Original Article

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TANAFFOS

Effect of Intravenous Ketamine on Extubation Time in ICU Patients Post-Coronary Artery Bypass Grafting

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Background: The rise in coronary artery disease (CAD) due to increased life expectancy has made coronary artery bypass grafting (CABG) more common. However, CABG often leads to pulmonary dysfunction from cardiopulmonary bypass (CPB)-induced inflammation. This study evaluated the effect of intravenous ketamine during anesthesia induction on ICU extubation time.

Materials and Methods: This randomized controlled trial adhered to the CONSORT guidelines and included 60 patients scheduled for CABG at the Hazrat Rasoul Akram Research Center. Patients were randomly assigned to either a ketamine (0.5 mg/kg) or a placebo group. Extubation time and respiratory parameters (SpO_2, PaO_2, $PaCO_2$) were measured and analyzed using SPSS 19 with significance at $p < 0.05$.

Results: No significant differences were observed between the control and intervention groups regarding demographic or surgical characteristics ($p>0.05$). Most patients in both groups were extubated within 6 hours of ICU admission, with no significant difference in extubation times between groups. However, the SpO_2 level was significantly higher in the ketamine group ($P=0.046$). No significant difference was found in $PaCO_2$ levels ($P=0.093$), while PaO_2 levels increased significantly in the ketamine group ($P < 0.05$).

Conclusion: This study assessed the effect of intravenous ketamine during anesthesia induction on extubation time in patients undergoing CABG. Results showed no significant impact on extubation timing, with most patients extubated within 6 hours. However, ketamine improved respiratory parameters (SpO_2 and PaO_2), suggesting potential benefits for postoperative respiratory function. Future research should explore its role in postoperative outcomes, dosing, combinations, and anti-inflammatory effects to fully assess its therapeutic value.

Keywords: Ketamine; Extubation; Intensive Care Unit; Coronary Artery Bypass Graft

INTRODUCTION

With improvements in living standards worldwide and increasing life expectancy, human longevity has increased, contributing to a higher prevalence of coronary artery disease (1, 2). The benefits of coronary artery bypass graft surgery in these patients have been well-established. Although this surgical procedure is recognized as one of the primary therapeutic and corrective options for cardiovascular diseases, it may be associated with various complications (3, 4). Cardiopulmonary bypass can impact pulmonary function due to the inflammatory response it induces, leading to impaired oxygenation, ventilation, and

perfusion abnormalities, as well as prolonged extubation time. Activation of the body's inflammatory system results in the entrapment of neutrophils within the pulmonary circulation, potentially causing lung tissue damage and reducing lung compliance (3,5,6).

Ketamine is an anesthetic drug with unique anti-inflammatory properties, capable of reducing inflammatory mediators (7). Given ketamine's distinctive role in modulating inflammatory responses, we aim to explore whether it may serve as an adjunct to standard anesthesia, potentially improving respiratory outcomes for high-risk patients. Therefore, this study aims to evaluate the specific impact of intravenous ketamine on oxygenation and extubation times in CABG patients, with a unique focus on respiratory parameters rather than extubation timing alone. By examining oxygenation markers such as SpO_2 and PaO_2, this research aims to address a gap in the anesthesia literature regarding ketamine's potential to improve postoperative respiratory function via its anti-inflammatory properties.

MATERIALS AND METHODS

We conducted this randomized controlled trial in accordance with the CONSORT guidelines. Our Institutional Ethics Committee (IR.IUMS.REC.1402.833) approved the study and registered it with the Clinical Trials Registry (IRCT20231021059795N1). The target population included patients eligible for the study and referred to the Hazrat Rasool Akram Research and Treatment Center at Iran University of Medical Sciences for coronary artery bypass grafting (CABG) surgery. Informed consent was obtained from all patients enrolled in the study.

Inclusion and Exclusion Criteria

Inclusion criteria were patients aged 40 to 80 years with ASA (American Society of Anesthesiologists) class I-III undergoing CABG. Exclusion criteria included chronic alcohol use, cerebrovascular disease, BMI>38, stroke, postoperative bleeding, excessive opioid use, prolonged surgery time, need for reoperation, underlying pulmonary disease, valve replacement surgery, ejection fraction (EF) less than 35%, preoperative creatinine levels above 1.8 mg/dl, and a history of steroid therapy.

Sample Size, Randomization, Blinding, and Researcher Intervention Protocol

Based on previous studies, including Hudetz and colleagues (8), and using a 95% confidence level and 80% power to detect a difference between groups, as determined with G*Power 3.1, 60 patients were randomly assigned to two groups: ketamine and placebo, using block randomization. Data analysis was performed using descriptive statistics, such as mean, standard deviation, frequency tables, and percentage frequencies. A significance level of 0.05 was used for all statistical tests, which were conducted in SPSS version 19. This study was a triple-blind trial, with the anesthetist, assessing nurse, patient, and statistician blinded to group assignments. Participants were divided into the ketamine and placebo groups and selected using convenience sampling. Block randomization with blocks of four was used to ensure balanced group allocation. The study drugs were placed in sealed, coded envelopes and administered by anesthesiologists not involved in the research. After anesthesia induction with a loading dose of propofol (1-2mg/kg), midazolam (0.05–0.5 mg/kg), fentanyl (2–10 mcg/kg), and atracurium (0.5 mg/kg), the intervention was administered. The ketamine group received 0.5 mg/kg (up to a maximum of 50 mg) diluted in 100 cc of saline over 5 minutes while the placebo group received an equivalent volume of saline infusion over the same period. Mechanical ventilation was standardized across patients at a tidal volume of 6–8 mL/kg to control for confounding variables. Anesthesia maintenance included a continuous infusion of fentanyl, atracurium, and midazolam at a rate of 10–15 cc/h. Continuous monitoring was maintained, including IBP, POM, ECG, bispectral index (BIS), CVP, and temperature. The BIS was maintained between 40 and 60. Anticoagulation was achieved with heparin (300–400 IU/kg) to maintain an activated clotting time above 480 seconds, with protamine sulfate (1 mg per 100 units of heparin) administered postoperatively to reverse its effects. Cardioplegia administration was at the discretion of the surgical team, and patients were subjected to induced hypothermia with a target core temperature of 30–34°C.

During cardiopulmonary bypass (CPB), hemodynamic parameters were maintained at a mean arterial pressure of 55–70 mmHg, PaO2 of 150–250 mmHg, and PaCO2 of 35–45 mmHg. Aortic clamp times and CPB durations were recorded. Blood transfusions were administered based on clinical indications, with the volume and type of transfusion documented.

Separation from CPB was managed using Epinephrine (1–20 µg/min), Dobutamine (2–20 µg/kg/min), or Norepinephrine (2–4 µg/min) as clinically indicated. Postoperatively, patients were transferred to the Intensive Care Unit (ICU) and continued on intubation and sedation with a propofol infusion (50–100 µg/kg/min). Ventilation and monitoring continued in a controlled ICU environment, where light, temperature, and noise conditions were standardized.

Extubation criteria included patient wakefulness, adequate spontaneous breathing, core body temperature ≥36°C, hemodynamic stability (with or without minimal inotropic support), absence of active bleeding, and absence of shivering(1). Criteria for weaning from mechanical ventilation included a vital capacity >15 ml/kg, alveolar-arterial oxygen gradient <35 cm H_2O with 100% oxygen, PaO2 >60 mmHg with FiO2<0.5, negative inspiratory pressure >20 cm H_2O, normal arterial pH, respiratory rate<20 breaths/min, and a dead space-to-tidal volume ratio<0.6 (9). The anesthesiologist made the final decision regarding weaning and extubation based on the patient's overall assessment. The exact time of extubation was recorded by a nurse blinded to the patient's group allocation.

To prevent bias, the questionnaires were coded so that neither participants nor researchers involved in data collection and analysis knew the group assignments.

Data Analysis

Data were analyzed using SPSS version 19. For descriptive statistics, frequency distribution tables were used for qualitative variables, and numerical indices, such as the mean and standard deviation, were used for quantitative variables. The normality of quantitative variables was assessed and confirmed using the Kolmogorov-Smirnov test. For inferential statistics, chi-square and Fisher's exact tests were used to examine the homogeneity of qualitative variables, and analysis of variance (ANOVA) was employed to compare quantitative variables. A significance level of 0.05 was considered for all tests.

RESULTS

Between April and May 2024, a total of 60 patients were enrolled in the study. No patients were excluded, resulting in 30 patients in each group. The patient allocation flow is illustrated in Figure 1.

There were no statistically significant differences in demographic characteristics or surgical variables between the control and intervention groups (P > 0.05) (Table 1, Figure 2). Within the first 4 hours after ICU admission, 7 patients (23.3%) in the control group and 9 (30%) in the intervention group were extubated. By 6 hours post-admission, 17 patients (56.7%) in the control group and 16 patients (53.3%) in the intervention group were extubated. In both groups, 10% of patients (3 patients in each group) were extubated within 8 hours of ICU admission; in the control group, 10% of patients (3 individuals were extubated within 12 hours of ICU admission, whereas in the intervention group, this proportion was 6.7% (2 individuals) (Figure 3). According to the chi-square test, there was no significant difference in the extubation time between the control and intervention groups (P>0.05).

Table 1. Comparison of background characteristics of intervention and control groups

Variable	Study Group	Count	Percentage	χ^2	P-value
Age (Year)					
40-60	Control	11	36.7	1.415	0.493
	Intervention	15	50.0		
60-70	Control	12	40		
	Intervention	8	26.7		
70-80	Control	7	23.3		
	Intervention	7	23.3		
Gender					
Male	Control	19	63.3	0.30	0.584
	Intervention	21	70.0		
Female	Control	11	36.7		
	Intervention	9	30.0		
ASA class					
1	Control	3	10.0		1.00*
	Intervention	2	6.7		
2	Control	27	90.0		
	Intervention	28	93.3		

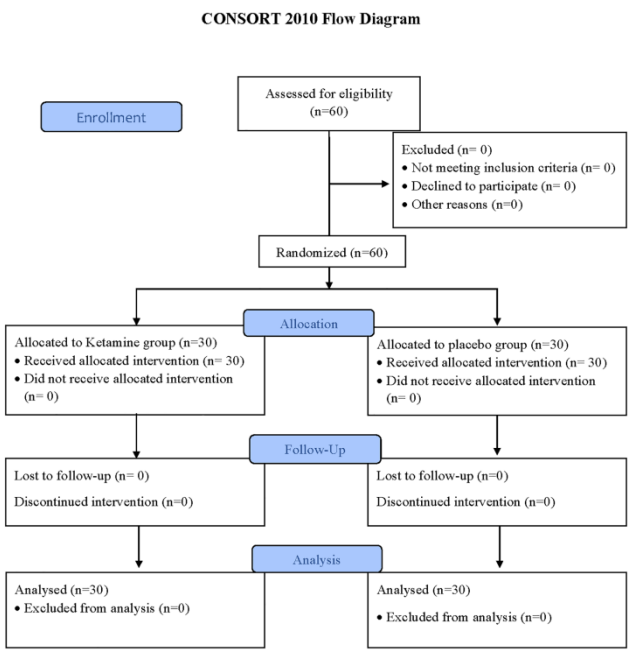


Figure 1. Participant Flow Diagram

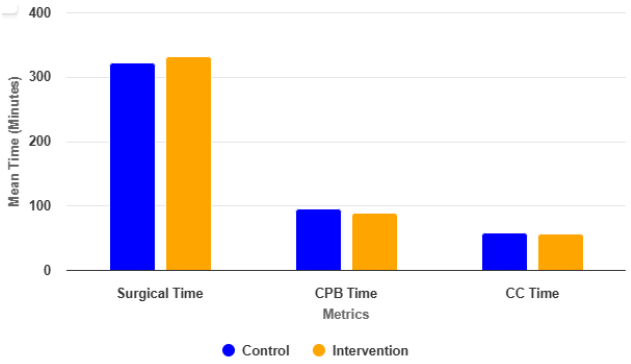


Figure 2. Comparison of surgical characteristics of control and intervention groups

The intervention resulted in a statistically significant increase in SpO_2 levels, with the intervention group consistently showing higher values than the control group across multiple time points (P=0.046). This finding suggests a positive impact of the intervention on oxygen saturation across the measured stages, though all values remained within the normal clinical range (Figure 4).

The comparative analysis of $PaCO_2$ levels between the control and intervention groups across measurement stages revealed no statistically significant differences, despite the intervention group consistently having lower $PaCO_2$ levels throughout the observation period. Upon entry, the mean $PaCO_2$ in the control group was 38.10±4.84 mmHg, whereas in the intervention group, it was 37.02±6.74 mmHg, yielding a p-value of 0.093, indicating no significant difference. During the ventilator weaning phase, the control group exhibited a mean $PaCO_2$ of 38.98±4.71 mmHg, compared with 39.46±39.00 mmHg in the intervention group (p=0.340), again indicating no significant difference. At the time of extubation, the control group had an average $PaCO_2$ of 39.77±3.73 mmHg, while the intervention group had an average $PaCO_2$ of 38.84±18.46 mmHg (p=0.400), further confirming the lack of statistical significance.

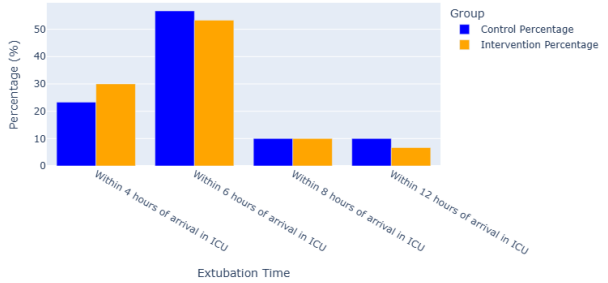


Figure 3. Comparison of extubation time of intervention and control groups

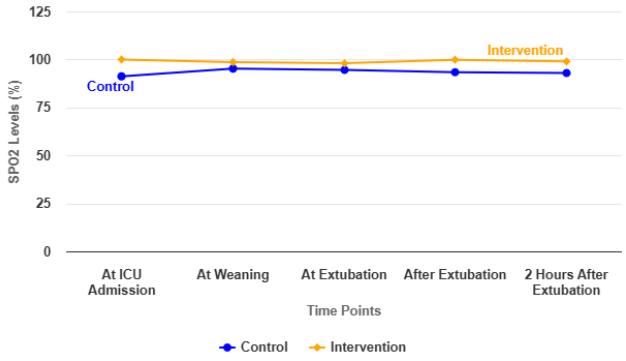


Figure 4. Comparison of SPO2 levels of intervention and control groups

Overall, the results of the independent t-tests suggest that the intervention did not produce a significant effect on $PaCO_2$ levels at any measured time point. These findings indicate that $PaCO_2$ levels remained stable in both groups, with no appreciable change in carbon dioxide retention or elimination attributable to the intervention. (Figure 5).

The independent t-test results revealed a statistically significant difference in PaO_2 levels between the intervention and control groups at all measured time points. Upon arterial blood gas (ABG) assessment following admission, the mean PaO_2 in the intervention group was 156.36, compared with 140.52 in the control group, a statistically significant difference (p=0.032). During the weaning phase from mechanical ventilation, the intervention group maintained a higher mean PaO_2 of 130.61, compared with the control group's 110.47, again demonstrating a significant difference (p=0.043). At the point of extubation, the intervention group continued to exhibit significantly elevated PaO_2 levels, with a mean of 114.21, compared to 90.53 in the control group (p = 0.031) (Figure 6). These findings suggest a consistent benefit in oxygenation in the intervention group, though the clinical relevance should be interpreted with caution, given that all PaO_2 values remained within normal ranges.

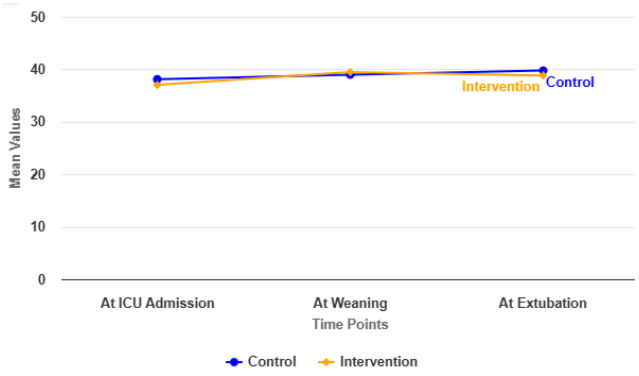


Figure 5. Comparison of average PaCO2 levels of intervention and control groups

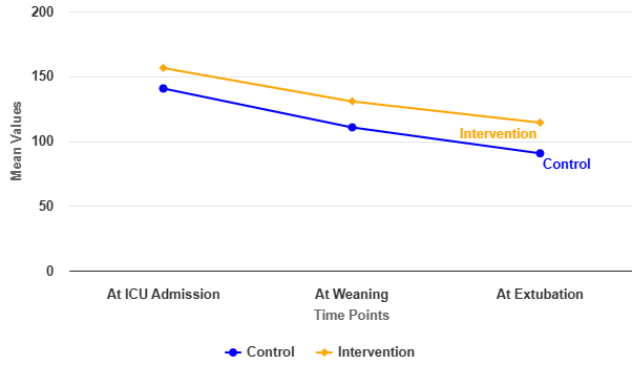


Figure 6. Comparison of PaO2 levels of intervention and control groups

As secondary objectives, the study evaluated postoperative hemodynamic parameters between the ketamine and placebo groups. The ketamine group exhibited a higher mean blood pressure (100±10 mmHg) than the placebo group (90±10 mmHg), though this difference did not reach statistical significance (P > 0.05). Similarly, the average heart rate was higher in the ketamine group (95±8 bpm) than in the placebo group (83±8 bpm) throughout the postoperative period, but this difference did not reach statistical significance (P>0.05). Notably, none of the patients in the ketamine group displayed signs of delirium or agitation.

DISCUSSION

The demand for high-quality, cost-effective care in surgical patients has led to a focus on strategies to reduce ICU stays and overall hospitalization duration (10). Coronary artery bypass grafting (CABG), an effective method for improving cardiac function and quality of life, is associated with prolonged mechanical ventilation, increased mortality, complications, and healthcare costs (11). Cardiac surgery involving cardiopulmonary bypass (CPB) often triggers a systemic inflammatory response, impairing pulmonary and cardiac function. Neutrophil activation in the lungs leads to endothelial damage, increasing capillary permeability, reducing lung compliance, and impairing gas exchange. Traditional anti-inflammatory treatments, such as corticosteroids and antioxidants, have shown limited efficacy and adverse effects, including delayed extubation times and worsened gas exchange, underscoring the need for more effective interventions (3).

Ketamine, an NMDA receptor antagonist, has shown notable anti-inflammatory properties, particularly through its ability to reduce inflammatory markers such as C-reactive protein (CRP) and interleukins IL-6 and IL-10 when administered as a single dose of 0.25 mg/kg before CPB in high-risk cardiac surgery patients (3,12,13). In elective CABG patients, ketamine effectively attenuates IL-

6 levels for up to seven days postoperatively and decreases neutrophil superoxide anion production, thereby reducing inflammatory damage. However, our study did not include measurements of acute-phase reactants such as CRP levels pre- and post-operation, which limits the direct evaluation of ketamine's anti-inflammatory effects. This limitation should be considered when interpreting our findings and addressed in future studies. Given its anti-inflammatory benefits, ketamine was selected for this study to improve extubation times and pulmonary function post-CABG (3). A ketamine infusion of 0.5 mg/kg (maximum of 50 mg) over five minutes during anesthesia induction was selected to balance efficacy and minimize potential side effects (14,15). Consequently, the administration of intravenous ketamine during anesthesia induction did not result in a significant difference in extubation time for patients undergoing CABG. A study by Kömürcü et al. evaluating the use of etomidate-midazolam versus ketamine-midazolam combinations during anesthesia induction in CABG surgery also found no statistically significant difference in postoperative mechanical ventilation time between the etomidate and ketamine groups (P=0.976) (16). Similarly, a study by Cameron et al. showed that intravenous administration of ketamine at a bolus dose of 0.5 mg/kg before skin incision, followed by an infusion of 0.5 mg/kg/hr until the end of the surgery, did not affect extubation time (P = 0.63) (17). In our study, the intervention had a notable effect on SpO_2 levels both within and between groups, with the ketamine group consistently showing higher SpO_2 than the placebo group across all measurement intervals.

Although $PaCO_2$ levels were lower in the ketamine group, the difference between the control and intervention groups did not reach statistical significance. Nevertheless, the persistent trend toward lower $PaCO_2$ levels in the ketamine group warrants further exploration, as it may suggest subtle respiratory benefits not captured by the current sample size.

Additionally, the PaO_2 levels in the ketamine group were consistently higher than those in the placebo group, further indicating ketamine's positive impact on oxygenation. In a 2020 study by Siripoonyothai and Sindhvananda, titled "Comparison between Propofol and Ketamine Infusion During Cardiopulmonary Bypass on Delirium Incidence in the First 24 Hours Postoperatively," it was found that intravenous ketamine administration had no significant impact on respiratory parameters (PaO_2 and $PaCO_2$) after the intervention, particularly in oxygenation and ventilation, compared to propofol administration. The observed difference in $PaCO_2$ levels between the two groups was close to statistical significance (P=0.07), highlighting the need for further investigation to determine the potential effects of ketamine in this context (P>0.05) (18).

Parthasarathy et al.'s study also examined the oxygenation index (P/F ratio) in two groups of patients receiving ketamine and in a control group. The P/F ratio, which represents the arterial oxygen pressure (PaO_2) to the fraction of inspired oxygen (FiO_2), is a standard measure for assessing patient oxygenation status. The study found that intravenous ketamine administration had no significant effect on the oxygenation index (P > 0.05) (19).

In our analysis, we observed a consistent improvement in PaO_2 levels, suggesting that ketamine's effects on oxygenation may be context-dependent. While ketamine did not reduce intubation times, its ability to improve oxygenation markers such as SpO_2 and PaO_2 underscores its potential benefits, likely due to its anti-inflammatory properties. This detailed investigation of ketamine's impact on respiratory parameters, particularly oxygenation, represents a novel contribution compared to prior studies, which focused primarily on extubation times and general outcomes. Although the trend toward lower $PaCO_2$ levels in the ketamine group was not statistically significant, it suggests potential respiratory advantages warranting further exploration, particularly in larger or more diverse patient populations. Highlighting these respiratory benefits contributes to the originality of this research, positioning ketamine as a potential adjunct for enhancing oxygenation without necessarily shortening extubation

times. This outcome may have practical significance, indicating that ketamine could be selectively used in anesthesia protocols for CABG patients, especially those with respiratory risks.

Clinically, these findings suggest that ketamine may improve pulmonary outcomes post-CABG by enhancing gas exchange efficiency, aligning with its role in reducing inflammatory mediators such as C-reactive protein and interleukins, common after cardiopulmonary bypass (3). Although ketamine may not directly reduce extubation time, incorporating it into anesthesia protocols could help optimize oxygenation in high-risk patients.

The improvement in oxygenation without a corresponding reduction in extubation time highlights the multifactorial nature of extubation readiness, which is likely influenced by a combination of patient-specific factors, ICU protocols, and surgical variables.

Future research should explore whether the respiratory benefits of ketamine extend to broader postoperative outcomes, including shorter ICU stays and a reduced incidence of respiratory complications. Investigating different dosages of ketamine or its use in combination with other anesthetic agents could provide valuable insights into optimizing its effects on these outcomes. Additionally, larger, multicenter trials should evaluate acute-phase reactants, such as CRP levels and interleukins, pre- and post-surgery, to better understand the scope of ketamine's anti-inflammatory effects. Such research has the potential to inform the development of optimized anesthesia protocols that improve both respiratory and systemic recovery following CABG surgery, with significant implications for reducing healthcare costs and improving patient outcomes. One of the main limitations of our study was the small sample size, which may limit the generalizability of the findings to other settings. Future studies should increase sample size and conduct multicenter research to enhance statistical power and generalizability. Furthermore, exploring the effects of ketamine in combination with other anesthetic agents across diverse patient populations with varying clinical conditions, as well as evaluating its anti-inflammatory potential in respiratory outcomes following CABG and other surgeries involving cardiopulmonary bypass, can provide deeper insights into the comprehensive impact of this drug.

CONCLUSION

This study explored the impact of intravenous ketamine administration during anesthesia induction on extubation time in patients undergoing coronary artery bypass graft (CABG) surgery. While ketamine administration during anesthesia induction did not shorten extubation time, it consistently improved oxygenation indicators (SpO_2 and PaO_2), underscoring its potential to support respiratory function in CABG patients. These findings suggest that ketamine may serve as a valuable adjunct to anesthesia protocols to enhance oxygenation. Discussing the observed respiratory benefits of ketamine within this study adds to existing knowledge and provides a basis for future investigations. Future studies should further evaluate ketamine's potential role in optimizing postoperative respiratory outcomes, investigate the effects of various dosages and combinations with other anesthetic agents, and explore its anti-inflammatory properties to better understand its comprehensive therapeutic potential.

Competing interests

The authors declare that they have no conflicts of interest.

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Data sharing statement

Data supporting the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES

1. Zhang WY, Wu WL, Gu JJ, Sun Y, Ye XF, Qiu WJ, et al. Risk factors for postoperative delirium in patients after coronary artery bypass grafting: A prospective cohort study. ***J Crit Care*** 2015;30(3):606-12.
2. Rahab M, Heydarpour E, Totonchi Z, Kachoueian N, Zeraatiannejad Davani S, et al. Effects of Dexmedetomidine on Clinical Outcomes and Renal Function after CABG. ***J Cell Mol Anesth*** 2021;6(1):31-8.
3. Parthasarathi G, Raman SP, Sinha PK, Singha SK, Karunakaran J. Ketamine has no effect on oxygenation indices following elective coronary artery bypass grafting under cardiopulmonary bypass. ***Ann Card Anaesth*** 2011;14(1):13-8.
4. Totonchi Z, Salajegheh S, Mohaghegh MR, Kiaei MM, Shirvani M, Ghorbanlo M. Hemodynamic effect of intravenous lidocaine during aortic cannulation in cardiac surgery. ***Interv Med Appl Sci*** 2017;9(2):56-60.
5. Zamani MM, Najafi A, Sehat S, Janforooz Z, Derakhshan P, Rokhtabnak F, et al. The effect of intraoperative lung protective ventilation vs conventional ventilation, on postoperative pulmonary complications after cardiopulmonary bypass. ***J Cardiovasc Thorac Res*** 2017;9(4):221-8.
6. Sehat Kashani S, Rokhtabnak F, Ghodraty M R, Zamani M M, Mesbah Kiaee M, Ghorbanlo M, et al . The Effect of Open Lung Ventilation on Respiratory Mechanics, Postoperative Organ Function, and Inflammatory Mediators in Coronary Artery Bypass Surgery. ***J Adv Med Biomed Res*** 2022; 30 (138): 12-6
7. Sangi S, Mesbah KM, Sedigh MS, Aligholizadeh M, Moradimajd P, Saei A. Shivering management in spinal anesthesia: evaluating the role of ketamine: a narrative review. ***Archives of Anesthesiology and Critical Care*** 2025; 11(1): 95-102.
8. Hudetz JA, Patterson KM, Iqbal Z, Gandhi SD, Byrne AJ, Hudetz AG, et al. Ketamine attenuates delirium after cardiac surgery with cardiopulmonary bypass. ***J Cardiothorac Vasc Anesth*** 2009;23(5):651-7.
9. Benhamou D. Stoelting's Anesthesia and Co-existing Disease**.** ***British Journal of Anaesthesia*** 2022; 128: 1059-60.
10. Bansal S, Thai HM, Hsu CH, Sai-Sudhakar CB, Goldman S, Rhenman BE. Fast track extubation post coronary artery bypass graft: a retrospective review of predictors of clinical outcomes. ***World Journal of Cardiovascular Surgery*** 2013;3(2):81-6.
11. Kumalasari RI, Kosasih CE, Priambodo AP. A Scoping Review of Factors Associated with Delayed Extubation in Post Cardiac Surgery Patients. ***Vascular Health and Risk Management*** 2025:1-15.
12. Viderman D, Aubakirova M, Nabidollayeva F, Yegembayeva N, Bilotta F, Badenes R, et al. Effect of Ketamine on Postoperative Neurocognitive Disorders: A Systematic Review and Meta-Analysis. ***J Clin Med*** 2023;12(13):4314.
13. Torsher L, editor. Advances in Anesthesia, E-Book 2022: Advances in Anesthesia, E-Book 2022. Elsevier Health Sciences; 2022.
14. Avidan MS, Maybrier HR, Abdallah AB, Jacobsohn E, Vlisides PE, Pryor KO, et al. Intraoperative ketamine for prevention of postoperative delirium or pain after major surgery in older adults: an international, multicentre, double-blind, randomised clinical trial. ***Lancet*** 2017;390(10091):267-75.
15. Perbet S, Verdonk F, Godet T, Jabaudon M, Chartier C, Cayot S, et al. Low doses of ketamine reduce delirium but not opiate consumption in mechanically ventilated and sedated ICU patients: A randomised double-blind control trial. ***Anaesth Crit Care Pain Med*** 2018;37(6):589-95.
16. Kömürcü Ö, Fırat AC, Bayraktar N, Sezgin A, Arslan G. Comparison of the hemodynamic effects of etomidate-midazolam and ketamine-midazolam combinations in anesthesia induction in coronary artery bypass surgery. ***Turkish Journal of Clinics and Laboratory*** 2023;14(1):89-94.
17. Cameron M, Tam K, Al Wahaibi K, Charghi R, Béïque F. Intraoperative Ketamine for Analgesia Post-Coronary Artery Bypass Surgery: A Randomized, Controlled, Double-Blind Clinical Trial. ***J Cardiothorac Vasc Anesth*** 2020;34(3):586-91.
18. Siripoonyothai S, Sindhvananda W. Comparison of postoperative delirium within 24 hours between ketamine and propofol infusion during cardiopulmonary bypass machine: A randomized controlled trial. ***Ann Card Anaesth*** 2021;24(3):294-301.
19. Parthasarathi G, Raman SP, Sinha PK, Singha SK, Karunakaran J. Ketamine has no effect on oxygenation indices following elective coronary artery bypass grafting under cardiopulmonary bypass. ***Ann Card Anaesth*** 2011;14(1):13-8.