Video assisted right mini-thoracotomy for aortic root replacement

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Abstract: Aortic root replacement is typically performed through a median sternotomy. The right anterior mini-thoracotomy approach has been shown to decrease hospital length of stay in aortic valve surgery when compared to sternotomy. This approach is rare in ascending aortic surgery due to technical challenges which include exposure and annular suture placement. Automated suturing technology is now available to facilitate the placement of annular sutures. The use of a camera greatly enhances visualization of the aortic root. A right anterior mini-thoracotomy is performed via a 5 cm incision in the right second intercostal space with a camera port placed lateral to the incision. Peripheral arterial and venous cannulation are performed. The aortic cross clamp is placed through a 5 mm incision in the third interspace anterior to mid axillary line. Histidine tryptophan ketoglutarate (HTK) cardioplegia is administered and deep hypothermic circulatory arrest is achieved followed by completion of the distal anastomosis with a 4-0 polypropylene running suture. After aortic leaflet removal, annular and prosthetic sutures are placed with shafted instruments or with automated suturing technology. Coronary button suturing and graft-to-graft anastomoses are performed with shafted instruments. Aortic root procedures can be performed safely through a right anterior mini-thoracotomy. The use of a camera and automated suturing technology may further facilitate this procedure, enabling more surgeons to offer this less invasive approach to patients.

Keywords: Right mini-thoracotomy; aortic root replacement; video-assisted; automated suturing device

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Introduction

Minimally invasive cardiac surgery is expanding the field of cardiac surgery. The range of procedures amenable to a minimally invasive approach continues to broaden with increased surgeon experience and technological advances that improve the visualization and safety of these procedures. With the advent of new technologies, such as transcatheter valves, patients are increasingly interested in minimally invasive approaches to cardiac surgery.

Aortic root replacement is traditionally performed through a median sternotomy (1). Mok *et al.* recently reported on a 25-year single institution experience with composite graft root replacements that demonstrated a low operative risk and excellent long-term survival, equivalent with age-gender matched controls (2). An increasing number of surgeons are employing a hemi-sternotomy approach to replace the aortic root (3,4). However, the right mini-thoracotomy approach for aortic root surgery is rare (5,6). Right mini-thoracotomy aortic valve replacement has been associated with decreased transfusion requirements, reduced pain, shorter hospital stays, and improved cosmesis when compared to sternotomy and hemi-sternotomy approaches (7,8). The success of the right mini thoracotomy approach for aortic valve surgery may translate into improved outcomes in select patients requiring aortic root replacement. In this report, we describe our right mini-thoracotomy approach for aortic root replacement.

Patient selection and workup

We select patients with ascending aortic root or hemiarch pathology only. Patients need to have normal or near

normal left and right ventricular function. The maximum age of patients considered is 75. Patients require normal cerebral circulation and minimal or only mild peripheral vascular disease. Severe atherosclerosis is a relative contraindication. We would not recommend this approach as a redo operation or in conjunction with a concomitant procedure. Patients with endocarditis may also be contraindicated. Patients are excluded if they have porcelain aorta or any contraindication to transesophageal echo (TEE) based on the American Society of Echocardiography guidelines (9).

Pre-operative preparation

We obtain an electrocardiogram, an echocardiogram, cardiac catheterization, and pulmonary function testing. Computed tomography is performed as needed to assess the anatomy of the aortic root.

Equipment preference card

The equipment for the operating room setup and the surgical instruments typically used in a right mini-thoracotomy aortic root replacement are listed in *Table 1*.

Procedure

The patient is intubated using a single lumen endotracheal tube. TEE and cerebral oximetry are initiated. Systemic and pulmonary arterial catheters are placed for hemodynamic monitoring. The patient is prepped from above the clavicles to the knees bilaterally. We make a 5 cm incision in the second intercostal space one cm lateral to the sternal border (*Figure 1*). The pectoralis muscle is then spread to expose the intercostal muscles. The right pleural space is entered lateral to the right internal thoracic artery (RITA). The RITA is ligated with ties and clips. We use a laparotomy pad to compress the lung. An Alexis wound protector (Applied Medical; Rancho Santa Margarita, CA, USA) and an intercostal retractor (Miami Instruments; Miami Lakes, FL, USA) are used to expose the mediastinum. If necessary, the second rib can be disarticulated from the sternum for additional exposure. We make a small incision for a 5 mm camera port in the same interspace lateral to our main incision. Carbon dioxide is infused into the wound through the camera port at 8 liters/min to reduce the risk of retained intracardiac air.

After identifying the phrenic nerve, the pericardium is opened just superior to the right atrial appendage. There is usually a potential space at this point which makes pericardial entry safer. Pericardial stay sutures are placed and brought out through separate 1–2 mm incisions using a surgical crochet hook. The medial stay sutures are clamped to the Alexis wound protector. Liberal use of stay sutures enhances exposure. We do a femoral cutdown preferably on the right side. The femoral vein and artery are then cannulated using Seldinger technique. The presence of the wire in the superior vena cava and aorta, respectively, are confirmed with TEE. A 25 Fr Quick Draw venous cannula (Edwards Lifesciences®, Irvine, CA, USA) is positioned over the wire into the SVC and confirmed with TEE guidance. The arterial cannula is positioned over the wire in the descending aorta under TEE guidance. We use an 18 Fr cannula for patients with body surface area (BSA) less than 2 and a 20 Fr cannula for patients with BSA greater than 2. Cardiopulmonary bypass (CPB) with vacuum assist is then initiated and the patient is then cooled down to 15–18 degrees Celsius.

In aortic insufficiency cases, we place a retrograde catheter whenever possible using TEE guidance. A 3-0 polypropylene purse-string suture is placed in the right atrium and the cannula is advanced through the purse-string into the coronary sinus. Pulsatile venous return confirms placement in the coronary sinus. If a retrograde catheter cannot be placed, direct coronary ostial perfusion is utilized. In aortic stenosis cases a single dose of histidine tryptophan ketoglutarate (HTK) cardioplegia is given antegrade. We place a 3-0 polypropylene purse-string in the right superior pulmonary vein. A catheter is then advanced through this purse-string across the mitral valve. A separate 5 mm incision is made in the third interspace anterior—mid axillary line to place our Chitwood Debakey aortic clamp (Scanlan International; St. Paul, MN, USA), which is "prepositioned" in the transverse sinus. The antegrade cardioplegia needle is placed next. The aorta is cross clamped and 20 mg of adenosine followed by 2 liters of HTK cardioplegia is administered. This will allow for approximately 2 hours of cross clamp time.

The aortotomy is made at the point of the antegrade needle insertion. The aorta is transected and a 2-0 silk stay suture is placed to retract the aorta cephalad. Commissural stay sutures are placed using 2-0 silk. A gauze pad is placed in the left ventricle temporarily to collect any debris. The leaflets are excised and the annulus sized. Calcium in the aortic annulus is debrided as necessary. Once satisfactory temperature is achieved, the patient is placed in

Table 1 Aortic root replacement equipment preference card

Setup
Wingman scope holder
Camera
Intercostal retractor
Weitlander
CO_2 tank
Video tower
Thoracotomy incision
Blades
Needle drivers
Forceps
Alexis wound protector
Estech shafted needle driver
Estech shafted grasper
Estech shafted scissors
2-0 silk
Crochet hook
Arterial cannulation
4-0 prolene
Red rubber catheter
Rummel tourniquet
5-0 Surgipro
Arterial cannula percutaneous kit with dilators
Venous cannulation
3-0 prolene
18-gauge needle
4-0 prolene
Red rubber catheter
QuickDraw venous cannula kit

Table 1 *(continued)*

Venous cannulation continued
Disposable clip applier
Small vessel clips
Vessel loops
Metzenbaum scissors
Milrinone spray/sponge
5-0 prolene
Rummel tourniquet
Aortic root placement
Chitwood Debakey aortic cross clamp
Large Metzenbaum scissors
Rongeur
Bulb syringe
Valve leaflet probe
4-0 prolene
2-0 Ethibond
Pledgets
5-0 prolene
COR-KNOT mini device kit
COR-KNOT quick loads
RAM device kit
SEW-EASY device kit
Freestyle aortic root bioprosthesis
On-X ascending aortic prosthesis
Vascutek Gelweave Valsalva graft
Homografts
Miscellaneous
BioGlue
FiberWire
Sternal saw

Trendelenburg and the cardiopulmonary bypass circuit is turned down to 50 cc/minute. The cross clamp is removed and the remaining segment of ascending aorta is resected up to the level of the innominate artery. Hemiarch resection may also be accomplished easily through this approach. In patients age 64 or younger, we typically use an On-X ascending aortic prosthesis (CryoLife Inc. Kennesaw, GA, USA). In patients 65 or older, we typically use the Vascutek Gelweave Valsalva graft (Terumo Cardiovascular Group, Tokyo, Japan) and sew a bioprosthetic valve into the graft using a running 3-0 polypropylene. The distal anastomosis is completed in the usual fashion using 4-0 polypropylene.

Figure 1 Right mini-thoracotomy Bentall procedure (10). Available online: http://asvidett.amegroups.com/article/view/22988

Cerebral vessels, aortic arch and graft are then de-aired and the aortic graft is clamped. CPB is then re-established and warming is commenced.

The aortic root is then exposed with stay sutures and the remaining portion of the aorta and sinuses are resected. We then construct the coronary buttons and retract them using stay sutures. The inflow suture line is created using 2-0 Ethibond sutures. Alternatively, when inserting a valve in the supra-annular position, an automated suture delivery system (RAM® and SEW-EASY®; LSI SOLUTIONS®, Victor, NY, USA) can be used. Once the valve conduit is seated, it is secured using the COR-KNOT® Device and titanium fasteners (LSI SOLUTIONS®, Victor, NY, USA). The left main coronary anastomosis is then completed with 5-0 polypropylene followed by the right main. The graft to graft anastomosis is completed in a running fashion using 4-0 polypropylene and de-airing is performed. BioGlue is used on all the anastomoses. The left ventricle and ascending aorta are de-aired and the cross clamp is removed. The anesthesiologist uses TEE to meticulously evaluate appropriate de-airing, ventricular function, and prosthetic valve function. CPB is then discontinued. The second rib is then secured to the sternum with FiberWire (Arthrex; Naples, FL, USA). Intercostal nerve blocks are performed under direct visualization with bupivacaine (0.25%) with epinephrine. Distal pulses are checked, two drains are placed and the wound is closed in layers.

Role of team members

The primary surgeon is responsible for the pre-operative, intraoperative and post-operative care of the patient. In addition, surgical trainees play an integral part in the case. The trainee routinely performs the incision and initial dissection and placement of pericardial stay sutures. The camera view greatly enhances the educational experience of the junior surgical resident as they begin to appreciate the appropriate needle angles, bite depth, etc. The camera view also enables the primary surgeon to assess the quality of the trainee's suturing.

The anesthesiology team places the arterial, central venous, and pulmonary artery catheters and performs endotracheal intubation. An anesthesiologist proficient in advanced perioperative TEE performs a comprehensive TEE examination at the beginning of the case and communicates findings to the surgical team. New or significant ventricular dysfunction or presence of unexpected valvular pathologies may prompt a change in surgical approach. During cannulation for CPB, cooperative TEE guidance helps to avoid intracardiac and aortic injury. Because a single lumen endotracheal tube is used, breath holding is necessary during the mediastinal dissection and placement of the pericardial stay sutures. Frequent and prompt communication between the anesthesiologists, surgeons, and perfusionists is necessary to optimally manage patient ventilation and hemodynamics.

Perfusionists need proficiency with HTK cardioplegia, vacuum assisted CPB, and ultrafiltration. They will interact frequently with the surgeon and anesthesiologist during the case. Nursing teams are actively involved in the pre, intra, and post-operative management of each patient, frequently assessing clinical status and ensuring adequate pain control to promote a quick recovery. Physical therapy plays a key role in helping the patient achieve early ambulation. Utilizing the expertise of this multidisciplinary team, patients can leave the hospital in as few as three days.

Post-operative management

Patients are transferred promptly to a cardiac intensive care unit and under the care of fellowship trained critical care intensivists. If there is no bleeding, the patient can be extubated early on post-operative day zero. We recommend early removal of chest tubes whenever feasible. Multimodal analgesic therapy, including intercostal nerve blocks, acetaminophen, and peri-incisional lidocaine patches, help to reduce narcotic pain medicine requirements and promote early mobilization.

Tips, tricks and pitfalls

Communication is essential between the surgeon and

anesthesiologist especially during the placement of the CPB wires/catheters. The surgeon should employ stay sutures liberally in order to mobilize the aorta prior to cross clamp. The bottom jaw of the aortic cross clamp must be placed through the upper part of the transverse sinus to avoid pulmonary artery injury when the aorta is clamped. It is critical to perform an excellent anastomosis at each site and in particular the left main coronary button anastomosis as bleeding can be more difficult to control through this incision. The use of the camera greatly enhances visualization of the aortic root. The automated suturing devices were recently introduced as a tool for minimally invasive cardiac surgery and is thought to facilitate supra-annular suture placement (11). Pacing wires can be trickier to place through this incision. It is important to have near normal left and right ventricular function as the aortic cross clamp time will probably be longer. One hundred and fifty minutes of cross clamp time is acceptable in this approach. We recommend sufficient experience be acquired using the video assisted right mini-thoracotomy approach for aortic valve replacement prior to the initiation of a mini-thoracotomy Bentall program.

Conclusions

Right anterior mini-thoracotomy aortic root replacement can be done safely in select patients. The use of a camera and automated suturing technology may facilitate this approach.

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Footnote

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