a body- immune reaction. This happens because the blood comes into contact with the machine the surgery causes damage to body tissues and there is a problem with blood flow going back after being cut off (1,2). When this happens the bodys immune system starts to react. This leads to levels of certain chemicals in the blood like IL-6 and TNF-α. These chemicals usually go up after the heart-lung machine is used and then go down as the patient starts to get better after the surgery. How strong this reaction is and how long it lasts might cause

problems with how organs work after surgery and slow down the recovery (2,3). This makes it important for the doctors to think about how to control this reaction during the time around the surgery (3).

Different types of anaesthesia have effects on the body. One type uses inhaled drugs and the other uses a drug given through a vein. These two types have ways of working in the body that might affect how the body reacts to the heart-lung machine. Inhaled drugs have been studied for their ability to protect the heart and other cells (4-6). They may help reduce the damage from lack of blood flow. Then the return of blood flow. The other drug, called propofol has properties that can reduce substances in the body during the return of blood flow. These differences, in how the drugs work give a reason to compare them in patients who are having heart surgery.. Just because there is a reason to think they work differently does not mean they will have different results after the surgery (4).

Previous studies have looked at anaesthesia and TIVA when it comes to how the body reacts with inflammation how patients recover after surgery how the lungs function and other things that happen around the time of surgery (3,7–9).. The results from these studies have not always been the same. This might be because the patients in the studies were different the surgeries they had were different the ways anaesthesia was given were different how outcomes were defined changed and when they checked for results after surgery was different. Especially the connection between the way anaesthesia was given during surgery how inflammation markers changed over time. How quickly patients recovered is still important. This is because changes in markers of inflammation might not always mean that the time a patient needs a breathing tube or how long they stay in the care unit will change (2,3,7,8).

Because of this this study was a controlled trial. It compared anaesthesia that used vapours with anaesthesia that used propofol in patients who had planned heart bypass surgery using a heart-lung machine. The goal was to see how the levels of IL-6 and TNF-α changed after surgery between the two types of anaesthesia. It also looked at differences, in how the heart and blood pressure worked during surgery how long it took to take the breathing tube out after surgery. How long patients stayed in the intensive care unit.

MATERIALS AND METHODS

This study was done at a hospital in the Khanewal area. The hospital deals with heart and chest problems. The study happened between May 2025 and January 2026. People between 45 and 70 years old who needed heart surgery were checked to see if they could join the study. The people had to be in health and have a heart that works well. People who needed emergency surgery or had problems with their liver or kidneys or had other health issues or had taken certain medicines recently or had a bad reaction to medicines in the study were not allowed to take part.

A total of 80 people who fit the rules were split into two groups. Each group had the number of people. One group had a type of medicine to keep them asleep that was inhaled. The other group had medicine through a tube into the blood. A computer made the list of who would go in which group. The list was kept secret. A person who was not part of the study opened the list after the patient got to the surgery room. The doctor who gave the medicine knew which group the patient was in because the medicines were different. The patients, the doctors who did the surgery the people who took care of the patient after surgery and the people who checked the results did not know which group the patient was, in.

The people who had the medicine got a medicine to start the sleep and then more medicine to keep them asleep. They also got a medicine that helped with pain. The people who had the medicine through the tube got a medicine to start the sleep and then more medicine to keep them asleep. They also got the pain medicine. The type of medicine was used through the surgery until the patient was taken to the recovery room. The use of the medicine was written down in a computer record.

The primary outcomes were serum IL-6 and TNF-α concentrations. Biomarkers were quantified using enzyme-linked immunosorbent assays at three predefined assessment points: baseline before induction of anaesthesia, immediately after cardiopulmonary bypass, and 24 hours postoperatively. Secondary outcomes comprised perioperative mean arterial pressure and heart rate, time to tracheal extubation, and intensive care unit length of stay.

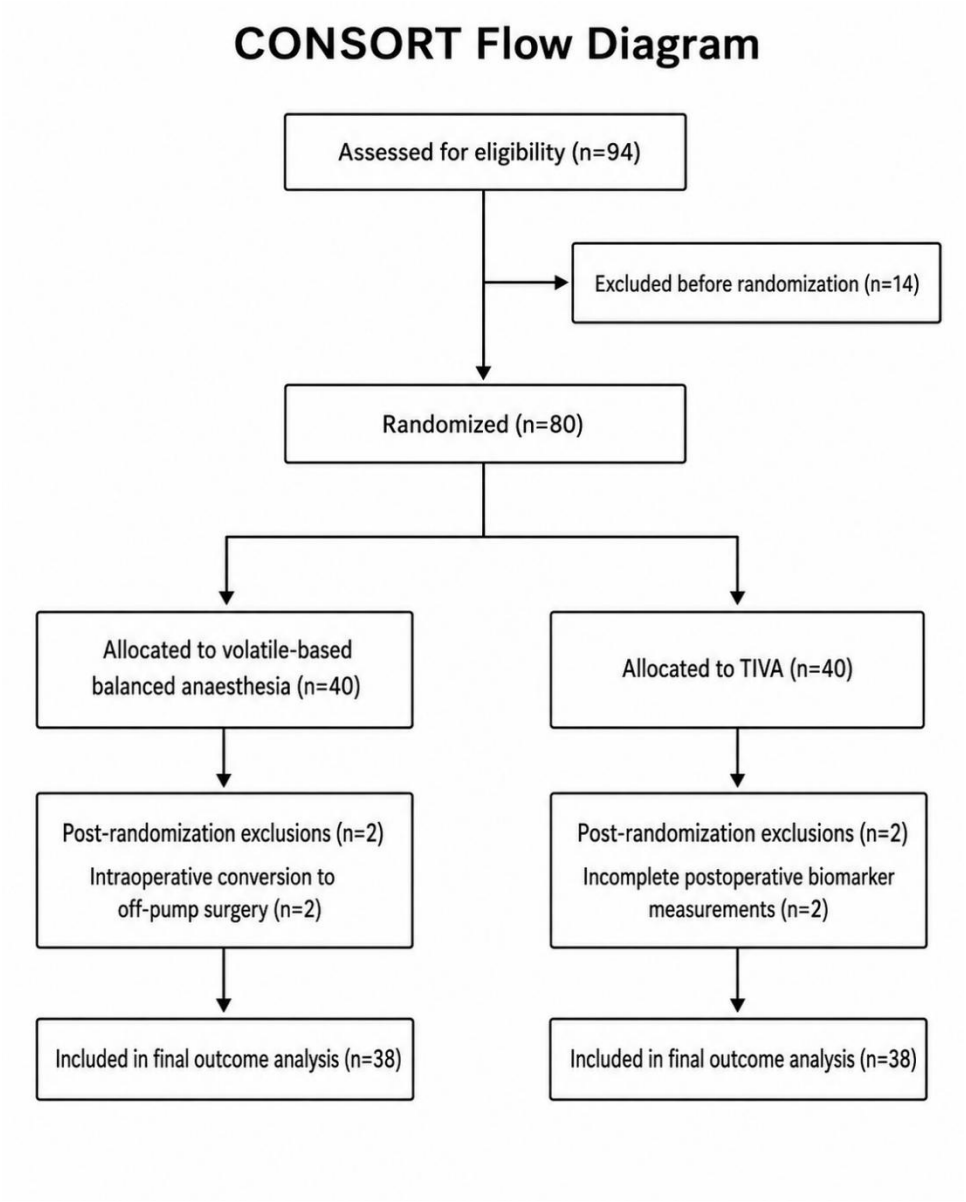

Figure 1 CONSORT Flowchart

Data distributions were assessed using the Shapiro–Wilk test. Between-group comparisons at individual assessment points were performed using independent-samples t-tests, whereas paired t-tests were used for within-group comparisons over time. Repeated-measures analysis of variance was used to evaluate temporal changes and the time × treatment-group interaction for repeated measurements. Pearson correlation analysis was used to assess the association between peak postoperative IL-6 concentration and the duration of mechanical ventilation. Statistical significance was defined as $p<0.05$. Outcome analyses were based on participants with analysable outcome data after post-randomization exclusions and incomplete biomarker measurements.

RESULTS

A total of 94 patients were screened during the study period, of whom 80 fulfilled the eligibility criteria and underwent randomization. Forty participants were allocated to volatile-based balanced anaesthesia

and 40 to TIVA. Four randomized participants did not contribute to the final outcome analysis. In the volatile-based anaesthesia group, two participants underwent intraoperative conversion to off-pump surgery. In the TIVA group, two participants had incomplete postoperative biomarker measurements. Consequently, the reported final outcome analysis included 76 participants, with 38 in each group.

Baseline characteristics of the full randomized population are presented in Table 1. The mean age of the study population was 58.4±6.2 years, 54 participants (67.5%) were male, mean body mass index was 26.8±3.1 kg/m², and mean left ventricular ejection fraction was 52.3±5.8%. Baseline characteristics were descriptively similar between the randomized groups.

Table 1. Baseline demographic and clinical characteristics of the randomized participants (N=80)

Characteristic	Total sample (N=80)	Volatile group (n=40)	TIVA group (n=40)
Age, years, mean ± SD	58.4 ± 6.2	57.9 ± 6.4	58.9 ± 6.0
Male sex, n (%)	54 (67.5)	28 (70.0)	26 (65.0)
Body mass index, kg/m², mean ± SD	26.8 ± 3.1	27.1 ± 3.3	26.5 ± 2.9
Left ventricular ejection fraction, %, mean ± SD	52.3 ± 5.8	52.8 ± 6.1	51.8 ± 5.5

Abbreviations: SD, standard deviation; TIVA, total intravenous anaesthesia.

The levels of biomarkers like IL-6 went up a lot after the cardiac surgery procedure called CPB in both groups of patients. These levels then went down by twenty four hours after the operation. They were still higher than what they were before the surgery.

After the CPB procedure the average level of IL-6 was one hundred forty two point five in the group that got volatile treatment and one hundred sixty eight point three in the group that got TIVA treatment. This means the difference between the two groups was twenty five point eight. At twenty four hours the level of IL-6 was still lower in the group with an average of eighty eight point two compared to one hundred four point six in the TIVA group. The difference here was sixteen point four.

The same thing happened with TNF-α. After the CPB procedure the average level of TNF-α was thirty two point four in the volatile group and thirty eight point nine in the TIVA group. The difference was six point five. At twenty four hours the levels were eighteen point six and twenty two point eight with a difference of four point two.

When we looked at how the levels of IL-6 and TNF-α changed over time in both groups we found that the patterns were different. This was true for IL-6 and for TNF-α. The levels of these biomarkers changed in ways, in the two treatment groups.

Table 2. Inflammatory biomarker concentrations according to treatment group (final analysed sample, n=76)

Outcome and time point	Volatile group (n=38), mean ± SD	TIVA group (n=38), mean ± SD	Mean difference (95% CI)	p-value
IL-6, pg/mL				
Baseline	12.4 ± 2.8	12.8 ± 3.1	—	—
Post-CPB	142.5 ± 22.4	168.3 ± 26.1	−25.8 (−36.8 to −14.8)	<0.001
24 h postoperative	88.2 ± 14.7	104.6 ± 18.2	−16.4 (−23.9 to −8.9)	<0.001
TNF-α, pg/mL				
Baseline	4.1 ± 0.9	4.3 ± 1.0	—	—
Post-CPB	32.4 ± 5.1	38.9 ± 6.3	−6.5 (−9.1 to −3.9)	<0.001
24 h postoperative	18.6 ± 3.4	22.8 ± 4.1	−4.2 (−5.9 to −2.5)	<0.001

Repeated-measures ANOVA: IL-6 time × group interaction, $F(2,148)=14.62$, $p<0.001$; TNF-α time × group interaction, $F(2,148)=11.35$, $p<0.001$. The overall time effect was $p<0.001$ for both biomarkers. Abbreviations: CI, confidence interval; CPB, cardiopulmonary bypass; IL-6, interleukin-6; SD, standard deviation; TIVA, total intravenous anaesthesia; TNF-α, tumor necrosis factor-alpha.

Secondary recovery outcomes are shown in Table 3. Mean time to tracheal extubation was shorter in the volatile group than in the TIVA group (5.8±1.2 vs 7.4±1.6 hours; $p<0.001$), and mean ICU length of stay was also shorter (2.1±0.4 vs 2.6±0.6 days; $p<0.001$). Mean arterial pressure was lower in the volatile group

(72.4±6.8 vs 75.8±7.1 mmHg; p=0.038), whereas mean heart rate did not differ significantly between groups (78.5±8.4 vs 76.2±8.1 beats/min; p=0.224). Peak postoperative IL-6 concentration showed a positive correlation with total mechanical ventilation duration (r=0.64, p<0.001).

Table 3. Secondary perioperative and recovery outcomes (final analysed sample, n=76)

Outcome	Volatile group (n=38), mean ± SD	TIVA group (n=38), mean ± SD	p-value
Mean arterial pressure, mmHg	72.4 ± 6.8	75.8 ± 7.1	0.038
Heart rate, beats/min	78.5 ± 8.4	76.2 ± 8.1	0.224
Time to tracheal extubation, hours	5.8 ± 1.2	7.4 ± 1.6	<0.001
ICU length of stay, days	2.1 ± 0.4	2.6 ± 0.6	<0.001

Abbreviations: ICU, intensive care unit; SD, standard deviation; TIVA, total intravenous anaesthesia.

DISCUSSION

This study looked at patients who had heart surgery using two ways to keep them asleep during the operation. One group got medicines that you breathe in. The other group got medicines that are given through a vein. The study found that patients who got the breathing medicines had levels of certain chemicals in their blood after surgery. These chemicals are linked to inflammation. The results showed that the way the body reacts to the surgery was different depending on which type of medicine the patient got (3,7–9).

These results came along with some benefits. Patients who got the breathing medicines were able to have their breathing tube removed faster. Spent less time in the intensive care unit. This suggests that the type of medicine used to keep someone during surgery might affect how much inflammation happens and how quickly a patient recovers after heart surgery. However the study had some limitations, like the number of patients involved and the way it was done (3–7).

The changes seen in the bodys chemicals are in line with studies that looked at the same types of medicines during heart surgery. Some research suggests that breathing medicines might change the way the body deals with blood flow and stress during surgery. On the hand the medicines given through a vein might help protect the body from damage caused by harmful molecules. Still other studies have shown results when it comes to how patients recover and need oxygen. This means that the effects of the medicines might not be the same for all patients (10–12).

This study adds information by showing that some patients had lower levels of certain chemicals and recovered faster.. It doesn't prove that one way of keeping someone asleep is always better, than the other.

There are a ways that volatile anaesthesia might lead to lower levels of inflammatory markers after surgery. Volatile anaesthesia is thought to help prepare the body for surgery reduce injury from lack of blood flow protect cells and mitochondria and decrease inflammation. These things could make the response after cardiopulmonary bypass smaller.

However this study only looked at two markers, IL-6 and TNF-α in the blood. It did not look at what's happening inside the cells. So we can only guess at the reasons why volatile anaesthesia might be better based on what other studies have found.

Other researchers have tried to find out if the type of anaesthesia used can affect how well organs are protected how many resources are needed in care and how quickly inflammation goes away after surgery. But it is hard to compare these studies because they were all done a bit differently the patients were different. The hospitals had different routines (4–6,11).

We should also consider that different studies on anaesthesia have had different results. This might be because the surgeries were different the patients had health problems their heart function was different or the anaesthesia was given in different amounts. How the patients were taken care of after surgery when they were taken off the ventilator and how recovery was measured might have been different.

In our study the patients who got anaesthesia had lower blood pressure on average but their heart rates were not significantly different. This does not mean that volatile anaesthesia is better at keeping blood pressure and heart rate stable (13,14).

Other studies have found that volatile anaesthesia can have effects, on the heart and blood vessels and these effects depend on how well the heart is working and what else is being done to take care of the patient (8,9,15).

So the important thing we found was that patients who got volatile anaesthesia could be taken off the ventilator and leave the ICU sooner not that their blood pressure and heart rate were more stable (16).

Peak postoperative IL-6 showed a positive correlation with mechanical ventilation duration, suggesting that a greater inflammatory response was associated with prolonged ventilatory support in this cohort. This relationship is consistent with previous work examining associations between postoperative cytokine concentrations and ventilation duration after cardiopulmonary bypass (17). Nevertheless, correlation does not establish that elevated IL-6 directly caused delayed extubation, because both outcomes may be influenced by operative complexity, cardiopulmonary bypass exposure, perioperative physiological stress, and other clinical factors. The study's randomized parallel-group structure and repeated biomarker measurements are strengths, but several limitations remain important. The final reported outcome analysis included 76 of the 80 randomized participants, the study was conducted at a single center, and patients with left ventricular ejection fraction ≤40% were excluded, limiting generalizability to higher-risk cardiac populations. The relatively small sample also restricts precision and the ability to evaluate less frequent clinical outcomes (18). Biomarker follow-up ended at 24 hours, preventing characterization of later inflammatory resolution, and longer follow-up in larger multicenter trials would provide a more complete assessment of the relationship between anaesthetic technique, inflammatory trajectories, and clinically important recovery outcomes (19).

CONCLUSION

Volatile-based balanced anaesthesia was linked to levels of IL-6 and TNF-α after surgery compared to propofol-based TIVA in patients having elective coronary artery bypass graft surgery with cardiopulmonary bypass. The group that used anaesthesia had shorter average times to have the breathing tube removed and shorter stays in the ICU. However the haemodynamic results did not show a benefit in overall stability. These findings suggest that volatile-based anaesthesia may help reduce the inflammatory response after surgery and improve some recovery measures in the group studied.. It is not possible to say it is better overall without more research, in larger well-reported studies involving many centers.

REFERENCES

1. Cho YJ, Choi S, Lee SM, Sul M. Inflammatory response syndrome triggered by extracorporeal circuit contact activation: a comparative trial of anesthetic modalities. Perfusion. 2023;38(4):712-720.

2. Zhang Y, Han J, Wang F, Jiang L. Temporal patterns of serum interleukin-6 and tumor necrosis factor-alpha surges following cardiopulmonary bypass. Cytokine. 2020;129:155041.

3. Bonanni A, Signori A, Alicino R, Mannucci I, Gratarola A. Inflammatory cytokine kinetics and clinical performance of inhalation vs. intravenous anesthesia in adult cardiac surgery: a systematic review and meta-analysis. Eur J Anaesthesiol. 2020;37(9):781-792.

4. Tanaka K, Kawamura T, Mori Y. Pharmacological preconditioning of volatile anesthetics versus free radical-scavenging properties of propofol during cardiopulmonary bypass. J Clin Anesth. 2022;78:110654.

5. Martinez-Rendon J, Martinez-Ojeda EM, Gonzalez-Guzman R. Endothelial protection and leukocyte-endothelial interactions under propofol and sevoflurane anesthesia in coronary bypass procedures. Med Gas Res. 2022;12(3):94-101.

6. Rossaint J, Zarbock A. Volatile anesthetics and phospholipid membrane stabilization during ischemia-reperfusion injury in cardiothoracic interventions. Front Immunology. 2021;12:642311.

7. Likhvantsev VV, Grebenchikov OA, Shafer AS, Gerasimenko KV, Levikov DI. Comparative analysis of volatile balanced anesthesia and total intravenous anesthesia regarding systemic inflammatory response during cardiopulmonary bypass. Khirurgiya. 2021;11(2):45-52.

8. Yu J, Wang L, Jiang Q, Feng J. Effect of volatile anesthetics versus total intravenous anesthesia on postoperative recovery and pulmonary complications in patients undergoing cardiac surgery: a meta-analysis of randomized controlled trials. J Cardiothorac Surg. 2021;16(1):142.

9. Landoni G, Lomivorotov VV, Nigro Neto C, Monaco F, Shmyrev VA, Pasyuga VV, et al. Volatile anesthetics versus total intravenous anesthesia in patients undergoing coronary artery bypass grafting: a randomized controlled trial. J Cardiothorac Vasc Anesth. 2020;34(5):1192-1201.

10. Jalonen J, Heikkilä H, Aho M, Korttila K. Postoperative mechanical ventilation duration and weaning characteristics: a randomized comparison between volatile and intravenous anaesthetic maintenance in cardiac units. Acta Anaesthesiol Scand. 2020;64(6):754-762.

11. Meier SP, Beck-Schimmer B. Cardioprotective properties of volatile anesthetics in the context of ischemia-reperfusion injury and systemic inflammation: a clinical update. Anesth Analg. 2022;134(3):512-523.

12. Wu X, Lu Y, Cao L, Wang X. Total intravenous anesthesia using propofol versus volatile balanced anesthesia on early extubation time in elective coronary surgery: a single-center parallel trial. BMC Anesthesiol. 2021;21(1):89.

13. De Hert S, Vanhuffel L, Cromheecke S. Evaluating ICU length of stay and organ function protection under different anesthetic regimens in high-risk cardiac surgery. Eur J Anaesthesiol. 2023;40(2):98-106.

14. Jerath A, Wong K, Wasowicz M. Volatile sedation and anesthesia in the cardiac intensive care unit: effects on systemic inflammation resolution and resource utilization. Intensive Care Med. 2021;47(8):841-851.

15. Schmidt M, Reichel J, Müller J. Discrepancies in clinical outcomes between volatile and total intravenous anesthesia in cardiac surgery: a review of confounding dietary and baseline patient traits. Anaesthesia. 2022;77(4):462-471.

16. Gomez-Rios MA, Garzon-Serrano J. Right ventricular and left ventricular function profiles during volatile-induced vasodilation in cardiopulmonary bypass patients. J Cardiothorac Vasc Anesth. 2020;34(11):3010-3018.

17. Sun Y, Zhou J, Liang X. Pearson correlation analysis between early peak interleukin-6 concentration and total mechanical ventilation hours post-bypass. Clin Hemorheol Microcirc. 2023;84(2):189-197.

18. Patel S, Chang H, Roberts J. Sample size constraints and generalizability limitations of single-center randomized controlled trials in cardiac anesthesia. Trials. 2024;25(1):34.

19. Jenkins C, Morrison W, Davies L. Future directions in multi-center cardiothoracic trials: tracking long-term cytokine resolution and microRNA expressions under volatile anesthetics. Br J Anaesth. 2024;132(3):421-429.