Transapical Aortic Valve Replacement Aided by Cardiopulmonary Bypass in a Patient with a Left Ventricular Thrombus

Short title: Transapical Aortic Valve Replacement

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Abstract

Aortic stenosis is one of the most common degenerative valvular diseases in the elderly. Transapical aortic valve implantation (TAVI) is an innovative technique for high-risk patients with severe, symptomatic aortic stenosis and multiple comorbidities. However, potential obstruction to the left ventricular outflow tract, from a left ventricular thrombus, poses significant patient risk and challenge for the anesthetist. An 82-year-old man with these conditions underwent TAVI and intracardiac thrombectomy under general anesthesia, combined with cardiopulmonary bypass. We abandoned traditional surgical aortic valve replacement and thrombectomy; a fast-track cardiac anesthesia strategy was adopted. No complications were observed during recovery. Cardiac function was normal upon follow-up 1 year, post-operatively. Transapical aortic valve replacement aided by cardiopulmonary bypass, implemented under Enhanced Recovery After Surgery (ERAS) strategy, is suitable for high-risk patients under similar conditions. Strategies and equipment should be maximized for analgesia, organ protection, and circulatory homeostasis for perioperative safety and enhanced prognosis.

Introduction

Aortic stenosis is one of the most common cardiac valve malformations in the elderly. Transapical aortic valve implantation (TAVI) has been shown to be an innovative cardiac surgery technique for elderly patients with symptomatic severe aortic stenosis and multiple comorbidities. [1] A thrombus in the left ventricle is very likely to lead to obstruction of the left ventricular outflow tract. Furthermore, a left ventricular thrombus is a relative contraindication for transcatheter aortic valve replacement (TAVI). Herein, we report a case of an elderly man who underwent TAVI and intracardiac thrombectomy under general anesthesia combined with cardiopulmonary bypass (CPB), which was successfully implemented under the Enhanced Recovery After Surgery (ERAS) strategy.

Case Report

An 82-year-old man who had been diagnosed with severe bicuspid aortic stenosis and a left ventricular thrombus visited our hospital for further management. He had a 30-year history of chronic obstructive pulmonary disease and pneumoconiosis. An echocardiography revealed severe aortic valve stenosis (area: 0.5 cm^2) with significant calcification, peak systolic blood flow velocity of 403 cm/s, a left ventricular ejection fraction of 39%, and an 18.8 × 17.1 mm thrombus floating in the blood within the left ventricle (Figure 1). Chest computed tomography (CT) revealed features suggestive of an infection in the lower lobe of the left lung and a left-sided pleural effusion.

The patient consented to routine preoperative monitoring. A continuous intravenous infusion of dexmedetomidine was administered 30 min preoperatively; left radial artery cannulation and right internal jugular vein catheterization were performed under ultrasound guidance 15 min following dexmedetomidine. The PiCCO system (PRO-AQT) and brain oxygen saturation monitoring system were used to monitor the patient's cardiopulmonary function and brain metabolism. An ultrasound-guided serratus anterior plane block (SAPB) was performed with the patient in the supine position. The anesthetist then placed an 8–13-MHz linear probe (SonoSite, Bothell, WA, USA) on the fifth rib in the midaxillary line. The needle pierced through the serratus anterior muscle until it reached the surface of the fifth rib. A total dose of 30 mL of 0.33% ropivacaine was injected after the needle was retracted by 1 mm. Fifteen min later, the tested blockade ranged was from T3 to T7 and from the midclavicular line to the posterior axillary line. Afterwards, a temporary pacemaker was embedded through the central venous catheter for rapid intraoperative ventricular pacing upon valve deployment.

Anesthesia was induced using midazolam, etomidate, sufentanil, and rocuronium. Five minutes later, the patient was intubated with a #7 tracheal tube. Tidal volume was set at 7 mL/kg and the end-tidal carbon dioxide pressure was restricted to approximately 35 mmHg. General anesthesia was maintained using sevoflurane with 55% air combined with 45% oxygen and remifentanil. The depth of anesthesia was monitored by maintaining bispectral index (BIS) values of between 40 and 60.

The CPB was constructed through the right femoral arteriovenous vessels using the beating heart strategy. The patient's hemodynamic parameters were stabilized using extracorporeal circulation and vasoactive drugs including epinephrine, norepinephrine, phenylephrine, lidocaine, and nicardipine. A cardioplegic solution was not used during CPB. Lidocaine was also infused continuously to stabilize the cardiac rhythm and to prevent arrhythmia.

The entry point of the left ventricular apex was confirmed using three-dimensional CT reconstruction (Figure 2), cardiac angiography, and transesophageal echocardiography (TEE). The left ventricular thrombus was completely removed (Figure 3) and TAVI was conducted immediately through the same incision. Rapid ventricular pacing was set at 140 beats per minute for 10 s during each period of balloon aortic valve dilatation and aortic valve implantation. No asymmetrical dilatation of the pupils and obvious reduction in cerebral oxygen saturation were observed perioperatively. The surgery lasted for 270 min, 130 min of which were spent under CPB. A total of 70 μg of sufentanil and 150 mg of rocuronium were administered.

Furthermore, 0.3 mg of ramosetron was injected as prophylaxis against post-operative nausea and vomiting; 200 mg of sugammadex sodium was administered to antagonize rocuronium in the immediate postoperative period after the BIS value had increased to 60. Spontaneous respiration recovered 10 min later and the patient was extubated 20 min, postoperatively. The visual analog scale (VAS) pain score was 2–3 points in the first 24 h, postoperatively. The patient was observed in the intensive care unit for 2 days, and his total postoperative duration of hospital stay was

12 days. No complications occurred during the recovery period. The patient had a normal cardiac function with a peak systolic blood flow velocity of 204 cm/s and left ventricular ejection fraction of 61% upon follow-up, 1-year post-operatively.

Discussion

We reported a case involving perioperative anesthesia management during TAVI and intracardiac thrombectomy.

Surgical aortic valve replacement and thrombus removal surgery under CPB with an arrested heart are conventional surgeries for a patient with severe aortic stenosis and a left ventricular thrombus. However, in elderly patients, the accompanying pulmonary complications and postoperative recovery also need to be taken into consideration. TAVI has been proven to be an effective therapy for patients with shorter hospital stay and faster recovery. Therefore, thrombus removal surgery through the same small transapical incision of TAVI under CPB was a superior approach in our case. It can be extremely challenging for anesthetists to manage the cardiopulmonary system while considering the outflow tract obstruction caused by the bicuspid aortic valve and detachment of the apical thrombus.

It was essential to establish CPB prior to thrombectomy, as it helped the anesthetists achieve hemodynamic stability upon excision of the thrombus from the left ventricle. The following needed to be noted pertaining the conduct of CPB: 1) large amounts of air must be prevented from entering the ventricle; 2) appropriate antihypertensive treatment could allow a relatively clearer operative field upon thrombectomy; 3) homeostasis must be maintained, and arrhythmia must be prevented.

The setting of CPB without cardioplegia may allow adequate visualization for surgeons and is suitable for TAVI.

In 1993, the concept of fast-track cardiac anesthesia was first proposed by Verrier. [2] By solely adjusting the anesthesia regimen, this technique could hasten postoperative recovery, allowing early tracheal extubation, fewer postoperative cardiorespiratory morbidities, and decreased health expenditure. Given the lung condition and early recovery of the patient, the dosage of sufentanil should be controlled. However, it remains to be considered that a satisfactory analgesic effect should still be ensured. It has been proven that fast-track cardiac anesthesia with perioperative multi-mode analgesia is beneficial for patients' prognosis and recovery. [3] Multi-modal pain management including nerve block and patient-controlled analgesia with opioid and nonsteroid drugs were used during the perioperative period. SAPB applied to the small incision provided an auxiliary analgesic effect and prevented the occurrence of postoperative hyperalgesia from opioid administration. Previous research has reported that SAPB provides beneficial analgesic effect by spreading local anesthetics within 10 cm^2 of the puncture site, [4] which is suitable for analgesia during minimally invasive cardiac surgery. [5] The VAS pain score was <3 points within the first 24 h, postoperatively, and no chest pain during inspiration was reported during our follow-up survey. For this patient, SAPB improved the postoperative VAS score and aided early recovery.

One of the most important indications of fast-track cardiac anesthesia is early tracheal extubation. For elderly patients with chronic pulmonary disease, early

tracheal extubation reduces postoperative cardiorespiratory morbidities and associated health costs. Additionally, sugammadex sodium showed a greater advantage over neostigmine in reversing the neuromuscular blockade caused by rocuronium bromide, with fewer adverse events and a faster recovery. [6] However, we should be forewarned that bradycardia and asystole could be caused by sugammadex in patients with severe heart disease.

In conclusion, the risk of TAVI is increased by the movement of an intraventricular thrombus which could lead to obstruction. A variety of anesthetic equipment and techniques were applied to ensure perioperative safety and enhanced prognosis. Further research on anesthesia-related complications in TAVI is needed to better understand and solve related challenges.

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Author contributions

All authors contributed to the study conception and design. The first draft of the manuscript was written by Mingyu Qu, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Figure legends

Figure 1. A thrombus located at the left ventricular apex

Figure 2. Three-dimensional computed tomography reconstruction of the thrombus

Figure 3. Completely excised left ventricular thrombus