Special Article

Minimally invasive approach to calcified aortic valve replacement: Anaesthetic considerations

Address for correspondence:
Dr. Tomas Vymazal,
V Úvalu 84, 15000 Prague 5,
Czech Republic.
E-mail: tomas.vymazal@fnmotol.cz

Tomas Vymazal
Department of Anesthesiology and Intensive Care Medicine, 2nd School of Medicine, Charles University, V Úvalu 84, 15000 Prague 5, Czech Republic

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ABSTRACT

For symptomatic patients with severe calcified aortic valve stenosis, open heart surgery for aortic valve replacement remains the gold standard. However, elderly patients with an increased risk profile can be treated by using transcatheter approaches (transcatheter aortic valve implantation [TAVI]). The major considerations related to use of general and local anaesthesia for TAVI are discussed in this review.

Key words: Anaesthesia, aortic valve replacement, calcified aortic valve, aortic valve stenosis, transcatheter aortic valve implantation

INTRODUCTION

Surgical replacement (aortic valve replacement [AVR]) via sternotomy utilising extracorporeal circulation and cardioplegia still remains the gold standard of therapy for patients with symptomatic stenosis of the aortic valve. Excellent long-term clinical results and low mortality, as well as morbidity are achieved in patients with a low perioperative risk.[1] The decision on the type of intervention is taken based on the patient's age, his/ her overall clinical condition, severity of his/ her problems, disease progression, as well as his/ her social background.[2] Interventional cardiology and cardiosurgery units offer minimally invasive, catheter-based AVR or transcatheter aortic valve implantation (TAVI), as an alternative to AVR.[3] In general, high-risk American Society of Anesthesiologists' (ASA physical status) III–IV patients are candidates for TAVI.[4,5] The risks and predicted mortality can be calculated using EURO score II, which is most commonly used in cardiac surgery. The score overestimates the calculated mortality and evaluation of some comorbidities appears insufficient. The success rate of procedures at specialised sites approaches 100%, with perioperative mortality rates reaching 1-5%, and are most commonly caused by acute heart failure.[6] Compared with classical AVR, important benefits offered by the TAVI procedure include its mini-invasiveness and the absence of surgical wound, no extracorporeal circulation, no cross-clamping of the aorta, and no need for administration of blood products.[3] Other benefits include early mobilisation and discharge to the home environment.[3,7,8] TAVI is the method of choice in patients with a markedly calcified ("porcelain") aorta.[5,9] However, TAVI is also associated with complications, the most common of which are acute left-sided heart failure, occlusion of coronary arteries, bleeding due to aortic injury and groin bleeding. In spite of demonstrably better results of TAVI compared with conventional treatment in patients contraindicated for AVR[10] and better short-term mortality in high-risk patients after TAVI compared with AVR,[11] better long-term results (3–5 years) have not yet been demonstrated for TAVI compared to AVR.

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Based on current evidences, TAVI appears to be a safe and less complicated method of AVR for high-risk patient groups.[7,8]

TRANSCATHETER AORTIC VALVE IMPLANTATION

In 2002, Alain Cribier performed the first catheter-based AVR via the femoral vein. Access to the right atrium through the venous circulation and transseptal access to the left-sided compartments have been replaced by the retrograde route via the femoral arteries, which is the most common route of access for TAVI today.[1] Transapical access is an alternative method in which a mini-thoracotomy is used to "puncture" the anterolateral wall of the left ventricle and an aortic valve is then inserted. However, this procedure is associated with a relatively higher number of complications including the rupture of the left ventricular apex or even aneurysm formation, injuries to the right ventricle, the inter-ventricular septum and coronary arteries, or damage to the mitral valve. Transapical implantation is more suitable in patients with limited femoral blood flow, or other contra indications for its catheterisation.[5,12] Considering the reduction in the sizes of instruments used for transfemoral access, as well as the generally lower complication rates, the transfemoral access has become the preferred access today.[5,12]

ANAESTHETIC TECHNIQUES FOR TRANSCATHETER AORTIC VALVE IMPLANTATION

Patients undergoing TAVI procedures are high-risk patients as mentioned already (ASA III–IV) and the decision about the anaesthesia management is very important. TAVI can be carried out under local anaesthesia, analgosedation, or general anaesthesia (GA). Spinal or epidural anaesthesia and analgosedation provide the advantage of a lower overall rates of complications for the patient without affecting cognitive functions and subsequent length of hospital stay.[13,14] Local anaesthesia can be used for TAVI when carotid artery is used as route of access.[15] Analysis of data from 2326 patients shows that transfemoral TAVI performed under local anaesthesia is generally preferred but there is a higher incidence of post-procedural aortic regurgitation.[16] We prefer GA for all TAVI procedures at our cardiac centre, including for high-risk patients. The internal jugular vein (most commonly on the right) is cannulated in all patients the evening before the procedure. Two units of red blood cells are reserved in the blood bank. Anticoagulant therapy is continued in these patients. On the day of the procedure, prophylactic antibiotics are administered and the radial artery is most often cannulated on the left, (based on the results of Allen's test) and a urinary catheter is inserted. The Catheterization laboratory is prepared to manage any potential complications [emergency cardiopulmonary bypass (extracorporeal circulation) and extracorporeal membrane oxygenation].[17] Under GA with tracheal intubation, transvenous right-ventricular stimulation electrode and trans-oesophageal echocardiography probe are inserted in the Catheterization laboratory. GA is induced using etomidate 0.2–0.3 mg/kg or propofol 1% 1–2 mg/kg; tracheal intubation is performed with rocuronium 0.6 mg/kg induced relaxation and analgesia provided by sufentanil 0.1–0.4 μg/kg as a single shot. GA is continued with oxygen, air and sevoflurane (expired concentrations not to exceed 1.2%). Sufentanil 10–20 μg is supplemented as necessary. At the end of the procedure, neuromuscular block is reversed with sugammadex 2 mg/kg and patient shifted to Intensive coronary care unit (ICCU). GA is needed in order to maintain ventilation and haemodynamic stability of the patient throughout TAVI implantation, particularly during the balloon valvuloplasty procedure that precedes the valve implantation. In both the phases of TAVI where the flow through the aortic orifice is virtually obliterated, an external pacemaker must be used for some time (usually 20–45 s), to reduce the cardiac output by initiating ventricular tachycardia (by "overstimulation" to approximately 180 beats/min). GA also allows for performing oesophageal echocardiographic assessment at any time during the procedure (to measure the annulus size, determine aortic pathology, determine the left ventricular function, evaluate mitral regurgitation, verify the position of the implanted valve and aortic regurgitation immediately after the procedure). GA is also convenient in the event of a protracted procedure when the patient is expected to be absolutely still.[18] The need for circulatory support using vasopressors (norepinephrine) or inodilators (milrinone, levosimendan) is not uncommon.[18] In the ICCU, trachea is extubated after 30–60 min. Since 2010, Medtronics CoreValve© (Medtronics, Minneapolis, Minnesota, U.S.A.) valves have been used at our unit and till the time of submission of this article, 112 valves have been inserted. Our 30-day mortality is at the same level as other large European medical centres. In order to prevent bleeding complications from the puncture site, surgical haemostasis should be ensured after the

procedure. We have not yet encountered post-procedure acute heart failure, adverse cerebrovascular events or coronary ischaemia; however, two patients needed surgical intervention for pericardial tamponade with successful outcomes.

ALTERNATIVE MINI-INVASIVE APPROACHES

In an effort to avoid difficulties following transfemoral and transapical access and in order to make TAVI suitable to patients with compromised femoral and iliac blood flow, some other approaches have been used with success.[19,20] Aortic valve can also be guided through the ascending aorta via a right-sided upper mini-thoracotomy (second or third right intercostal space), in the parasternal region under direct vision.[21] Selective ventilation of the left lung throughout the procedure is necessary (performed at our centre); it ensures better surgeon comfort. This is done by inserting a double lumen endobronchial tube (insertion of a bronchial blocker is an alternative without the need of reintubating using a regular endotracheal tube at the end of the procedure). Selective ventilation of the left lung may, however, precipitate hypoxia in haemodynamically unstable patients with risk of subsequent cardiac failure. This procedure provides the advantage of inserting the instruments in the ascending aorta under visual control.[18,19] It is not suitable for patients with pleural adhesions as there could be incomplete collapse of the lung during one-lung ventilation. Implantation via brachiocephalic artery is suitable in patients with severe atherosclerosis, if the diameter of femoral arteries is less, if there is sepsis in the region of subclavian artery access, prior intrathoracic surgery and in severe calcification of the aorta. It is usually recommended to monitor cerebral tissue oxygen saturation during the procedure.[20,22] Implantation via left carotid artery is suitable and safe in patients where the transfemoral, transapical or transaxial access cannot be used. It is advisable to monitor cerebral tissue oxygen saturation during this procedure also. Transient cerebral ischaemia is a possible complication.[20,23] Implantation via axillary artery is suitable for patients in whom the use of other modes of access is not possible. Dissection of the subclavian artery may be a complication.[24,25] Direct access from the subclavian artery is the method of choice and the most common access.[26]

PARTIAL UPPER STERNOTOMY

This approach provides the advantages of a smaller surgical wound, lower blood loss without the need for blood transfusion, better healing, fewer infectious complications, and a shorter time of overall hospitalisation.[27] This approach is also convenient for repeated surgeries and after previous intrathoracic procedures.[28] It is becoming more popular and even the technique of choice for TAVI.[29,30] A disadvantage of this procedure is the relatively limited orientation of structures and difficulty in tissue manipulation in the event of sudden massive surgical bleeding. Partial upper sternotomy has also been described as an urgent, life-saving approach to handle complications during TAVI using transfemoral access.[31] The greatest advantages of upper partial sternotomy for TAVI include simpler handling of instruments and the incision of the distal part of the ascending aorta, which is then used to insert the instruments.[29,30] This approach does not require one-lung ventilation, and therefore it is well tolerated in compromised patients.

SUMMARY

Surgical replacement remains the gold standard of therapy in patients with symptomatic stenosis of the aortic valve. This procedure is not suitable for certain groups of high-risk patients where mini-invasive, catheter-based AVR is the method of choice. Over the last 12 years, a number of implantation techniques have been developed. The choice of anaesthesia, local or general, is different in different centres. Each technique has its own merits and demerits; we prefer GA in our centre.

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