

# Minimally Invasive Cardiac Surgery Using a Flexible Aortic Clamp

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## ABSTRACT

Minimally invasive surgery for mitral valve disease has been performed using a variety of technologies, some of which are complex, have a steep learning curve, and are expensive. We have adopted a simple cost-effective approach over the last 7 years to perform a variety of minimally invasive procedures with excellent outcomes. There have been no strokes, no mortalities, and no episodes of limb ischemia in our series. No patient has required reoperation.

## INTRODUCTION

Minimally invasive mitral valve repair via a right minithoracotomy has been performed since the mid 1990s with several variations [Casselman 2003; Sobieski 2003; Walther 2004; Chitwood 2005; Reichenspurner 2005; Ryan 2005; Aybek 2006]. Modifications include central versus peripheral cannulation [Aybek 2006], use of a pulmonary vent [Ryan 2005], antegrade versus combined antegrade and retrograde cardioplegia [Ryan 2005], and balloon versus external aortic clamping techniques [Reichenspurner 2005]. This approach results in less trauma, less pain, shortened hospital stay and reductions in cost. We have chosen a simple and low-cost method in 25 cases with favorable outcomes.

## TECHNIQUE

Patients were selected for mitral valve repair/replacement based on echocardiographic findings of mitral pathology and normal coronary anatomy. After intubating with a double lumen endotracheal tube, a 16 F cannula (Research Medical Incorporated, Edwards Lifesciences, Irvine, CA, USA) was placed in the right internal jugular vein after administering

5000 units of heparin. A Swan-Ganz catheter was also placed in right internal jugular vein more cranially.

The patient was positioned on the table with right chest elevated 30 degrees using an inflatable bladder (Roho pump and bladder; Crown Therapeutics, Belleville, IL, USA) with the right arm tucked. A self-balancing camera holder (Olympus scope holding arm, Center Valley, PA, USA) was attached to the table on the right side and a sterile metal bar for mitral valve retraction on the left side (Retracto robot; Elmed, Addison, IL, USA).

Using a 5- to 7-cm incision in the submammary fold, the 4th intercostal space was entered. A large soft tissue retractor (Cardiovations, Somerville, NJ, USA) and a self-retaining retractor (Estech, Danville, CA, USA) were placed. The diaphragm is retracted if necessary using a silk suture brought out through the chest wall inferiorly. The camera port is placed in the 4th space mid axillary line laterally and a 10-mm video camera inserted. We insert a 5-mm port in the 6th space for the left atrial vent and for CO<sub>2</sub> insufflation.

Simultaneously the right femoral vessels were exposed using a 1-inch incision. After heparinization, the femoral artery is cannulated with a 19 F (17-21 F) cannula (Medtronic, Minneapolis, MN, USA) using Seldinger technique. Similarly, a 22 F venous cannula (Cardiovations, Quickdraw) is inserted into femoral vein and tip positioned in the superior vena cava or right atrium under transesophageal echocardiography guidance.

Cardiopulmonary bypass is instituted and the pericardium opened. A flexible aortic clamp (Vitalitec, Plymouth, MA, USA) is positioned with its posterior jaw in the transverse sinus. A cardioplegia catheter (Medtronic) is placed in the ascending aorta via thoracotomy with a Y connector for the venting. The aorta is cross clamped after cooling to 32 degrees. The rigid clamp becomes flexible after withdrawal of its sheath and is brought out through the left upper corner of the incision along with the antegrade cardioplegia catheter. Only intermittent antegrade cardioplegia is utilized. Figure 1 presents a diagram of the technique.

Procedures performed include mitral valve repair or replacements in 21, one tricuspid valve replacement, one atrial septal defect closure, and Cox Cryo Maze IV with biatrial ablation lines in 2 cases during the period from 1999 to 2006.

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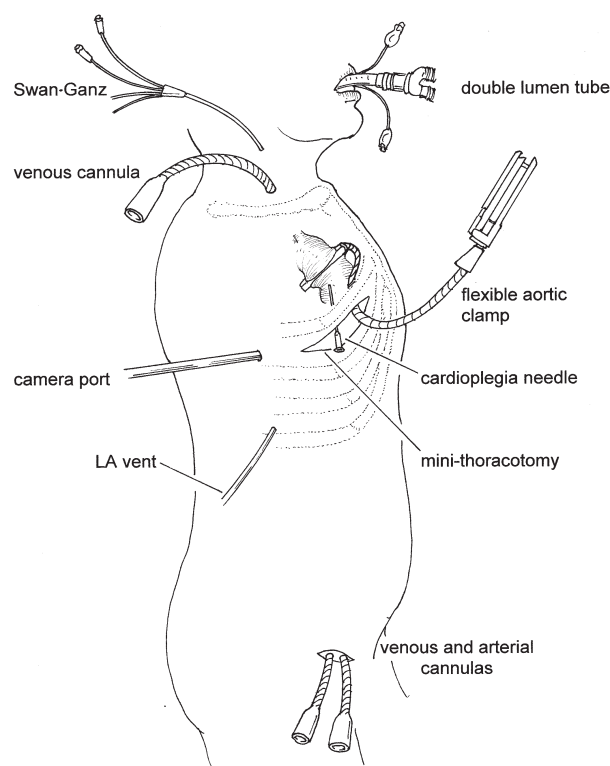


Figure 1. Line diagram showing the incision, cannulation, and clamp placement.

## DISCUSSION

Since the mid 1990s, minimally invasive mitral valve repair has been performed using a variety of technology ranging from use of high-cost robotics [Walther 2004; Chitwood 2005] to complicated endoaortic balloon occlusion. Femoral arterial cannulae incorporating an endoaortic balloon (Cardioventions) are expensive [Walther 2004; Reichenspurner 2005]. There is a steep learning curve, multiple time consuming steps, a 1% risk of aortic dissection [Casselman 2003; Ryan 2005], and a 1% risk of leg ischemia. Furthermore, the balloon can encroach on the left atrial wall with an inherent risk of rupture associated with sutures near the left trigone. The retrograde cardioplegia cannula is also time consuming to insert, expensive, and may result in unpredictable cardioplegia delivery [Casselman 2003; Ryan 2005]. Pulmonary vents are expensive, time intensive, and the need for them is a measure of inadequate venous drainage.

We have adopted a simple technology and cost-effective approach.

### Arterial Access

A simple femoral cannula provides predictable arterial access in most cases; except in patients with peripheral vascular disease who may need central cannulation.

### Venous Drainage

Predictable and adequate drainage is achieved with percutaneously placed right jugular and femoral venous cannulae connected with a Y connector. This bicaval cannulation technique provides adequate venous drainage and avoids the need for a pulmonary vent.

### Cardioplegia

Intermittent antegrade blood cardioplegia administered every 20 minutes with systemic cooling to 30 degrees has provided predictable myocardial protection in our series. However, the ideal method of myocardial protection involves combined antegrade and retrograde cardioplegia. The insertion of a retrograde catheter in minimally invasive procedures can be challenging. All the patients in this series had normal coronary anatomy, further reducing the need for retrograde cardioplegia. Redo procedures with adhesions around the aorta were cooled to 28 degrees and the fibrillatory arrest technique was used selectively.

### Aortic Clamping

A flexible aortic clamp (Figure 2) can be placed via minithoracotomy, avoiding the need for additional holes in the chest wall, and is unlikely to compress the superior vena cava, since it exits anteriorly. It also occupies very a small part of the incision in its flexible form once the covering sleeve is withdrawn. This clamp is reusable, with disposable inserts.

### Incision

The length of the incision ranges from 5 to 8 cm. Camera and vent holes can be used for placing chest tubes.

Procedures on mitral, tricuspid valves, and both atria including surgical maze procedures can be safely performed. For right-sided procedures, the superior vena cava can be clamped using the same flexible aortic clamp after its removal from the aorta. Inferior vena cava clamping can be similarly achieved if necessary [Dandolu 2005], thereby avoiding caval snaring with the inherent risk of injury in the minimally invasive setting. The quality of exposure is satisfactory and is comparable to or better than median sternotomy. There have been no instances of compromise of the procedure due to inadequate exposure.

### Follow-up

There were no instances of trauma or dissection related to the clamp in the series. Myocardial protection was adequate

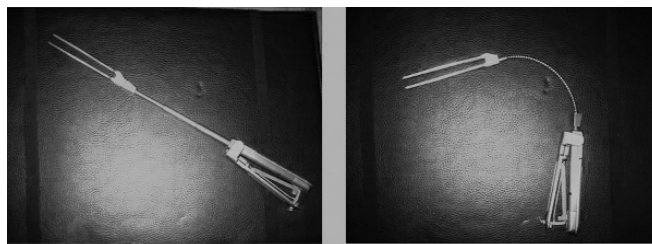


Figure 2. Picture of the clamp in straight and flexible forms.

as demonstrated by the minimal need for inotropes. Venous drainage was adequate with an occasional need for repositioning the cannulae. During the follow-up, there were no problems related to clamp, exposure, and repair.

In conclusion, procedures on the mitral and tricuspid valves and both atria can be accomplished in a minimally invasive fashion via a 5- to 8-cm right thoracotomy using a flexible, reusable aortic clamp and other inexpensive and readily available technology.

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## REVIEW AND COMMENTARY

### *Editorial Board Member SO115 writes:*

In surgery in general, mini-invasive techniques are based on the principle of performing an operation (the "same" operation) with alternative techniques and approaches with the goal of reducing postoperative morbidity. In cardiac surgery, in particular, this means not only using smaller or alternative (theoretically less painful) incisions, improving cosmetic results, reducing postoperative pain and postoperative complications (for instance, respiratory infections), and expediting postoperative recovery, but also reducing

complications related to cardiopulmonary bypass and cardioplegic arrest.

This paper reports the use of a flexible aortic clamp, introduced through the same right thoracotomy incision used to approach the mitral valve. Obviously, this technique is intriguing, as it avoids the use of an "extra" thoracic incision to apply an extracorporeal aortic clamp or the use of an occlusive intra-aortic balloon, which may be cumbersome to insert into the aorta. Balloon occlusion may also carry substantial risks of occlusion or embolization of a major head vessel. However, there are some concerns about this clamping technique. Performing a right thoracotomy that allows adequate exposure of the mitral valve through a left atriotomy, as described in the paper, requires lateral extension of the thoracotomy and spreading of the intercostal space that becomes narrower and narrower as one proceeds laterally, especially if additional exposure is required to introduce and directly apply the aortic clamp. Pain and discomfort with this incision may become an issue. Our experience shows that this incision is associated with considerably more pain than a standard sternotomy. It would have been of interest to compare thoracotomy and sternotomy in terms of objective measurement of pain experienced by the patients and an exact amount of pain medication required.

The other concern is related to the length of cardiopulmonary bypass and of cross-clamping times compared to a "standard" group of patients. The importance of this is that the size of incision is not the key factor, but reduction in morbidity is the hallmark of minimally invasive surgery. In cardiac surgery, the introduction of off-pump coronary artery bypass surgery allowed comparison of homogeneous groups of patients undergoing the same surgery with and without cardiopulmonary bypass and cardioplegic arrest. The advantages include avoidance of morbidity associated with the heart-lung machine, cardioplegic arrest, and ischemia/reperfusion injury. Accordingly, we feel the technique needs to be evaluated from the point of the length of the entire procedure, pump and cross-clamping times, compared to a group of patients undergoing the same procedure through the standard approach. Regarding the cardioplegia technique, the authors utilized antegrade cardioplegia only, despite the fact that both antegrade and retrograde cardioplegia are needed for "ideal" protection. However, in fairness to the authors, many surgeons administer antegrade cardioplegia only in such cases.

In conclusion, validity of this technique regarding occurrence of pain and its treatment, and duration of cardiopulmonary bypass and aortic cross clamping compared to a group of patients undergoing the same procedure through a standard sternotomy approach is needed before recommendation for widespread use.