Minimally invasive mitral valve repair: the Liverpool Heart and Chest Hospital Technique—tips for safely negotiating the learning curve

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Introduction

Minimally invasive mitral valve surgery (MIMVS) is technically challenging with a learning curve of 75-125 cases, and aspects of the procedure such as a 4 cm incision, no rib spreading, endoaortic balloon occlusion and a totally thoracoscopic technique increase the level of difficulty (1). Undoubtedly, one year of fellowship training in a high volume centre with plenty of operative exposure is important, but starting a new programme can still be daunting especially in the era of surgeon-specific data reporting. Selection of appropriate patients is probably the most important variable; choice of less complex repairs in patients with a normal body mass index (BMI) and no aortic valve incompetence is helpful. Thereafter, avoiding aspects of the technique that increase the level of difficulty becomes important. This video demonstrates a simple and reproducible technique that provides a safe platform that can be built upon as one's experience increases. It is a good starting point for surgeons wishing to introduce this into their practice and safely negotiate the learning curve.

Clinical vignette

A 53-year-old male was referred with an 8-month history of mild dyspnoea on exertion (New York Heart Association class II). He had no prior history of a heart murmur and no family history of Barlow's disease. Similarly, there was no prior history of myocardial infarction, stroke, pulmonary disease, peripheral vascular disease, hypertension or rheumatic fever. Clinical examination confirmed a grade IV pansystolic murmur heard all over the precordium; both femoral pulses were strong and palpable.

Transoesophageal echocardiography (TOE) confirmed prolapse of the lateral border of P2 with a severe jet of mitral regurgitation directed anteriorly. There was no aortic regurgitation, the TV diastolic annular diameter was 3.2 cm and the ejection fraction was >60%. There was no coronary disease on radial angiography. A CT of the chest, abdomen and pelvis excluded the presence of aortic atherosclerosis. His femoral arteries were 9 mm diameter. He therefore underwent a minimally invasive mitral valve repair.

Surgical techniques

The patient underwent general anaesthesia with placement of a left-sided double lumen endotracheal tube. Using the Seldinger technique and TOE guidance, a 17Fr arterial cannula (Biomedicus, Medtronic, MN) was inserted into the right internal jugular vein and positioned just beyond the confluence of the brachiocephalic veins. We routinely drip heparinised saline through this line until cardiopulmonary bypass (CPB) is established.

The patient was positioned with the right chest rotated 30° anteriorly by a roll under the right scapula and with the pelvis flat on the table. The right arm was padded and held at the patient's side with the shoulder extended. Prior to skin preparation, the port sites were marked. The femoral vessels are always exposed first for a primary procedure to ensure they are >6.5 mm and thus able to support femoral arterial perfusion; for a redo procedure, the minithoracotomy incision should be performed first to ensure that the right pleural cavity is not obliterated. A 2-3 cm right groin skin crease incision was performed preserving all lymph nodes to reduce the risk of seroma formation post-operatively and 4/0 prolene pursestrings placed.

A 7 cm right anterolateral minithoracotomy in the 4th intercostal space was performed and a soft tissue retractor deployed. A pledgetted 2/0 ethibond suture was used to retract the diaphragm inferiorly. A 5 mm camera port with CO_2 at 4 L/min connected to the side arm was inserted in the 3rd intercostal space anterior to the shoulder. A 7 mm suction port was placed in the 6th intercostal space just anterior to the anterior axillary line and a LA retractor (HV retractor, USB Medical, PA) was inserted in the 4th intercostal space just lateral to the sternum under videoscopic control to avoid injury to the right internal mammary artery.

Heparin was then administered and the femoral vessels cannulated using a Seldinger technique and TOE guidance (femoral artery: 21Fr Biomedicus; femoral vein: 23/25Fr Estech dual stage cannula). Vacuum-assisted CPB was commenced and the pericardium opened 3 cm anterior to the phrenic nerve. A long aortic root cannula was placed into the aortic root with pledgetted 3/0 prolene and a Chitwood transthoracic clamp placed through the 4th intercostal space in the mid axillary line with the posterior tine of the clamp through the transverse sinus. The heart was then arrested with 1.5 L antegrade cold blood cardioplegia and the systemic temperature dropped to 28 ℃—we cool more for minimally invasive than sternotomy procedures to decrease the rate of myocardial rewarming. Maintenance cardioplegia (500 mL) was administered every 20-30 minutes into the aortic root. The LA was opened through Waterston's groove and the HV retractor positioned to expose the mitral valve.

The next stage of the operation was identical to a sternotomy repair—annuloplasty sutures, valve analysis, leaflet repair, annuloplasty ring. Thus, 2/0 ethibond annuloplasty sutures were placed from commissure to commissure with the addition of a sternal wire through the chest wall in the 2nd intercostal space in the midclavicular line to retract the 8-10 o'clock sutures cranially to improve the view of the valve. A chordae gauge was used to size a set of polytetrafluoroethylene (PTFE, Goretex) loops from the posterior head of the anterior papillary muscle to the plane of the valve annulus defined by a non-prolapsing segment. The loops (14 mm) were then implanted onto the papillary muscle and attached to the prolapsing segment as two pairs with 4/0 Goretex. A 34 mm Physio II ring (Edwards Lifesciences, CA) completed the repair. A hydrostatic test revealed a competent valve and an ink test revealed >6 mm of coaptation (2).

The LA was closed with 3/0 prolene and the heart deaired across the LA suture line and the root vent. Right ventricular pacing wires were placed before unclamping. After reperfusion and rewarming, CPB was temporarily weaned to check the repair and the TOE showed no residual MR, a mean gradient of 2 mmHg, no systolic anterior motion and 8-9 mm coaptation. CPB was then reinstituted to remove the root cannula. A 19Fr Blake drain was positioned through the skin incision for the LA retractor into the oblique sinus, CPB was again weaned and the pericardium was approximated in two places. A 28Fr apicobasal right sided chest tube was positioned through the 7 mm port site, followed by a thoracoscopically-guided paravertebral catheter for post-operative analgesia. Two pericostal sutures were placed to prevent lung herniation.

Comments

Minimally invasive mitral valve surgery is technically challenging and appropriate training and patient selection are the two most important considerations when embarking on this journey. However, there are a number of technical aspects to the procedure which decrease the complexity which should be highlighted and are extremely helpful at the start of the learning curve:

- Almost all of the operation can be done under direct vision although the camera is useful for visualising the posterior papillary muscle. A direct line of sight from one's eyes to the mitral valve is all that is needed and this can be accomplished with minimal rib spreading (1-1½ inches maximum) and a slightly larger incision (6-8 cm or larger rather than 4-6 cm). As one becomes more experienced, then increasing reliance on video-assistance through a non-rib spreading 4 cm incision occurs naturally to the point where a totally thoracoscopic skill set is achieved.
- The 'loop technique' has completely obviated the risk of knot slippage when tying with a knot pusher and is probably one of the most significant developments in mitral valve surgery in the last 15 years. However, the Achilles Heel of this technique is getting the measurement correct (3). Nevertheless, the length of the loops is very reproducible with posterior leaflet loops usually being 10-16 mm and if one is implanting loops outside this range then the accuracy of the measurement should be questioned.
- Aortic occlusion with a transthoracic clamp rather than an endoballoon. Many surgeons achieve fantastic results with the endoballoon but it needs (I) constant

vigilance as its position is less stable and therefore needs bilateral radial artery pressure monitoring to detect distal migration (II) a larger femoral arterial cannula with bilateral femoral cannulation in up to one in three patients to keep the arterial line pressures <300 mmHg. In the current financial climate, it is also significantly more expensive and is single use.

- Thoracoscopic paravertebral catheter—this is widely used in VATS lung surgery and we have applied this to mini mitral surgery. It is important to place this when the heparin has been reversed and to get this as close to the paravertebral space as possible otherwise only one or two intercostal nerves are blocked. We have found that this is a very reliable form of post-operative analgesia and generally leave this *in situ* for 48 hours.

These techniques collectively simplify an otherwise challenging procedure, make it highly reproducible and provide a safe foundation upon which one can build. Appropriate patient selection is obviously paramount and isolated posterior leaflet prolapse is a good starting point due to the reproducibility and durability of repair. Avoidance of patients with an elevated BMI, expected complex repair or any aortic incompetence is advisable. As one's experience increases, then these patients can be tackled also. Thus, a repair rate of >90% can be achieved and patients can benefit from a 3-week recovery period rather than the 3-month recovery period associated with a sternotomy.

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