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Review Article

Comprehensive Review of Anesthesia Selection for TAVR: Comparing MAC and General Anesthesia

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Abstract

Transcatheter aortic valve replacement (TAVR) has become the preferred treatment for severe symptomatic aortic stenosis, particularly in high-risk patients. This review evaluates the impact of two anesthesia approaches—general anesthesia (GA) and monitored anesthesia care (MAC) with local anesthesia (LA)—on patient outcomes during transfemoral TAVR procedures. Key outcomes assessed include 30-day mortality rates, hospital length of stay, and postoperative complications.

A systematic review of 17 qualitative and quantitative studies that met predefined inclusion criteria was conducted. These studies examined the use of GA, MAC, or LA in TAVR procedures, focusing on safety and effectiveness. The analysis revealed that MAC was associated with a 30-day mortality rate of 6.9%, compared to 11.8% for GA. Additionally, MAC demonstrated potential advantages, including shorter hospital stays and fewer postoperative complications, suggesting improved procedural efficiency and enhanced recovery for patients.

Although both GA and MAC remain viable anesthetic options for TAVR, MAC is emerging as a promising alternative due to its favorable impact on patient outcomes and healthcare resource utilization. However, further research is needed to evaluate long-term outcomes and optimize anesthesia protocols to ensure the best possible care for patients undergoing this increasingly prevalent procedure.

Keywords: Transcatheter Aortic Valve Replacement (TAVR), Monitored Anesthesia Care (MAC), General Anesthesia (GA), Aortic Stenosis, Comparative Analysis, Patient Outcomes, Mortality Rates, Hospital Stay, Procedural Complications

INTRODUCTION

Transcatheter aortic valve replacement (TAVR) has emerged as a preferred treatment for severe symptomatic aortic stenosis, particularly in high-risk patients and those with multiple comorbidities, offering a less invasive alternative to surgical aortic valve replacement (SAVR) [1-3]. Traditionally, TAVR has been performed under general anesthesia (GA) due to its ability to manage complex cases and facilitate transesophageal echocardiography (TEE). However, recent advancements in valve technology and procedural techniques have shifted attention toward monitored anesthesia care (MAC) as a viable alternative. MAC may offer several advantages, including reduced hemodynamic instability, lower rates of pulmonary complications, and decreased reliance on vasoactive medications, making it particularly suitable for elderly patients and those with compromised pulmonary function [4,5].

Despite the widespread use of GA in TAVR procedures, growing interest in MAC is driven by its potential to minimize complications and improve resource efficiency. Studies suggest that MAC, performed with local anesthesia and minimal sedation, may reduce hospital stays, ICU time, and procedural costs while maintaining safety and efficacy [6-8]. Early evidence indicates that MAC, when used with the Edwards SAPIEN valve, allows TAVR to be performed without intubation, avoiding complications and costs associated with GA [9,10].

The feasibility and safety of MAC for TAVR remain underexplored, with limited research comparing it directly to GA. Observational studies and registry data suggest that MAC is associated with shorter procedural times, fewer postoperative complications, and reduced mortality rates at one month and one year compared to GA [12,12]. Regional differences in anesthetic practices are also evident. For instance, while 95% of TAVR centers in North America primarily use GA, only 30% in Europe rely on it, reflecting a shift toward MAC in some regions [13-15].

TAVR technology has rapidly evolved, initially targeting patients at very high risk for surgical replacement of the aortic valve [16,17]. The procedure involves implanting an artificial aortic valve within a stent delivered via a catheter, typically through the transfemoral approach, which is the most common method. Other access methods, such as transapical or transaortic approaches, are utilized when the transfemoral route is unsuitable due to anatomical constraints [18-21]. The procedure's minimally invasive nature has made it a transformative option for patients previously deemed ineligible for surgery.

Although advancements in MAC have prompted a paradigm shift in anesthetic strategies for TAVR, research remains limited, particularly regarding the reasons for MAC failure and the need for conversion to GA. This review aims to provide a comprehensive analysis of the efficacy, safety, and feasibility of MAC compared to GA in TAVR, addressing critical gaps in the literature. By highlighting procedural outcomes, resource utilization, and patient-centered benefits, this study seeks to guide clinical practice and promote evidence-based anesthetic decision-making in TAVR.

METHODOLOGY

Eligibility Criteria: The systematic review included retrospective studies that assessed the effectiveness of various anesthetic techniques for patients undergoing transcatheter aortic valve replacement (TAVR) or transcatheter aortic valve implantation (TAVI). Studies were eligible if they compared general anesthesia (GA) and monitored anesthesia care (MAC) in adult patients with TAVR for aortic stenosis and reported outcomes such as hospital length of stay, 30-day mortality, or complications. Studies involving patients with severe comorbidities were included to capture the broader applicability of anesthesia techniques. Exclusion criteria included:

- Studies not describing pertinent clinical outcomes.
- Studies involving pediatric populations.
- Trials with inadequate data to compare anesthetic procedures.

Information Sources: A comprehensive literature search was conducted using multiple databases and resources, including PubMed, EMBASE, MEDLINE, Google Scholar, Web of Science, Cochrane Library, and PakMediNet. The search also utilized gray literature sources to ensure a thorough review. The final search strategy was executed to identify studies published up to the present date.

Search Strategy: The search terms included "local anesthesia (LA)," "general anesthesia (GA)," "monitored anesthesia care (MAC)," "transcatheter aortic valve replacement (TAVR)," "transcatheter aortic valve implantation (TAVI)," and "anesthesia." Boolean operators ("AND" and "OR") were used to refine the search and combine relevant terms. Variations of key terms and synonyms were applied to broaden the search scope. Manual searching of references in included studies was also performed to identify additional relevant publications.

Selection Process: All identified records were imported into a reference management tool to facilitate deduplication. Two independent reviewers screened titles and abstracts for relevance. Full-text articles were then reviewed against the eligibility criteria. Discrepancies between reviewers were resolved through discussion or consultation with a third reviewer.

Data Collection Process: Data were extracted independently by two reviewers using a standardized data extraction form. The extracted data included study characteristics (authors, year, setting), patient demographics (age, sex, comorbidities), anesthetic techniques (GA, MAC, LA), and clinical outcomes (hospital length of stay, 30-day mortality, complications). Discrepancies were resolved by consensus or consultation with a third reviewer.

Data Items: The primary data items of interest were:

- Thirty-day mortality and one-year follow-up for patients undergoing TAVR/TAVI with different anesthetic techniques (GA, MAC, LA).
- Secondary data items included socio-demographic characteristics (age, sex, comorbidities) and clinical outcomes (hospital length of stay and complications).

Effect Measures: The primary effect measures were the risk ratios (RRs) for 30-day mortality and one-year follow-up across the three anesthetic groups (GA, MAC, LA). For continuous outcomes, mean differences were calculated, while categorical outcomes were reported as proportions with corresponding confidence intervals (CIs).

RESULTS

Study Selection: A total of 313 research studies were assessed based on the predefined inclusion and exclusion criteria. Of these, 25 full-text articles were shortlisted for eligibility. Following detailed evaluation, 17 studies (a combination of qualitative and quantitative research) were included in this systematic review. The studies primarily focused on transfemoral transcatheter aortic valve replacement (TAVR) or implantation (TAVI) under different anesthesia conditions: monitored anesthesia care (MAC), general anesthesia (GA), and local anesthesia (LA).

Table 1: Baseline clinical characteristics by anesthesia type

Variables	MAC (n= 589)	GA (n=106)
Gender (Male)	50.8%(248/ 589)	50% (53/ 106)
Age	78.9 ± 6.9	80.7 ± 9.7
BMI	28 ± 7	32 ± 10.8
Hypertension	93.5%(567/589)	88.9% (90/ 106)
Diabetes	34% (200/ 589)	36.5% (54/ 106)
Hyperlipidemia	79% (495/ 589)	80.6% (87/106)
COPD	35.9% (210/589)	30.5% (32/ 106)
Smoking	40% (236/ 589)	4.9% (5/ 106)
Atrial fibrillation/flutter	45% (265/ 589)	37.5% (40/ 106)
CKD	49.3% (290/589)	64.7% (68/ 106)
Carotid artery disease	25.7% (151/589)	19.6% (21/ 106)
BAV	27.6% (163/589)	49.5% (53/ 106)
CABG	36.5% (215/589)	38.4% (41/ 106)
Percutaneous coronary intervention	39.5%(233/ 589)	30.7% (33/ 106)
MI	20.6% (121/589)	25.6% (27/ 106)
Cancer	29% (171/ 589)	38.7% (41/ 106)

Note: CABG, coronary artery bypass graft surgery; MAC, monitor anesthesia care; GA, general anesthesia; LA, local anesthesia; CKD, chronic kidney disease; CHF, congestive heart failure; BMI, body mass index; COPD, chronic obstructive pulmonary disease; MI, myocardial infection; BAV, balloon aortic valvuloplasty.

Study Characteristics: The selected studies were non-randomized and were assigned SIGN level 2 evidence. The total sample size across the included studies was N = 971, distributed as follows: MAC (n = 589), GA (n = 106), and LA (n = 206). Baseline demographic and clinical characteristics are summarized in Table 1. Significant variables included body mass index (BMI) and the use of balloon aortic valvuloplasty (BAV). Hypertension, hyperlipidemia, and chronic kidney disease (CKD) were common comorbidities across all groups.

Table 2: Baseline echocardiographic parameters by anesthesia type

Variable	MAC (n= 589)	GA (n= 106)
LVEF (% mean ± SD)	55.9 ± 15.7	58.78 ± 17.68
PASP (mmHg)	49.9 ± 20	50.78 ± 24
Aortic valve max velocity	5.8 ± 1.09	6.8 ± 1.79
Aortic valve mean pressure gradient	59.6 ± 15.9	58.4 ±17
AR (Moderate to severe)	6.8% (34/ 499)	10.9% (12/ 106)
MR (Moderate to severe)	12.9% (65/ 499)	18.9% (21/ 106)

Note: AR, aortic regurgitation; LA, local anesthesia; GA, general anesthesia; MAC, mitral annular calculation; MR, mitral regurgitation; PASP, pulmonary artery systolic pressure; LVEF, left ventricular ejection fraction

Results of Individual Studies: The analysis revealed that there was no statistically significant difference in 30-day mortality between GA and MAC groups (GA: 11.8%, MAC: 6.9%, p = 0.17). However, at the one-year follow-up, mortality was significantly higher in the GA group (29.5%) compared to the MAC group (20.4%). This suggests a possible longer-term survival benefit for patients undergoing TAVR/TAVI with MAC. LA demonstrated an intermediate trend, with one-year mortality reported at 31.5%. Table 3 provides detailed short- and long-term outcomes.

Table 3: In-hospital, short-term, and long-term outcomes by anesthesia type

Variables	MAC (n= 589)	GA (n= 106)
Transfemoral approach	98% (577/ 589)	99% (104/ 106)
In- Hospital stay Outcomes		
VARC-2 (major vascular complication	12.6% (66/ 530)	11.5% (11/ 99)
VARC-2 (minor vascular complication)	25.4% (134/530)	28.4% (28/ 99)
VACR-2 stroke	4.9% (26/ 530)	7.0% (7/ 99)
Excessive bleeding	3.1% (16/ 530)	3.8% (4/ 99)
Minor bleeding	18.0% (18/ 530)	16.4% (16/ 99)
Hospital stay mortality	5.2% (30/ 589)	8.9% (9/ 106)
Mortality		
With-in 1 month	6.9% (41/ 589)	11.8% (13/ 106)
Mortality during 1 year	20.4% (120/589)	29.5% (31/ 106)

Results of Syntheses: Baseline echocardiographic parameters (e.g., left ventricular ejection fraction (LVEF), pulmonary artery systolic pressure (PASP), and aortic valve gradients) were comparable across anesthesia groups, with no statistically significant differences noted (Table 2). In-hospital outcomes showed a slightly lower mortality rate in the MAC group (5.2%) compared to GA (8.9%) and LA (10.9%). VARC-2 major and minor vascular complications were similar across groups, though minor complications were slightly higher in the GA group (28.4% vs. 25.4% in MAC). Stroke rates were higher in the GA group (7%) compared to MAC (4.9%).

DISCUSSION

This study reinforces the safety and efficacy of transfemoral transcatheter aortic valve replacement (TAVR) under monitored anesthesia care (MAC) compared to general anesthesia (GA). It highlights that in-hospital complication rates under MAC are comparable to those under GA, with MAC offering several advantages, including reduced mortality rates at one month and one year, shorter hospital stays, and cost-effectiveness. While MAC facilitates practical and safe intra-procedural transesophageal echocardiography (TEE), it has been associated with a higher rate of acute renal injury. The shorter ICU and hospital stays observed with MAC suggest its suitability for centers with limited resources or those seeking to optimize patient outcomes [22-28].

In North America, 95% of TAVR centers use GA, contrasting with Europe, where only 30% use GA, reflecting a growing trend toward MAC. For example, data from the FRANCE-2 Registry reveal a shift from 14% MAC utilization in 2010 to 59% in 2011, indicating evolving practices. However, the absence of randomized controlled trials (RCTs) directly comparing MAC and GA limits the ability to draw definitive conclusions. Observational studies, such as those from the EUROSTAR and TCVT/EORP databases, suggest that MAC may provide a survival benefit in high-risk groups, though GA may still have a role in managing complications in less experienced centers [29-31].

The Brazilian TAVR Registry emphasizes GA's role in reducing post-procedural severe aortic regurgitation, highlighting its importance in centers with limited experience or complex patient cases. Additionally, hemodynamic instability in GA patients is frequently attributed to the adverse effects of anesthetics and increased vasopressor use, contributing to higher mortality rates. Conversely, MAC enables continuous monitoring of neurological and pain responses, which aids in detecting complications early and potentially contributes to better outcomes [32-37].

MAC also demonstrates benefits for patients with compromised pulmonary function, as highlighted by the reduced incidence of aspiration pneumonia in the FRENCH-2 Registry [38]. However, the conversion from MAC to GA, although rare (3.1%), is typically driven by cardiovascular instability. An interdisciplinary team approach is critical to ensuring seamless transitions and managing complications effectively [39-43].

Despite the promise shown by MAC, this study acknowledges limitations, including potential selection bias, reliance on retrospective observational data, and the lack of RCTs. Future research should prioritize randomized trials to validate the findings and explore long-term outcomes, including patient satisfaction, quality of life, and neurocognitive results. Additionally, investigating the impact of anesthetic type on post-TAVR delirium and cognitive function could inform tailored anesthesia strategies for high-risk patients.

CONCLUSION

This study suggests that MAC is a safe and effective alternative to GA for transfemoral TAVR procedures. Its advantages include lower mortality rates, fewer complications, shorter hospital stays, and cost-effectiveness, making it particularly suitable for high-risk patients and resource-limited settings. However, GA remains a valuable option for specific scenarios, particularly for patients requiring intensive intraoperative monitoring or those with complex comorbidities. To optimize patient care, precise guidelines tailored to institutional resources and patient-specific needs are essential. Future research should focus on high-quality RCTs to further establish the comparative benefits of MAC and GA in TAVR.

AUTHORS' CONTRIBUTION

MAZ, HMFI, MRK, HN, DHK, and MAR: Concept and design, data acquisition, interpretation, drafting, final approval, and agree to be accountable for all aspects of the work. MAZ, HMFI, MRK, HN, DHK, and MAR: Data acquisition, interpretation, drafting, final approval and agree to be accountable for all aspects of the work.

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