Kingery et al. *HCA Healthcare Journal of Medicine* (2022) 3:4
https://doi.org/10.36518/2689-0216.1396

Clinical Review

Complications of TAVR From an Anesthesia Perspective

David R. Kingery Jr, MD[1]; Alex Roberts, DO[1]; Derek Horstemeyer, MD[1]; Russell Stahl, MD[1]

Author affiliations are listed at the end of this article.

Correspondence to:
David R. Kingery Jr
Grand Strand Medical Center
809 82nd Parkway
Myrtle Beach, SC 29572
(David.Kingery@hcahealthcare.com)

Abstract

Description

Transcatheter aortic valve replacement (TAVR) has become the predominant technique for aortic valve replacement in the United States. Initially approved for high surgical risk patients, TAVR is now approved for most patients requiring valve therapy, including younger, lower-risk patients. The procedure is ideally performed in a hybrid operating room equipped with fluoroscopic equipment and transesophageal echocardiogram (TEE) imaging that can be viewed simultaneously by the operating team. The operating room should also be equipped to allow initiation of cardiopulmonary bypass, if necessary. Cardiac anesthesia teams are often involved with the management of these patients. This mini-review is designed to summarize potential complications that anesthesiologists may contend with during TAVR.

Keywords

transcatheter aortic valve replacement; TAVR; anesthesia; cardiac catheterizations; aortic valve stenosis; heart valve prostheses implantation; cardiac valve prostheses; adverse effects

Introduction

Every year, over 70 000 patients undergo transcatheter aortic valve replacement (TAVR).[1] TAVR is performed in all 50 United States, more frequently than surgical aortic valve replacements (approximately 57 000 in 2019).[1] Most TAVR procedures are performed with a transfemoral technique, during which large-bore catheters or sheaths are placed via the common femoral artery. The crimped valve and delivery system are then passed in a retrograde fashion via the iliofemoral arteries and the aorta to engage the native aortic valve. Patients are evaluated for the appropriateness of this approach using multi-dimensional CT scanning (TAVR CTA), which also allows sizing of the aortic annulus and appropriate valve size selection.[3] If the TAVR CTA is inadequate or there are concerns about contrast exposure, such as renal insufficiency, a 3D transesophageal echocardiogram (TEE) is used to confirm the annular area for sizing the prosthesis. A minority of patients require alternative access such as transaxillary, transcarotid, transaortic, transsubclavian, or transapical approaches.[4] At our center, any alternative access TAVR procedure is done with general anesthesia and endotracheal intubation. Most transfemoral cases at our institution are performed with monitored anesthesia care, or a so-called "minimalist approach." The purported advantage of a minimalist approach is faster recovery and earlier discharge from the hospital.[5] Therefore, one of the first responsibilities of the anesthesia team is to assess the appropriateness of the patient for monitored anesthesia care vs. general anesthesia. Patients who will require TEE, have difficulty lying supine, high anxiety states, or impaired cardiopulmonary function may benefit from a general anesthetic.

Intraoperative and Postoperative Considerations

There are technical differences between types of transcatheter valves. A balloon-expandable valve, such as the Edwards S3 Ultra device, is positioned within the aortic annulus and then deployed by balloon expansion during a rapid pacing sequence (typically 180 beats per minute), which markedly reduces cardiac output and systolic pressure, to ensure safe and accurate deployment.[6] Self-expanding transcatheter valves, such as the Medtronic Evolut Proplus device, are more slowly deployed, often using measured cardiac pacing at a slower rate (90-120 beats per minute) to modestly reduce the blood pressure until annular contact of the stent frame is made and the transcatheter valve is sufficiently deployed to allow opening and restoration of transvalvular flow and systolic blood pressure.[7] Thus, the anesthesia team should be prepared with vasopressors and dilators drawn up and ready for immediate use to treat persistent hypotension, or rebound hypertension, after deployment of the valve. For patients undergoing TAVR with markedly reduced left ventricular systolic function, it may be prudent to have epinephrine drawn up and on the field, for the implanting physicians to administer directly into the aorta This is only done if the patient is refractory to conventional intravenous resuscitation with vasopressors.[8]

Other complications that may occur during TAVR include:

Respiratory Complications

Hypoventilation due to sedation, and subsequent respiratory acidosis, can be problematic and contribute to hemodynamic instability during valve deployment.[9] Our facility no longer obtains pulmonary function tests as part of our pre-operative testing for TAVR, but an awareness of underlying lung disease and obstructive sleep apnea is essential. Vigilance is required in elderly patients who may be more sensitive to the effects of prolonged sedation. As with other surgeries performed under moderate or deep sedation, anesthesia providers should be prepared for advanced airway management and conversion to general anesthesia.

Arrhythmias

Bradycardia and heart block may occur immediately after valve deployment. A temporary right ventricular pacing wire is usually in place for a TAVR procedure, to perform rescue pacing if necessary, but some valve teams pace via the left ventricular guide wire.[9] Preoperative ECG should be reviewed for pre-existing bundle branch block or bradyarrhythmia to determine if a patient is at increased risk of bradyarrhythmia after valve deployment. For those patients, a temporary pacing lead can be placed via the internal jugular vein so that leads can be left in place for 24-hour monitoring without confining the patient to bed rest, as would be required with a trans-femoral pacing lead. A small percentage of patients develop heart block greater than 24 hours after the procedure, including some who are already discharged from the hospital.[10] Post-anesthesia care unit staff should be made aware of the increased risk of postoperative arrhythmias.

Tachyarrhythmias may occur during TAVR procedures. The most common tachyarrhythmia is atrial fibrillation or atrial flutter. Treatment with antiarrhythmic drugs should be judicious and discussed with the heart team, given the previously described risk of heart block. Ventricular tachycardia or ventricular fibrillation is rare, but defibrillation pads are routinely placed. Treatment by advanced cardiac life support protocol is recommended.[11]

Bleeding

A variety of techniques are used to control bleeding from the femoral access sites.[12] Closure devices are common and may be imperfect with regard to controlling bleeding from access sites.[12] Blood loss can usually be controlled by direct pressure but occasionally requires endovascular or open surgical treatment. Reversal of heparin is contraindicated while endovascular devices are being used. If the case is complicated by a major bleed and the valve has been deployed, endovascular devices can be removed and protamine can be promptly administered. Occult retro-peritoneal bleeding from iliac rupture can present with insidious hypotension. The anesthesia team should be monitoring for hypotension and have the ability to trend hemoglobin and hematocrit levels. Equipment for blood product transfusion should be readily available.

A rare complication is myocardial perforation, from either right ventricular or left ventricular

devices.[13] Myocardial perforation can manifest as pericardial effusion and tamponade resulting in low cardiac output and hypotension. When a minimalist approach is being used, the patient does not have a TEE probe in place and the presence of tamponade may be diagnosed by rising central venous pressure or jugular vein distension, hypotension, a widened cardiac silhouette on fluoroscopy, or transthoracic echocardiography. The heart team is able to drain the pericardium and relieve tamponade with either a catheter or an incision, which may not immediately stop the bleeding. If a Cell Saver is available, heterologous blood transfusion may be minimized.

Annular rupture may also result in pericardial tamponade and cardiogenic shock.[14] Treatment would require emergency open heart surgery and the anesthesia team should be prepared with an endotracheal tube, appropriate venous access, and medications to facilitate surgery.

Femoral Artery Occlusion and Limb Ischemia

Occasionally, the common femoral artery becomes obstructed after the sheath is removed, due to trauma to the intima or dissection of the vessel. The heart team would typically treat the obstruction with endovascular techniques. There may be a subsequent period of ischemia reperfusion, resulting in metabolic acidosis and electrolyte disturbance. The anesthesia team should be prepared to monitor arterial blood gases, point-of-care electrolytes, and anticoagulation as the heart team works to restore limb perfusion.

Coronary Artery Obstruction

Although careful measurements of valve stent height, sino-tubular junction height, sinus of Valsalva diameter, leaflet calcification, and coronary artery heights are made in the TAVR planning stages, there may be unexpected coronary artery obstruction after valve deployment.[15] This obstruction can result in acute myocardial ischemia, myocardial dysfunction, and cardiogenic shock. The anesthesia team must be prepared with inotropes, antiarrhythmic medications, and potential preparations for cardiopulmonary bypass. The heart team can avoid this complication with careful preoperative planning, pre-placement of a coronary stent ("parked" in the coronary artery, but not deployed), or 70% deployment of a self-expanding valve. At that point, aortic root angiography can help determine if a coronary obstruction will occur. The self-expanding valve can be recaptured and removed if a coronary obstruction appears likely to occur.

Misplaced Heart Valve

A transcatheter valve can be deployed in a way that creates severe aortic valve insufficiency.[16] Obstruction of the left ventricular outflow tract is extremely unlikely. Valvular insufficiency may be treated by secondary balloon dilation, to further expand the valve, or by the placement of another transcatheter heart valve. If the patient is hemodynamically unstable due to severe, acute, aortic regurgitation, the anesthesia team should be prepared to support the patient with appropriate inotropic therapy. Valves that embolize may become lodged in the aorta, often without any particular hemodynamic impact. Embolization into the left ventricle is more serious, as surgery is the only means of removing the valve. The anesthesia team should be actively involved in conversations with the heart team about potential cardiopulmonary bypass and open techniques to retrieve or repair the misplaced valve.

Acute Aortic Dissection

Rarely, deployment of a transcatheter valve results in an intimal injury near the sino-tubular junction.[17] These injuries may cause acute aortic dissection, which presents with unexpected chest pain. If the patient is in a hybrid operating room, TEE or angiography may confirm it. If the patient is in the recovery area, an emergent computed tomographic angiography would be diagnostic. Control of blood pressure within a normal range would be the primary goal of the anesthesia team, in these cases, and preparations for emergency surgery would be expected. Consideration should be given to the placement of hemodynamic monitoring catheters, recognizing that right axillary artery cannulation for cardiopulmonary bypass may be necessary.

Conclusion

When considering complications of TAVR, the anesthesia team should be prepared for both common and unusual events. TAVR is generally

safe, even with a minimalist approach, performed in the heart catheterization laboratory. The anesthesiologist is sometimes called upon to treat emergent conditions in the perioperative period of TAVR cases; in this regard, "forewarned is forearmed".

Conflicts of Interest

The authors declare they have no conflicts of interest.

The authors are employees of Grand Strand Medical Center, a hospital affiliated with the journal's publisher.

This research was supported (in whole or in part) by HCA Healthcare and/or an HCA Healthcare affiliated entity. The views expressed in this publication represent those of the author(s) and do not necessarily represent the official views of HCA Healthcare or any of its affiliated entities.

Author Affiliations

1. Grand Strand Medical Center, Myrtle Beach, SC

References

1. Carroll JD, Mack MJ, Vemulapalli S, et al. STS-ACC TVT Registry of Transcatheter Aortic Valve Replacement. *J Am Coll Cardiol*. 2020;76(21):2492-2516. doi:10.1016/j.jacc.2020.09.595
2. Afshar AH, Pourafkari L, Nader ND. Periprocedural considerations of transcatheter aortic valve implantation for anesthesiologists. *J Cardiovasc Thorac Res*. 2016;8(2):49-55. doi:10.15171/jcvtr.2016.10
3. Leipsic J, Gurvitch R, Labounty TM, et al. Multidetector computed tomography in transcatheter aortic valve implantation. *JACC Cardiovasc Imaging*. 2011;4(4):416-429. doi:10.1016/j.jcmg.2011.01.014
4. Jensen HA, Syed A, Furtado A, Murdock JE, Thourani VH. Alternate vessel approaches to transcatheter aortic valve replacement (TAVR). In: Ailawadi G, Kron I, eds. *Catheter Based Valve and Aortic Surgery*. New York: Springer, 2016. https://doi.org/10.1007/978-1-4939-3432-4_7
5. Ben-Dor I, Looser PM, Maluenda G, et al. Transcatheter aortic valve replacement under monitored anesthesia care versus general anesthesia with intubation. *Cardiovasc Revasc Med*. 2012;13(4):207-210. doi:10.1016/j.carrev.2012.02.002
6. Huang PH, Eisenhauer AC. Transcatheter aortic valve replacement using the Edwards SAPIEN transcatheter heart valves. *Cardiol Clin*. 2013;31(3):337-350. doi:10.1016/j.ccl.2013.05.009
7. Manuals.medtronic.com. 2021. [online] Available at: <https://manuals.medtronic.com/content/dam/emanuals/cardio/M987524A-001DOC1_RevG_view_color.pdf> [Accessed 6 October 2021].
8. Mayr NP, Wiesner G, Husser O, et al. Critical adverse events during transfemoral TAVR in conscious sedation. Is an anesthesiologic support mandatory?. *Cardiovasc Revasc Med*. 2018;19(6S):41-46. doi:10.1016/j.carrev.2018.06.014
9. Faurie B, Souteyrand G, Staat P, et al. Left Ventricular Rapid Pacing Via the Valve Delivery Guidewire in Transcatheter Aortic Valve Replacement. *JACC Cardiovasc Interv*. 2019;12(24):2449–2459. doi:10.1016/j.jcin.2019.09.029
10. Sandhu A, Tzou W, Ream K, et al. Heart block after discharge in patients undergoing TAVR with latest-generation valves. *J Am Coll Cardiol*. 2018;71(5):577–578. doi:10.1016/j.jacc.2017.11.057
11. Liang Y, Dhoble A, Pakanati A, et al. Catastrophic cardiac events during transcatheter aortic valve replacement. *Can J Cardiol*. 2021;37(10):1522-1529. doi:10.1016/j.cjca.2021.05.002
12. Seeger J, Gonska B, Rodewald C, Rottbauer W, Wöhrle J. Impact of suture mediated femoral access site closure with the Prostar XL compared to the ProGlide system on outcome in transfemoral aortic valve implantation. *Int J Cardiol*. 2016;223:564-567. doi:10.1016/j.ijcard.2016.08.193
13. Provaznik Z, Holzamer A, Camboni D, et al. Perforation of myocardial wall and great vessels after cardiovascular interventions-a 5-year analysis. *J Thorac Dis*. 2017;9(12):5288-5294. doi:10.21037/jtd.2017.10.113
14. Yu Y, Vallely M, Ng MK. Valve-in-valve implantation for aortic annular rupture complicating transcatheter aortic valve replacement (TAVR). *J Invasive Cardiol*. 2013;25(8):409-410.
15. Quail MA, Nordmeyer J, Schievano S, Reinthaler M, Mullen MJ, Taylor AM. Use of cardiovascular magnetic resonance imaging for TAVR assessment in patients with bioprosthetic aortic valves: comparison with computed tomography. *Eur J Radiol*. 2012;81(12):3912-3917. doi:10.1016/j.ejrad.2012.07.014
16. Giri J, Bortnick AE, Wallen T, et al. Procedural and clinical outcomes of the valve-in-valve technique for severe aortic insufficiency after balloon-expandable transcatheter aortic valve replacement. *Catheter Cardiovasc Interv*. 2012;80(1):139-147. doi:10.1002/ccd.23451

17. Généreux P, Webb JG, Svensson LG, et al. Vascular complications after transcatheter aortic valve replacement: insights from the PARTNER (Placement of AoRTic TraNscathetER Valve) trial. *J Am Coll Cardiol*. 2012;60(12):1043-1052. doi:10.1016/j.jacc.2012.07.003