Aortic Valve Bypass: A Case Summary and Discussion of Anesthesia Considerations

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Aortic valve replacement (AVR) is a common surgical intervention for symptomatic aortic stenosis. For many high-risk patients with severe symptomatic aortic stenosis, AVR is not an option. Aortic valve bypass (AVB), a less common surgical procedure compared to AVR surgery, can bypass a stenotic aortic valve in lieu of replacing it and can offer surgical intervention for candidates unable to undergo AVR. AVB is an alternative to AVR that avoids median sternotomy, cardiopulmonary bypass, cross clamping the aorta, manipulation of the native aortic valve, and aortic cannulation. This case summary reviews the anesthetic management of a patient undergoing AVB.

Keywords: Aortic stenosis, aortic valve, aortic valve bypass, apicoaortic conduit, surgery.

Aortic stenosis (AS) is the most common valvular heart disease and occurs most often in elderly patients.1-3 Because of the possible risks associated with aortic valve replacement (AVR) in the elderly, almost 60% of patients with symptoms related to AS are never referred to surgery.2,4 The survival rate for patients with severe AS is poor; only 20% survive 3 years after diagnosis without surgical intervention.3,4 Aortic valve bypass (AVB) surgery may be an option for patients who are too high risk for AVR.3-8 Transcatheter aortic valve implantation (TAVI) is a minimally invasive alternative to AVR for high-risk patients with AS. The aortic valve prosthesis may be inserted transfemoral or transapical after balloon valvuloplasty. Balloon valvuloplasty predisposes the patient to thromboembolic complications, especially major strokes. High doses of intravenous contrast dye are associated with renal failure. A high risk of arrhythmias and an increased incidence of vascular complications are associated with TAVI.3,9

The typical high-risk AS patient is often elderly and has other cardiovascular comorbidities such as ascending aortic calcification, coronary artery disease, prior cardiac surgery, or left ventricular dysfunction.3,6,10,11 Congestive heart failure, angina, and syncope resulting from hypotension from decreased cardiac output or arrhythmias are the classic triad of signs and symptoms of worsening AS.1 High-risk patients with AS who have not had surgical intervention have a mortality rate of 41% to 44%.3,4 AVB carries a mortality rate of 13% to 14% and is an option for those 60% of patients who are not candidates for AVR.3,4 Complications associated with AVR in high-risk patients are thromboembolism, with 20% suffering a stroke or renal failure, and conduction system injury, with 3% to 6% requiring a pacemaker.6 The elimination of aortic cross clamping and minimal use of cardiopulmonary bypass explain the complete lack of perioperative neurological complications and the reduced renal failure complications associated with AVB.5

AVB surgery was originally developed to treat pediatric patients with complex left ventricular outflow tract obstruction (LVOTO).2,6,12 AVB is an alternative to AVR for the treatment of AS when standard sternotomy is contraindicated, if aortic cross clamping is anticipated to be difficult, or in patients with a coronary graft lying adjacent to the posterior surface of the sternum.13 Indications for AVB surgery include a heavily calcified ascending aorta, prior thoracic surgery that makes sternal reentry unsafe, structures adhering to the sternum, and a prior sternal infection with a muscle flap.11 Contraindications to AVB include severe aortic insufficiency, left ventricular thrombus, and major descending aorta disease.14 Potential complications of AVB include conduit dehiscence from left ventricular apex, pseudoaneurysm of the left ventricle, myocardial infarction, mitral regurgitation, chest infections, pulmonary embolism, thrombus formation in the aorta, arrhythmias, sepsis, endocarditis, and bleeding.11 AVB was first successfully performed in 1962 but fell out of favor as AVR became more popular.4,6 While infrequent, more than 100 cases of AVB surgery have been reported in high-risk adult patients with AS.4 AVB is an alternative to AVR that avoids median sternotomy, cardiopulmonary bypass, cross clamping the aorta, manipulation of the native aortic valve, and aortic cannulation.2,7,8,10,15 The goal of AVB is to relieve the LVOTO from AS.2,6,8,14

AVB surgery may be performed through a left thoracotomy approach with or without cardiopulmonary bypass. An aortic valved conduit, also known as apicoaortic conduit, relieves AS by shunting blood from the apex of the left ventricle to the descending thoracic aorta through a valve conduit, while leaving the native valve in place (Figure).14 AVB surgery requires the construction of a vascular graft containing a prosthetic valve.
The graft connects the apex of the left ventricle to the descending thoracic aorta. There is a large increase in stroke volume after AVB surgery. Vliek et al. report that stroke volume increases from 60 mL ± to 22 mL before AVB to 99 mL ± 25 mL after AVB. Also, 58% to 72% of cardiac output is ejected through the conduit postoperatively, while the remaining blood is ejected through the native valve. Gammie et al. found that cardiac output increased by approximately 40%. AVB surgery not only relieves the LVOTO but also appears to halt the progression of stenosis in the native aortic valve.

Cerebral blood flow continues to be supplied by blood ejected through the native aortic valve. The following case summary examines the anesthetic considerations encountered with the patient having AVB surgery.

**Case Summary**

An ASA physical status 4, 185 cm, 97.9 kg, 74-year-old man presented to the preoperative area for an AVB secondary to severe AS. The patient had severe symptomatic AS and was experiencing progressive dyspnea with exertion.

The patient's medical history included AS, coronary artery disease, carotid artery disease, diabetes, hypertension, hypercholesterolemia, deep vein thrombosis, and pulmonary embolism. The surgical history consisted of a right carotid endarterectomy and coronary artery bypass surgery in 2006. Preoperative testing and diagnostic studies included transthoracic echocardiogram, which showed a valve surface area of 0.95 cm², aortic mean pressure gradient of 29.8 mm Hg, aortic peak pressure gradient of 54.1 mm Hg, severe aortic stenosis, mild mitral regurgitation, mild tricuspid regurgitation, and an ejection fraction of 45% to 50%. To evaluate the graft position and patency, computed tomography and angiography were done preoperatively. The patient's left internal mammary graft was found to be laying midline across the sternum, complicating safe redo-sternotomy. All prior bypass grafts were patent, and all other laboratory results and testing were within normal limits. The decision was made for AVB surgery.

Vital signs included a blood pressure of 128/78 mm Hg, heart rate of 70/min, sinus rhythm, and a room air SpO₂ of 93%. The patient was pain free and denied any shortness of breath. Midazolam (2 mg) was given intravenously before the insertion of a 20-gauge right radial arterial line and 18-gauge peripheral intravenous line.

Anesthesia was induced with etomidate (20 mg). The sympathetic response to intubation and analgesia was maintained with fentanyl. Vecuronium (10 mg) was used to facilitate endotracheal intubation and for surgical relaxation. The patient's trachea was intubated with a 37 French left-sided double-lumen tube and the placement was confirmed with a fiberoptic bronchoscope. The patient remained hemodynamically stable throughout induction. A pulmonary artery catheter was placed via right internal jugular vein. Transesophageal echocardiography (TEE) showed an aortic valve surface area of 0.95 cm², aortic mean pressure gradient of 30 mm Hg, aortic peak pressure gradient of 56 mm Hg, moderate aortic regurgitation with no pericardial effusion, mild mitral regurgitation, and a left ventricular ejection fraction of 50%.

Perioperative TEE was performed to assist in placing the aortic valved bypass conduit. Bispectral index monitor was also used to monitor the patient's level of consciousness and prevent intraoperative awareness and prolonged anesthetic effects. The patient was positioned in right lateral decubitus position with hips externally rotated. Normothermia was maintained perioperatively. Anesthesia was maintained with isoflurane, fentanyl, and vecuronium, and one-lung ventilation was used to facilitate operative exposure. The patient tolerated one-lung ventilation without any problems. Heparin (5,000 U) was given intravenously after the left thoracotomy was performed. Activated clotting times (ACT) were checked every 30 minutes and heparin was redosed to maintain an ACT of over 200 seconds. Two doses of amiodarone (150 mg) were given to decrease premature ventricular contractions and short bursts of rapid atrial fibrillation. An esmolol infusion was started at 50 µg/kg/min before manipulation of the heart to slow the rate, which provided better access and improved the surgical field. An infusion of regular insulin was titrated to keep glucose
levels between 120 and 150 mg/dL. Glucose levels were checked every 30 minutes. The valve conduit was connected from the descending thoracic aorta to the apex of the left ventricle successfully. Once the valve conduit was connected, the cardiac index increased from 1.9 L/min/m² to 3 L/min/m² and mixed venous oxygen saturation increased from 68% to 77%.

Postoperatively the aortic valve gradient dropped from 56 mm Hg to 25 mm Hg. Blood pressure was supported intermittently in the perioperative period and immediately in the postoperative period with a norepinephrine infusion titrated to maintain systolic blood pressure greater than 100 mm Hg. Dexmedetomidine infusion was started at 0.2 µg/kg/h, 1 hour before the end of surgery for sedation to facilitate extubation of the trachea. The double-lumen tube was replaced with an 8-mm single-lumen endotracheal tube at the end of the case.

The patient was transported postoperatively to the surgical intensive care unit on a dexmedetomidine regimen without inotropic support. In the surgical intensive care unit the patient had an episode of wide complex tachycardia with hypotension that resolved spontaneously. An amiodarone infusion was started at 0.5 mg/min.

On postoperative day 1, vital signs were stable on a low dose of dobutamine at 3 µg/kg/min and amiodarone. The patient was comfortable and extubated without difficulty. On postoperative day 2, dobutamine was discontinued. On postoperative day 3, the patient had episodes of supraventricular tachycardia with a heart rate of 110/min to 140/min. The patient denied chest pain, shortness of breath, or syncope. He was given adenosine (12 mg) intravenously, which converted his rhythm to atrial fibrillation. A diltiazem infusion at 5 mg/min was then started to keep the heart rate approximately 60/min to 80/min. On postoperative day 4, the diltiazem drip was weaned off and an amiodarone drip was restarted at 0.5 mg/min. On postoperative day 5, all intravenous antiarrhythmics were discontinued. On postoperative day 7, diltiazem (5 mg) given intravenously converted the patient’s rhythm to sinus rhythm. The remainder of the patient’s hospitalization was uneventful. The patient was discharged home on postoperative day 13 with home health and physical therapy without any significant postoperative complications.

Discussion

Aortic stenosis is the most commonly acquired valvular disease in the elderly population. As that population in the United States continues to age, that percentage is anticipated to increase sharply. AVB surgery expands the scope of treatment of AS in high-risk patients. It effectively relieves the ventricular LVOTO of AS, increases stroke volume and cardiac output, and slows the progression of native aortic valve stenosis. AVB surgery avoids median sternotomy, cardiopulmonary bypass, cross clamping the aorta, manipulation of the native aortic valve, and aortic cannulation. While AVB may be done on or off pump, anesthetic considerations for off-pump AVB will be reviewed.

Managing patients presenting for AVB surgery presents unique challenges for the anesthetist. These patients usually have extremely poor cardiac reserve preoperatively because of the indication for AVB. A variety of anesthetic considerations must be discussed and incorporated into the anesthetic plan. General anesthesia may be combined with limited use of regional anesthesia. Thoracic epidural anesthesia is not generally used in cardiac surgery because of the high doses of heparin used, although Odonkor et al9 state that it may be useful in facilitating early extubation and proving analgesia postoperatively. Paravertebral blocks or intercostal nerve blocks may be performed at the time the thoracic incision is closed.9

Off-pump cardiac cases can be challenging with pronounced swings in hemodynamics and lethal arrhythmias resulting from cardiac manipulation. Vigilant monitoring and timely interventions are essential in maintaining hemodynamic stability. Close communication between surgeon and anesthetist is essential. The challenge is to correct hemodynamic fluctuations without overreacting. Careful attention to prevent hypotension, hypertension, bradycardia, tachycardia, and normothermia and the proper placement of the double-lumen endotracheal tube are critical to providing safe anesthesia to this unique patient population. It is essential to maintain coronary perfusion pressure to prevent hypotension-induced ischemia, which would be followed by ventricular dysfunction and worsening hypotension. Bradycardia will reduce cardiac output and systemic arterial pressure. Elderly patients have a reduced sympathetic response and are more predisposed to significant bradycardia. Tachycardia also should be avoided because it increases myocardial oxygen consumption and decreases left ventricular diastolic filling, which can result in ischemia or infarction. Hypovolemia, myocardial depression, vasodilation, tachycardia, or dysrhythmias can lower the cardiac output precipitously. Hemodynamic goals for the patient with severe AS are to maintain adequate preload by maintaining adequate intravascular volume, preserving afterload to maintain the coronary perfusion gradient, and to maintain sinus rhythm.

Anesthetic management must be tailored, taking into consideration the patient comorbidities and preoperative hemodynamic stability. Preoperatively, patients may receive premedication for anxiolysis, amnesia, and analgesia for invasive line insertion. The induction of anesthesia is a critical period for patients with AS. Induction can be accomplished with etomidate or propofol, short-acting opioids such as sufentanil or remifentanil, and short-to-intermediate-acting neuromuscular blocking agents. The patient is positioned in right lateral decub-
tus position with hips externally rotated for possible left femoral cannulation.12

Anesthesia can be maintained with inhalation anesthetics, narcotics, small doses of benzodiazepines, and neuromuscular blockers.19 Inhalation agents are beneficial because of their rapid titratable ability, amnesia, and suppression of sympathetic responses to surgical stress, bronchodilation, and rapid elimination.1,20 Volatile anesthetics may also protect against ischemia by reducing myocardial oxygen demand, although it is important to consider that all inhalational agents are myocardial depressants.1,13 Anesthetic agents are titrated to maintain hemodynamic stability and prevent awareness. Inotropic agents, vasodilators, and vasopressors are used to maintain coronary perfusion.13 Phenylephrine, vasopressin, norepinephrine, and calcium work to offset the decreased systemic vascular resistance occurring with anesthetic drugs and are less likely to cause tachycardia.9 Epinephrine and dobutamine are useful if left ventricular function is depressed. Blood pressure is kept at 90 mm Hg to 100 mm Hg systolic to decrease bleeding at anastomosis sites. An esmolol infusion effectively reduces the heart rate approximately 60/min to minimize cardiac movement and facilitate the surgical exposure.14 Amiodarone is effective in decreasing the arrhythmias induced by cardiac manipulation. Insulin drip is used to keep blood glucose levels between 120 mg/dL and 150 mg/dL. Patients undergoing off-pump cardiac procedures may be fully or partially heparinized with 150 U/kg to 400 U/kg of heparin, maintaining an ACT of >250 seconds.6,10,12,21 Others advocate a target ACT of twice baseline.18

Hemodynamic changes may occur rapidly and can have significant effects on myocardial function and recovery.10 Continuous cardiac output, electrocardiogram, ETCO2 measurement, pulmonary artery pressures, and blood pressures are continually monitored. Right axillary artery compression, resulting from right lateral positioning, may be detected by right radial arterial pressure monitoring.9 Core temperature and urine output are monitored throughout the surgery. Normothermia is essential for all off-pump cardiac surgery cases.16 Core temperatures should be kept between 35°C and 37°C.9 Hypothermia is linked to increased blood loss, delayed extubation, increased wound infections, and ventricular fibrillation.1,9 External defibrillator pads are placed on the patient, and internal defibrillator paddles are available to quickly eliminate lethal arrhythmias. Transesophageal echocardiography is used preoperatively, perioperatively, and immediately postoperatively to monitor native aortic valve function, cardiac function, positioning of guide wires and cannulas, assessing for intracardiac air, and function of the AVB.11,14

A double-lumen endotracheal tube facilitates surgical exposure by isolating the left lung.4,6,12 A double-lumen tube is preferred over a bronchial blocker because the position is more secure and less likely to be dislodged during repositioning.1,9 Positioning of the double-lumen tube is critical to ensure a quiet surgical field and to allow effective TEE imaging of prosthetic valve leaflets and outflow portion of the aortic valve conduit.9,12 At the conclusion of the surgery, the left lung should be cautiously reinflated, and the double-lumen endotracheal tube should be changed to a single-lumen endotracheal tube. Dexmedetomidine provides effective postoperative sedation without respiratory depression, is short-acting, is easily titrated, and provides analgesia.9

Postoperatively, patients are monitored closely in the intensive care unit. Hemodynamic fluctuations are kept minimal to prevent graft disruption and cardiac ischemia. Chest tube output should be closely monitored and coagulopathies treated aggressively. Once the patient is hemodynamically stable, early extubation of the trachea will reduce the development of pulmonary complication.9

Providing general anesthesia for a patient with severe AS presenting for AVB is an anesthetic challenge for anesthesia providers, who must consider the complex hemodynamic needs of this patient population. Comprehensive literature on the anesthetic considerations for AVB was minimal because of the infrequency of the AVB. The purpose of this case summary is to encourage more research on anesthetic considerations for the AVB surgery.

REFERENCES


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