



## The Analysis Study of Impact of Anesthesia on Patients with Cardiovascular Disease: A Comprehensive Systematic Review

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### ABSTRACT

**Background:** Anesthesia is a cornerstone of modern surgery, providing the necessary sedation, pain control, and muscle relaxation that make complex procedures possible. However, its effects extend far beyond simply putting patients to sleep, particularly in those with preexisting cardiovascular disease. This systematic review aims to synthesize current evidence regarding the impact of anesthesia on patients with cardiovascular disease. **Methods:** The study followed PRISMA 2020 guidelines, reviewing English-language publications from 2015 to 2025. Editorials, duplicate reviews from the same journal, and papers lacking a DOI were excluded. The literature search was conducted using PubMed, SagePub, SpringerLink, and Google Scholar. **Result:** A total of 2,172 articles were initially identified through online databases (PubMed, SagePub, SpringerLink, and Google Scholar). After three rounds of screening, eight relevant studies were selected for full-text analysis. **Conclusion:** Anesthesia significantly impacts patients with CVD, requiring careful selection of agents and techniques to minimize perioperative risks. Volatile anesthetics improve outcomes in cardiac surgery, while conscious sedation offers advantages in TAVR procedures.  $\alpha$ 2-Adrenoceptor agonists, EEG-guided anesthesia, and multidisciplinary perioperative management are essential for optimizing patient outcomes. Further research is needed to enhance perioperative care for this high-risk population.

**Keywords:** anesthesia, cardiovascular diseases, adverse events

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## INTRODUCTION

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Anesthesia is a cornerstone of modern surgery, providing the necessary sedation, pain control, and muscle relaxation that make complex procedures possible. However, its effects extend far beyond simply putting patients to sleep, particularly in those with preexisting cardiovascular disease. The cardiovascular system is inherently dynamic, continuously adjusting to maintain oxygen delivery and organ perfusion.<sup>1-3</sup>

When anesthesia is introduced, it can significantly alter these delicate physiological balances, affecting heart rate, blood pressure, and myocardial oxygen demand. In patients with underlying cardiac conditions such as coronary artery disease, heart failure, or arrhythmias, these changes can be profound and, in some cases, life-threatening. Understanding how different anesthetic techniques and agents interact with the cardiovascular system is therefore essential for optimizing patient outcomes and minimizing perioperative complications.<sup>4,5</sup>

The relationship between anesthesia and cardiovascular outcomes is complex and remains a subject of ongoing research. Some studies suggest that certain anesthetic agents, particularly volatile anesthetics like sevoflurane and isoflurane, may have cardioprotective effects by reducing ischemia-reperfusion injury and improving myocardial tolerance to surgical stress. Conversely, other anesthetics, such as propofol and high-dose opioids, have been associated with myocardial depression and hemodynamic instability in vulnerable patients.<sup>6,7</sup>

Additionally, the mode of anesthesia—whether general, regional, or a combination—can play a significant role in perioperative cardiac risk. While general anesthesia provides complete unconsciousness and muscle relaxation, it can also cause fluctuations in systemic vascular resistance and cardiac output, increasing the risk of intraoperative hypotension. On the other hand, regional anesthesia, including neuraxial techniques like spinal or epidural anesthesia, may offer benefits such as improved pain control and reduced sympathetic stimulation, potentially leading to better hemodynamic stability in high-risk patients.<sup>8-10</sup>

Recent clinical trials and meta-analyses have attempted to clarify the impact of anesthetic choices on cardiovascular outcomes, yet the findings remain mixed. Some studies indicate that volatile anesthetics may reduce myocardial injury biomarkers, such as troponin levels, and even lower the risk of major adverse cardiac events following cardiac surgery.<sup>11,12</sup> In this systematic review, we aim to synthesize current evidence regarding the impact of anesthesia on patients with cardiovascular disease.

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## METHODS

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### Protocol

The study strictly adhered to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020 guidelines to ensure methodological rigor and accuracy. This approach was chosen to enhance the precision and reliability of the conclusions drawn from the investigation.

### Criteria for Eligibility

This systematic review aims to synthesize current evidence regarding the impact of anesthesia on patients with cardiovascular disease based on literatures of the last decade. The review aimed to provide insights to improve patient treatment strategies, with an emphasis on the significance of key findings in the reviewed studies. Inclusion criteria for the study included: 1) Papers published in English, and 2) Papers published between 2014 and 2024. Exclusion criteria were: 1) Editorials, 2) Papers without a DOI, 3) Previously published review articles, and 4) Duplicate entries in journals.

### Search Strategy

The keywords used for this research are anesthesia, cardiovascular diseases, adverse events. The Boolean MeSH keywords inputted on databases for this research are: *("anaesthesia"[All Fields] OR "anesthesia"[MeSH Terms] OR "anesthesia"[All Fields] OR "anaesthesias"[All Fields] OR "anesthesias"[All Fields]) AND ("cardiovascular diseases"[MeSH Terms] OR ("cardiovascular"[All*

*Fields] AND "diseases"[All Fields]) OR "cardiovascular diseases"[All Fields] OR ("cardiovascular"[All Fields] AND "disease"[All Fields]) OR "cardiovascular disease"[All Fields]) AND (("adverse"[All Fields] OR "adversely"[All Fields] OR "adverses"[All Fields]) AND ("event"[All Fields] OR "event s"[All Fields] OR "events"[All Fields]))).*

## Data retrieval

Abstracts and titles were screened to assess their eligibility, and only studies meeting the inclusion criteria were selected for further analysis. Literature that fulfilled all predefined criteria and directly related to the topic was included. Studies that did not meet these criteria were excluded. Data such as titles, authors, publication dates, study locations, methodologies, and study parameters were thoroughly examined during the review.

## Quality Assessment and Data Synthesis

Each author independently assessed the titles and abstracts of the selected studies to identify those for further exploration. Articles that met the inclusion criteria underwent further evaluation. Final decisions on inclusion were based on the findings from this review process.

**Table 1.** Article Search Strategy

| Database       | Keywords                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Hits |
|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| Pubmed         | ("anaesthesia"[All Fields] OR "anesthesia"[MeSH Terms] OR "anesthesias"[All Fields]) AND ("cardiovascular diseases"[MeSH Terms] OR ("cardiovascular"[All Fields] AND "diseases"[All Fields]) OR "cardiovascular diseases"[All Fields] OR ("cardiovascular"[All Fields] AND "disease"[All Fields]) OR "cardiovascular disease"[All Fields]) AND (("adverse"[All Fields] OR "adversely"[All Fields] OR "adverses"[All Fields]) AND ("event"[All Fields] OR "event s"[All Fields] OR "events"[All Fields])) | 466  |
| Springer Link  | ((anesthesia) AND (cardiovascular disease)) AND (adverse events)                                                                                                                                                                                                                                                                                                                                                                                                                                         | 402  |
| Sagepub        | ((anesthesia) AND (cardiovascular disease)) AND (adverse events)                                                                                                                                                                                                                                                                                                                                                                                                                                         | 500  |
| Google Scholar | ((anesthesia) AND (cardiovascular disease)) AND (adverse events)                                                                                                                                                                                                                                                                                                                                                                                                                                         | 804  |

**Table 2.** JBI *Critical appraisal of Study*

| Parameters                                                                                                                               | Uhlig<br>(2016) | Atkinson<br>(2017) | Hymann<br>(2017) | Docherty<br>(2016) | Demiri<br>(2019) | Punjawan<br>(2018) | Nissen<br>(2016) | Farmanis<br>(2016) |
|------------------------------------------------------------------------------------------------------------------------------------------|-----------------|--------------------|------------------|--------------------|------------------|--------------------|------------------|--------------------|
| <b>1. Bias related to temporal precedence</b>                                                                                            |                 |                    |                  |                    |                  |                    |                  |                    |
| Is it clear in the study what is the “cause” and what is the “effect” (ie, there is no confusion about which variable comes first)?      | Yes             | Yes                | Yes              | Yes                | Yes              | Yes                | Yes              | Yes                |
| <b>2. Bias related to selection and allocation</b>                                                                                       |                 |                    |                  |                    |                  |                    |                  |                    |
| Was there a control group?                                                                                                               | Yes             | Yes                | Yes              | Yes                | Yes              | Yes                | Yes              | Yes                |
| <b>3. Bias related to confounding factors</b>                                                                                            |                 |                    |                  |                    |                  |                    |                  |                    |
| Were participants included in any comparisons similar?                                                                                   | Yes             | Yes                | Yes              | Yes                | Yes              | Yes                | Yes              | Yes                |
| <b>4. Bias related to administration of intervention/exposure</b>                                                                        |                 |                    |                  |                    |                  |                    |                  |                    |
| Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest? | No.             | No.                | No.              | No.                | No.              | No.                | No.              | No.                |
| <b>5. Bias related to assessment, detection, and measurement of the outcome</b>                                                          |                 |                    |                  |                    |                  |                    |                  |                    |
| Were there multiple measurements of the outcome, both pre and post the intervention/exposure?                                            | Yes             | Yes                | Yes              | Yes                | Yes              | Yes                | Yes              | Yes                |
| Were the outcomes of participants included in any comparisons measured in the same way?                                                  | No.             | No.                | No.              | No.                | No.              | No.                | No.              | No.                |
| Were outcomes measured in a reliable way?                                                                                                | Yes             | Yes                | Yes              | Yes                | Yes              | Yes                | Yes              | Yes                |
| <b>6. Bias related to participant retention</b>                                                                                          |                 |                    |                  |                    |                  |                    |                  |                    |
| Was follow-up complete and, if not, were differences between groups in terms of their follow-up adequately described and analyzed?       | Yes             | Yes                | Yes              | Yes                | Yes              | Yes                | Yes              | Yes                |
| <b>7. Statistical conclusion validity</b>                                                                                                |                 |                    |                  |                    |                  |                    |                  |                    |
| Was appropriate statistical analysis used?                                                                                               | Yes             | Yes                | Yes              | Yes                | Yes              | Yes                | Yes              | Yes                |

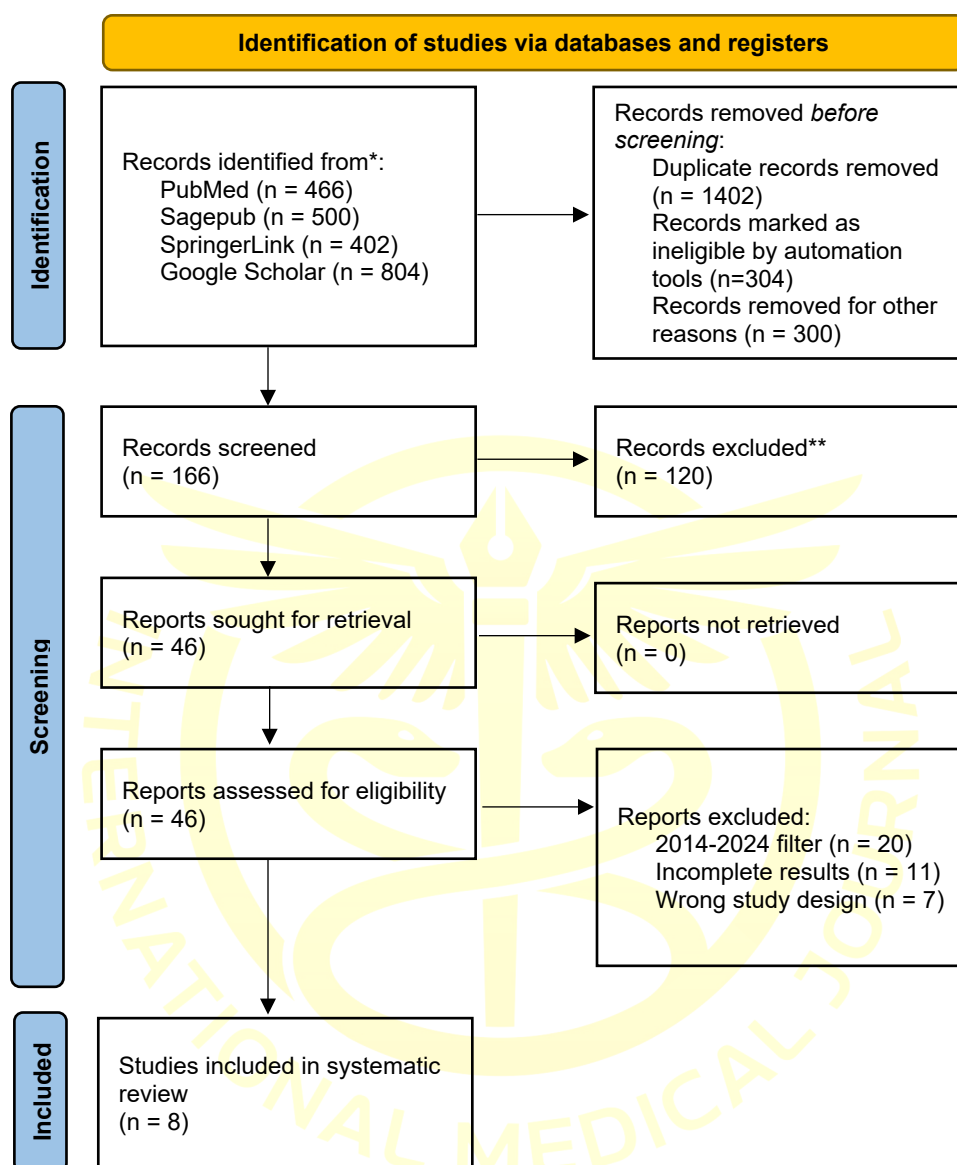


Figure 1. Article search flow chart

## RESULT

The initial number of articles retrieved from online databases (PubMed, SagePub, SpringerLink, and Google Scholar) is 2,172 articles. After conducting three levels of screening, eight articles that directly relate to the current systematic review have been chosen for further assessment through full-text reading and analysis. Table 3 presents the selected literature included in this analysis.

**Table 3. The literature included in this study**

| No. | Author                                | Origin      | Method              | Sample | Result                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-----|---------------------------------------|-------------|---------------------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.  | Uhlig, et al. <sup>13</sup> (2016)    | Multicenter | Retrospective study | 7104   | 68 randomized controlled trials involving 7,104 patients found that in cardiac surgery, the use of volatile anesthetics was associated with significantly reduced mortality (OR = 0.55, P = 0.007) and a lower incidence of pulmonary (OR = 0.71, P = 0.038) and other complications (OR = 0.74, P = 0.020) compared to total intravenous anesthesia. However, in noncardiac surgery, volatile anesthetics did not demonstrate a significant reduction in mortality (OR = 1.31, P = 0.242) or complications. These findings suggest that volatile anesthetics provide major benefits in cardiac surgery, while their role in noncardiac procedures remains uncertain, warranting further investigation. |
| 2.  | Atkinson, et al. <sup>14</sup> (2017) | USA         | Retrospective study | -      | Carbon dioxide insufflation during laparoscopic surgery can lead to significant hemodynamic and                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |

|    |                                    |     |                     |       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|----|------------------------------------|-----|---------------------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    |                                    |     |                     |       | ventilatory effects, including increased intraabdominal pressure, hypercarbia, elevated afterload and preload, decreased cardiac output, increased airway pressures, and reduced pulmonary compliance. These effects are particularly pronounced in patients with preexisting cardiovascular conditions such as heart failure, ischemic heart disease, valvular disease, pulmonary hypertension, and congenital heart defects. To minimize cardiovascular complications, a thorough understanding of these physiological changes is essential, along with a well-coordinated operative strategy developed by a multidisciplinary team involving the preoperative consultant, anesthesiologist, and surgeon. |
| 3. | Hyman, et al. <sup>15</sup> (2017) | USA | Retrospective study | 10997 | In a study of 10,997 transcatheter aortic valve replacement (TAVR) cases, conscious sedation was used in 15.8% of procedures, with its usage increasing over time ( $P<0.001$ ). Procedural success rates were similar between conscious sedation and general anesthesia (98.2% vs. 98.5%, $P=0.31$ ), but conscious sedation was associated with lower in-hospital (1.6% vs. 2.5%, $P=0.03$ ) and 30-day                                                                                                                                                                                                                                                                                                   |

|    |                                       |    |                     |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|----|---------------------------------------|----|---------------------|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    |                                       |    |                     |      | <p>mortality (2.9% vs. 4.1%, <math>P=0.03</math>). After adjusting for 51 covariates, conscious sedation remained linked to slightly lower procedural success (97.9% vs. 98.6%, <math>P&lt;0.001</math>) but significantly lower mortality at both in-hospital (1.5% vs. 2.4%, <math>P&lt;0.001</math>) and 30-day (2.3% vs. 4.0%, <math>P&lt;0.001</math>) time points. Additionally, it was associated with reduced inotrope use, shorter ICU and hospital stays (6.0 vs. 6.5 days, <math>P&lt;0.001</math>), and lower 30-day death/stroke rates (4.8% vs. 6.4%, <math>P&lt;0.001</math>). No significant differences were found in vascular complications, bleeding, or new pacemaker/defibrillator implantation. These findings suggest that conscious sedation is a safe alternative to general anesthesia for TAVR, though observational data cannot definitively establish its superiority.</p> |
| 4. | Docherty, et al. <sup>16</sup> (2016) | UK | Retrospective study | 3033 | <p>3,033 patients with cardiovascular disease assessed the impact of restrictive versus liberal transfusion strategies. No significant difference in 30-day mortality was observed between the two groups (RR = 1.15, 95% CI 0.88–1.50, <math>P=0.50</math>), with minimal heterogeneity (<math>I^2=14\%</math>). However, patients managed with a restrictive transfusion</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

|    |                       |        |                     |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|----|-----------------------|--------|---------------------|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    |                       |        |                     |      | threshold had a significantly higher risk of acute coronary syndrome compared to those receiving liberal transfusions (RR = 1.78, 95% CI 1.18–2.70, P=0.01, I <sup>2</sup> =0%). These findings suggest that a restrictive transfusion strategy (<80 g/L) may not be safe for patients with acute coronary syndrome or chronic cardiovascular disease. Given the uncertainty regarding its effects on mortality and other outcomes, a more liberal transfusion threshold (>80 g/L) should be considered until further high-quality randomized trials are conducted in this population. |
| 5. | Demiri, et al. (2019) | France | Retrospective study | 4868 | 4,868 patients found that the use of $\alpha$ 2-adrenoceptor agonists, clonidine and dexmedetomidine, was associated with frequent perioperative hypotension. Bradycardia occurred specifically with dexmedetomidine, while dexmedetomidine also provided protective effects against intraoperative hypertension and tachycardia. Subgroup analysis indicated that the risk of hypotension and bradycardia persisted even after treatment cessation. However, intraoperative hypotension and postoperative bradycardia                                                                 |

|    |                                            |          |                     |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|----|--------------------------------------------|----------|---------------------|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    |                                            |          |                     |      | were not observed when dexmedetomidine was administered as a bolus dose of less than 0.5 µg/kg or as a continuous infusion. These findings provide strong evidence that α2-adrenoceptor agonists carry a risk of hypotension and bradycardia while offering benefits in controlling hypertension and tachycardia during surgery.                                                                                                                                                                                                                                                                                                                                                                       |
| 6. | Punjasawadwong et al. <sup>17</sup> (2018) | Thailand | Retrospective study | 2929 | <p>The findings suggest that processed EEG-guided anesthesia likely reduces the risk of postoperative delirium (POD) within seven days after surgery (RR = 0.71, 95% CI 0.59–0.85) and may also lower the risk of postoperative cognitive dysfunction (POCD) at 12 weeks (RR = 0.71, 95% CI 0.53–0.96). However, its impact on POCD at one week (RR = 0.84, 95% CI 0.69–1.02) and at 52 weeks (RR = 0.30, 95% CI 0.05–1.80) remains uncertain. One trial suggested a lower risk of postoperative complications with EEG-guided anesthesia (RR = 0.51, 95% CI 0.37–0.71), while no significant effect was observed on all-cause mortality (RR = 1.01, 95% CI 0.62–1.64) or length of hospital stay.</p> |
| 7. | Nissen, et al. <sup>18</sup> (2016)        | USA      | Retrospective study | 8910 | A trial involving 8,910 overweight or obese participants with increased cardiovascular risk assessed                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

|    |                                       |        |                     |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|----|---------------------------------------|--------|---------------------|---|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    |                                       |        |                     |   | the effects of naltrexone-bupropion compared to placebo. The mean participant age was 61 years, 54.5% were female, 32.1% had a history of cardiovascular disease, and 85.2% had diabetes. In an interim analysis, major adverse cardiovascular events (MACE) occurred in 1.3% of placebo-treated patients and 0.8% of naltrexone-bupropion patients (HR = 0.59, 95% CI 0.39–0.90) at 25% of planned events. At 50% of planned events, MACE was reported in 2.3% of placebo patients and 2.0% of naltrexone-bupropion patients (HR = 0.88, adjusted 99.7% CI 0.57–1.34). Adverse effects, particularly gastrointestinal (14.2% vs. 1.9%, $P < .001$ ) and central nervous system symptoms (5.1% vs. 1.2%, $P < .001$ ), were more common in the naltrexone-bupropion group. |
| 8. | Farmakis, et al. <sup>19</sup> (2016) | Greece | Retrospective study | - | Levosimendan, an inodilator used for decompensated heart failure with low cardiac output, has pleiotropic effects beyond its inotropic properties. These include anti-inflammatory, anti-oxidative, and anti-apoptotic actions, which are not solely explained by cardiac function enhancement. However, the underlying                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

|  |  |  |  |  |                                                                                                                                                                                                                                                                                                                                 |
|--|--|--|--|--|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  |  |  |  |  | <p>mechanisms remain unclear, necessitating further mechanistic studies and well-designed clinical trials.</p> <p>This position paper, developed by 35 experts from 22 European countries, reviews existing evidence, explores potential new clinical applications, and highlights research gaps that need to be addressed.</p> |
|--|--|--|--|--|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

## DISCUSSION

Anesthesia management plays a critical role in patients with cardiovascular disease (CVD) undergoing surgery. The selection of anesthetic agents and techniques is crucial due to altered physiological responses, increased perioperative risks, and potential cardiovascular complications. This systematic review evaluates the effects of anesthesia on patients with CVD, current guidelines, and recommended anesthetic strategies based on existing evidence.<sup>20,21</sup>

Anesthetic agents influence hemodynamic stability in patients with CVD. Uhlig et al. (2016) found that volatile anesthetics reduce mortality (OR = 0.55, P = 0.007) and pulmonary complications (OR = 0.71, P = 0.038) in cardiac surgery patients compared to total intravenous anesthesia. However, in noncardiac surgeries, volatile anesthetics did not significantly affect mortality or complications.<sup>16</sup> Additionally, Atkinson et al. (2017) highlighted that carbon dioxide insufflation in laparoscopic procedures exacerbates cardiovascular instability by increasing intraabdominal pressure, leading to hypercarbia, elevated afterload, and reduced cardiac output, posing risks for patients with heart failure and ischemic heart disease.<sup>14</sup>

International guidelines emphasize tailored anesthetic approaches to minimize cardiovascular risks. The American Heart Association (AHA) and the European Society of Cardiology (ESC) recommend preoperative cardiovascular risk stratification, optimization of comorbidities, and careful anesthetic selection.

Perioperative monitoring should include continuous electrocardiography (ECG), invasive blood pressure measurement, and transesophageal echocardiography for high-risk cardiac patients. Restrictive transfusion strategies in patients with CVD remain controversial; Docherty et al. (2016) found a higher risk of acute coronary syndrome with restrictive transfusion (RR = 1.78, P = 0.01), suggesting a more liberal transfusion threshold may be beneficial.<sup>16</sup>

Volatile anesthetics provide cardioprotective effects in cardiac surgeries. Uhlig et al. (2016) demonstrated that volatile anesthetics reduce perioperative complications in cardiac surgeries. Conscious sedation in transcatheter aortic valve replacement (TAVR) procedures also offers advantages; Hyman et al. (2017) reported lower in-hospital mortality (1.6% vs. 2.5%, P = 0.03) and reduced ICU stays with conscious sedation compared to general anesthesia. This highlights the potential benefits of avoiding general anesthesia when feasible.<sup>13</sup>

$\alpha$ 2-Adrenoceptor agonists impact perioperative hemodynamics in CVD patients. Demiri et al. (2019) found that dexmedetomidine and clonidine are associated with perioperative hypotension and bradycardia, though dexmedetomidine also protects against intraoperative hypertension and tachycardia. Low doses (<0.5  $\mu$ g/kg bolus or continuous infusion) minimize adverse events, indicating the need for cautious dosing and monitoring in CVD patients.<sup>22</sup>

Postoperative cognitive dysfunction (POCD) and delirium are concerns in cardiac surgical patients. Punjasawadwong et al. (2018) found that EEG-guided anesthesia reduces the risk of postoperative delirium (RR = 0.71, 95% CI 0.59–0.85) and cognitive dysfunction at 12 weeks (RR = 0.71, 95% CI 0.53–0.96). Individualized anesthetic depth monitoring plays a key role in preventing neurocognitive complications.<sup>17</sup>

A collaborative approach is essential for optimizing anesthetic management in CVD patients. Atkinson et al. (2017) emphasized the importance of coordination between anesthesiologists, cardiologists, and surgeons in perioperative planning. Comprehensive preoperative assessment, including echocardiography and

functional stress testing, can guide intraoperative strategies and reduce complications.<sup>14</sup>

Postoperative monitoring is critical in detecting complications such as myocardial infarction, arrhythmias, and hemodynamic instability. Continuous ECG monitoring and arterial blood pressure tracking should be maintained in the immediate postoperative period, particularly for high-risk patients. Vasoactive support and optimized fluid management may benefit patients with reduced cardiac output or preexisting arrhythmias, preventing hemodynamic deterioration.<sup>23</sup>

Research gaps remain regarding the optimal anesthetic approach for different CVD subgroups. Farmakis et al. (2016) emphasized the need for mechanistic studies and randomized trials to explore the pleiotropic effects of inodilators like levosimendan. Large-scale trials comparing regional versus general anesthesia in CVD patients undergoing noncardiac surgery are also warranted.<sup>19</sup>

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### CONCLUSION

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Anesthesia significantly impacts patients with CVD, requiring careful selection of agents and techniques to minimize perioperative risks. Volatile anesthetics improve outcomes in cardiac surgery, while conscious sedation offers advantages in TAVR procedures.  $\alpha$ 2-Adrenoceptor agonists, EEG-guided anesthesia, and multidisciplinary perioperative management are essential for optimizing patient outcomes. Further research is needed to enhance perioperative care for this high-risk population.

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