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Review Article

Anesthetic management of Transcatheter Aortic Valve Replacement (TAVR): A guide

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Abstract...

Introduction and objectives: Transcatheter Aortic Valve Replacement (TAVR) has expanded from a treatment for high-risk surgical candidates to a standard therapy across all risk categories. Despite its widespread adoption, anesthetic management remains variable. This review aims to provide an anesthesiology-focused guide to contemporary TAVR practice, emphasizing evidence-based anesthetic strategies and perioperative considerations.

Methods: A narrative review of the literature was conducted examining TAVR expansion, institutional and procedural requirements, anesthetic techniques, and perioperative outcomes. Evidence comparing Monitored Anesthesia Care (MAC) and general anesthesia was reviewed to inform a standardized anesthetic approach.

Results: Monitored anesthesia care, commonly using propofol and dexmedetomidine, is associated with shorter procedure times, reduced intensive care unit and hospital length of stay, lower vasopressor use, and comparable or improved short-term outcomes compared with general anesthesia in appropriately selected patients. Essential anesthetic elements include hemodynamic monitoring, anticoagulation, rapid ventricular pacing, and echocardiographic assessment. Major complications include coronary obstruction, pericardial tamponade, annular or ventricular rupture, and conduction disturbances.

Conclusion: Conscious sedation is a safe and effective anesthetic strategy for most transfemoral TAVR procedures and offers advantages in efficiency and recovery. Anesthetic management should remain individualized, with anesthesiologists playing a key role in procedural success through vigilant monitoring and prompt management of complications.

Keywords: Aortic valve; Echocardiography; Femoral artery; Propofol; TAVR.

Introduction

Transcatheter Aortic Valve Replacement (TAVR) is a less invasive alternative to Surgical Aortic Valve Replacement (SAVR) for the treatment of aortic valve stenosis. Since its first successful implementation in 2002, TAVR has quickly become a standard treatment, with an increasing volume of cases nationally. However, few reports discuss what is or even should be the standard anesthetic management in a TAVR procedure. We provide a guide to building a robust TAVR program from an anesthesiology standpoint. We review the clinical evidence supporting TAVR expansion to lower-risk populations, outline

current institutional requirements, and detail the procedural components. Our anesthetic management protocol emphasizes Monitored Anesthesia Care (MAC) using propofol and dexmedetomidine infusions, with preparation for general anesthesia when needed. We discuss the evidence supporting conscious sedation over general anesthesia, including reduced procedure time, decreased ICU and hospital stays, lower mortality rates, and fewer complications. Additionally, we outline five major complications. This guide aims to standardize anesthetic practice for TAVR procedures, ultimately improving patient outcomes through evidence-based protocols.

Why TAVR?

Building a robust TAVR (Transcatheter Aortic Valve Replacement) program has become increasingly desirable and accessible for healthcare institutions due to several compelling factors.

First, TAVR has demonstrated exceptional clinical effectiveness beyond its initial purpose of treating severe aortic stenosis patients who were poor surgical candidates. Research consistently shows that TAVR delivers comparable or superior outcomes to Surgical Aortic Valve Replacement (SAVR) in high-risk and intermediate-risk patients while offering significant advantages: less invasiveness, smaller incisions, shorter recovery times, and reduced morbidity [1]. Notably, 5-year follow-up studies of high-risk patients revealed no significant differences between TAVR and SAVR regarding valve hemodynamic preservation, all-cause mortality, cardiovascular mortality, stroke, or rehospitalization rates [2].

Second, the FDA significantly expanded TAVR accessibility in 2019 by extending approval to include low-risk patients, those with minimal risk for complications or death from SAVR [3]. This regulatory evolution mirrors TAVR's clinical journey from initial trials on inoperable patients to including high-risk candidates and finally encompassing low-risk populations through pivotal randomized controlled studies like NOTION [4], Evolut R Low Risk, and PARTNER III [5]. The PARTNER III trial provided particularly compelling evidence that influenced the FDA's guideline changes, demonstrating TAVR's superior outcomes and comparable complication rates to SAVR. At one-year follow-up, TAVR showed better results in preventing new-onset atrial fibrillation, reducing all-cause mortality, and minimizing rehospitalization compared to SAVR [5].

Requirements

The national coverage determination for TAVR in 2019 reduced several volume qualifications required to establish a TAVR program, making implementation more feasible for institutions [6].

Pre-2019 requirements to initiate a TAVR program without prior TAVR experience:

- At least 50 total aortic valve replacements in the previous year, including at least 10 high-risk patients.
- At least 2 physicians with cardiac surgery privileges.
- At least 1,000 catheterizations annually, including at least 400 Percutaneous Coronary Interventions (PCIs).

Revised 2019 requirements:

- At least 50 open heart surgeries in the year prior to TAVR program initiation
- At least 20 aortic valve-related procedures in the 2 years before program initiation
- At least 2 physicians with cardiac surgery privileges
- At least 1 physician with interventional cardiology privileges
- At least 300 Percutaneous Coronary Interventions (PCIs) annually

These revised guidelines, combined with the expanded inclusion of low-risk patients, have made volume targets for establishing and maintaining TAVR programs more attainable. Consequently, smaller and rural hospitals now have greater opportunities to become TAVR-eligible institutions, expanding this valuable treatment option to broader patient populations.

Overview of surgical procedure

TAVR is a procedure to insert a new aortic bioprosthetic valve in a patient with severe aortic stenosis. TAVR is traditionally performed using a trans-femoral approach (84.7% in the United States) [7]. Once vascular access through the femoral artery is established, a hollow sheath is inserted through the femoral artery that serves as the train track for subsequent catheters to pass through.

In some procedures, a Balloon Aortic Valvuloplasty (BAV) is performed before the insertion of the new valve as a bridge to TAVR. Indications for BAV include severe valve calcification, an extremely high transvalvular gradient, a bicuspid aortic valve, or trouble crossing the valve. In BAV, a balloon catheter is passed through the sheath, aorta, and aortic valve. Once placed in the aortic annulus, the balloon at the end of the catheter is inflated to clear space in a patient's narrowed, calcified aortic valve for the new valve. The balloon catheter is then deflated and removed.

Finally, a delivery catheter, with the new transcatheter heart valve attached, is guided via fluoroscopy through the sheath to the aortic valve. There are currently two types of transcatheter heart valves: balloon expandable (Edwards SAPIEN3) and self-expandable (Medtronic Evolut). In a balloon expandable device, the balloon at the end of the delivery catheter is inflated to expand the new valve into the stenosed aortic annulus. In a self-expandable device, the valve expands into the aortic annulus without the use of a balloon. If placed correctly, the new valve should be functional immediately. Checking the position of the newly placed valve is essential and is traditionally done through fluoroscopy and transthoracic echocardiography. After the proper placement of the new valve is confirmed, the catheter and sheath are subsequently removed.

Anesthetic management

Meds/Set up

- Propofol 30-50 mcg/kg/min
- Precidex 0.5 mcg/kg/hr.
- Bolus syringes: Epinephrine, Levophed, Nitroglycerin

- BP management
- Heparin syringe, Protamine
- Hot line setup with extension
- Arterial line set up: Left Radial/Brachial
- 2 pacing boxes: 1 for deployment, 1 as backup

Anesthesia case flow

TAVR anesthetic management includes the preparation of cases to be done under Monitored Anesthesia Care (MAC) using Propofol and Precidex infusions. (However, preparation for general anesthesia and induction should also be on-hand in case of emergency.) Core components of preparation include monitoring and access, warming to prevent hypothermia, imaging using transthoracic echocardiogram, anticoagulation with heparin, rapid pacing, and safety procedures after sheath removal towards the end of the procedure.

Monitoring/access

18G peripheral IV in the left arm preoperatively and placement of a left radial arterial line for monitoring. Hook up the hot line with blood tubing. Use standard ASA monitors and defibrillator pads. Two groin arterial lines will be placed by the surgery team. Two arterial access sheaths on the right and left femoral arteries. One access sheath is used for the delivery device. One venous access sheath is placed for temperature, pacing, and volume infusion in the femoral vein.

Warming

Use a gel warmer to avoid hypothermia.

Imaging

Transthoracic Echocardiogram (TTE) should be used preoperatively and post-deployment of the valve. Pre-operatively, it can be used to establish the diagnosis and severity of the patient's aortic stenosis and can aid in valve sizing. After the valve is deployed, it can be used to check for valve function, paravalvular leaks, and other complications. If the valve is insufficiently expanded, the patient can have residual aortic stenosis that may require balloon valvuloplasty. Paravalvular leaks post-deployment can turn aortic stenosis into aortic regurgitation and will require re-expansion of the valve or placement of a completely new valve.

Anticoagulation

Heparin is used for anticoagulation before the femoral arterial sheath is placed. ACT levels should be measured three times: baseline preoperatively, after heparin is first given, and after protamine is administered towards the end of the procedure. The heparin dose should be 200 units/kg with an ACT goal >250.

Rapid pacing

Pacing is traditionally done by the electrophysiology nurse. This is done to lower the left ventricular cardiac output during BAV and valve deployment. The standard pacing rate is 180 bpm -200 bmp (VOO) when opening the valve via balloon and when deploying the valve. Do not treat hypotension when rapid pacing is occurring because hypotension associated with rapid pacing is transient, and the pressure usually recovers once rapid pacing is stopped.

Post-sheath check

Once the sheath is pulled from the patient, check the patient's distal pulses and get a lower extremity angiogram. Protamine (with rechecking of ACT levels) should be administered after the aforementioned steps are completed.

Discussion

General anesthesia vs conscious sedation

In the first human case description of TAVR in 2002, the procedure was done under mild sedation and local anesthesia [6]. However, there has been ongoing debate on whether to use general anesthesia versus conscious sedation when undergoing TAVR procedures, and it can vary widely between institutions. In the past, the decision was primarily location-based: General Anesthesia (GS) was more common in the US, and Conscious Sedation (CS) was more common in Europe. However, there has been considerable growth in the use of conscious sedation in the United States, likely due to recent studies suggesting equal or potentially superior outcomes. Oftentimes, hospitals will start off using general anesthesia when they first open a TAVR program, then transition into conscious sedation once they feel more comfortable with the procedure.

Our guide recommends using conscious sedation due to the many benefits it provides. First, TAVR is already a minimally invasive procedure, and physicians can further reduce this procedure's invasiveness by using conscious sedation. This includes having advantages such as a reduced procedure time, duration of ICU and hospital stay, and a reduction in vasopressor and inotrope use intraoperatively [8]. From an institution perspective, resource consumption is reduced due to a reduction in procedure time (no intubation and extubation) and hospital stay. From a patient perspective, patients will be able to ambulate sooner after procedures and can be discharged relatively faster.

Second, TAVRs are traditionally done in high-risk, older patients, who generally may not tolerate general anesthesia well. The mean age of patients who underwent TAVRs in 2019 was 80 [9]. Through conscious sedation, we can avoid the respiratory complications associated with elderly or hemodynamically fragile patients dealing with general anesthesia.

Finally, the primary reason is that there are studies - from both Europe and the US - showing that the use of conscious sedation is associated with better outcomes. Two large observational studies showed a significant decrease in mortality and major complications with the use of sedation versus general anesthesia. The first study [10], a large German study including 16,543 patients, found that conscious sedation had a lower 30-day mortality (even after adjustment with matching) and lower rate of complications, including embolization, vascular complications, conversion to sternotomy, and device malposition, than GA. The second study [10], an American study that included 10,997 patients between April 2014 to June 2015, found lower length of hospital/ICU stay, lower in-hospital and 30-day mortality, and a lower rate of complication in the form of 30-day stroke rates when conscious sedation was used over general anesthesia. Another meta-analysis [11], including 32 studies, also found that using conscious sedation for TAVR was associated with decreased 30-day mortality, hospital length of stay, and inotropic support than general anesthesia.

Finally, a critical randomized-controlled study, the randomized SOLVE-TAVI trial, further supported the safety of conscious

sedation by showing a decreased need for vasopressors or inotropes with the use of CS and no significant difference in 30-day mortality, stroke, infection, myocardial infarction, and acute kidney injury between conscious sedation and general anesthesia

Overall, the main advantages to using CS mentioned in recent literature include reduced ICU and hospital stay, decreased need for catecholamines and vasopressors, shorter procedure time, and potentially decreased rate of complications (varies based on study).

Despite these promising studies, it's still important to note that most studies suggesting the effectiveness of conscious sedation are observational studies. There is potential for confounding due to selection and chronological bias, such as general anesthesia often being used during the initial phases of a TAVR program when physicians are still learning techniques. Therefore, the choice of anesthesia should be a personalized decision determined based on each patient's characteristics. Some cases where general anesthesia may be more beneficial but are not limited to patients who require TEE intraoperatively, have difficulty lying supine, have high anxiety, have impaired cardiopulmonary function or chronic respiratory problems, or have severe sleep apnea.

Common complications of TAVR

Transcatheter Aortic Valve Replacement (TAVR) has revolutionized the treatment of severe aortic stenosis, particularly for high-risk surgical candidates. However, several potentially life-threatening complications can occur during and after the procedure. Anesthesiologists must be prepared to recognize and manage these complications. Five major TAVR complications include the following:

Coronary artery obstruction

Coronary obstruction occurs when the native valve leaflets are displaced against the coronary ostia during valve deployment, blocking coronary blood flow.

Prevention

- Careful pre-procedure planning with measurements of the patient's aortic valve annulus, coronary height, and sinus dimensions.
- Pre-placement of coronary stents in high-risk patients.
- 70% deployment strategy for self-expanding valves, allowing repositioning if needed.

Management

- Preparation with inotropes, antiarrhythmics, and potential cardiopulmonary bypass.
- Valve recapture and removal if obstruction appears imminent.
- Immediate coronary intervention if obstruction occurs.
- Support for acute myocardial infarction, dysfunction, and potential cardiogenic shock.

Pericardial effusion and tamponade

Pericardial effusion may result from perforation of the right ventricle by pacing wires, guidewire-induced injury, or more severe complications like aortic or ventricular rupture.

Recognition:

- Rising central venous pressure or jugular vein distension.
- Progressive hypotension despite vasopressor support.
- Widened cardiac silhouette on fluoroscopy.
- Confirmation by transthoracic echocardiography.

Management:

- Immediate pericardial drainage via catheter by the cardiology team.
- Volume resuscitation and hemodynamic support.
- Surgical intervention for severe cases.

Aortic valve rupture

An annular rupture is rare but carries mortality rates approaching 50%, typically associated with balloon-expandable valves.

Risk factors:

- Excessive valve oversizing.
- Heavy calcification.
- Aggressive balloon pre-dilation.

Management:

- Immediate recognition and hemodynamic support.
- Potential conversion to open surgical repair.
- Preparation for massive transfusion and vasopressor therapy.

Left ventricular rupture

LV rupture presents as pericardial effusion, tamponade, and low cardiac output with refractory hypotension.

Management:

- Pericardial drainage for effusion.
- Hemodynamic support with inotropes and vasopressors.
- Surgical consultation for potential emergency repair.
- Preparation for extracorporeal membrane oxygenation in severe cases.

Arrhythmias

Conduction abnormalities are among the most common TAVR complications, resulting from the close proximity of the atrioventricular conduction system to the aortic valve apparatus.

Prevention and preparation:

- Preoperative ECG review to identify patients at increased risk (pre-existing bundle branch blocks or bradyarrhythmias).
- Prophylactic temporary pacing wire placement via internal jugular vein for high-risk patients.
- Defibrillation pads placement for all patients.

Management approaches:

- Rapid ventricular pacing during balloon valvuloplasty or valve deployment.

- Right ventricular temporary pacing for rescue in high-risk patients.
- Left ventricular guidewire pacing as an alternative technique.
- Prophylactic permanent pacemaker implantation for patients with pre-existing high-grade conduction abnormalities.
- Treatment of tachyarrhythmias with appropriate antiarrhythmics.
- Conversion to permanent pacemaker if conduction abnormalities persist.

Successful management of TAVR complications requires vigilance, preparation, and a coordinated team approach. Anesthesiologists play a critical role in early recognition and prompt intervention, which can significantly impact patient outcomes. Understanding these complications and their management strategies is essential for the safe and effective care of patients undergoing TAVR procedures.

Conclusion

The evolution of TAVR from a high-risk alternative to a standard treatment across risk categories represents a significant advancement in cardiovascular care. The evidence increasingly supports conscious sedation as the preferred anesthetic approach, offering advantages including shorter procedure times, reduced resource utilization, decreased hospital stays, and potentially improved clinical outcomes compared to general anesthesia. However, anesthetic choice should remain individualized, with general anesthesia reserved for specific patient populations, such as those requiring TEE monitoring, experiencing severe anxiety, or having significant cardiopulmonary impairment.

The anesthesiologist's role extends beyond sedation management to include vigilant monitoring for potential complications and coordinating rapid responses when needed. Through thorough preparation, standardized protocols, and a deep understanding of TAVR-specific complications, anesthesiologists contribute significantly to procedural success and patient safety. As TAVR technology continues to evolve and expand to broader patient populations, ongoing refinement of anesthetic techniques will remain essential. Future research should focus on patient-specific risk stratification for anesthetic approaches and standardized protocols for complication management. By implementing the evidence-based recommendations outlined in this guide, institutions can optimize their TAVR programs to deliver efficient, safe, and effective care for patients with aortic stenosis.

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