Port-access surgery as elective approach for mitral valve operation in re-do procedures

Port-Access Surgery as Elective Approach for Mitral Valve Operation in Redo Procedures

Davide Ricci, MD[2]

Carlo Pellegrini, MD, PhD[1]

Marco Aiello, MD[1]

Alessia Alloni, MD[1]

Barbara Cattadori, MD[1]

Andrea M. D'Armini, MD[1]

Mauro Rinaldi, MD[2]

Mario Viganò, MD[1]

[1] Division of Cardiac Surgery, Foundation I.R.C.C.S Policlinico San Matteo, University of Pavia, 27100 Pavia Italy

[2] Division of Cardiac Surgery, San Giovanni Battista Hospital "Molinette", University of Torino, 10126 Torino Italy

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Address for correspondence:

- Davide Ricci, MD
Division of Cardiac Surgery

San Giovanni Battista Hospital "Molinette", University of Torino

10126 Torino, Italy

Telephone: +390116336131

Fax: +390116336130

e-mail: dricci@molinette.piemonte.it

ABSTRACT

***Background*.** Redo mitral valve procedures performed through median sternotomy carry substantial mortality and morbidity. To avoid complications of sternal re-entry and to provide adequate mitral valve exposure, antero-lateral thoracotomy has been suggested by some authors.

***Methods*.** From October 1997 to January 2007, 677 mitral valve operations have been performed in our center using port-access video-assisted right mini-thoracotomy. Among these, 241 (35.6%) were performed on patients who had undergone one or more previous cardiac surgery procedures.

***Results*.** Mean cardiopulmonary bypass time and endo-clamp time were 117±46 minutes and 71±31 minutes, respectively. Arterial cannulation was performed either on the ascending aorta, with the endo-direct cannula, (112 patients, 46.5%), or peripherally with a femoral artery approach (129 patients, 53.5%). Conversion to median sternotomy was necessary in only two patients (0.8%) due to aortic dissection (1 case) and left ventricle free wall rupture (1 case). Median intensive care unit stay was 24 hours, median mechanical ventilation time was 12 hours; median hospital stay was 8 days. Bleeding requiring surgical revision occurred in 12 patients (4.9%). Hospital mortality was 4.9% (12/241 pts).

***Conclusions*.** Port-Access video-assisted right mini-thoracotomy allows good results in a difficult subset of patients; it allows minimal adhesion dissection, short ICU and hospital stay. In our practice, this technique has become the treatment of choice for mitral valve redo surgery.

Abstract: 217 words

Introduction

Reoperative mitral valve procedures performed through longitudinal median sternotomy are characterized by substantial mortality and morbidity. The peculiar anatomy of the mitral valve and its position under all other cardiac structures makes its approach difficult also during first operation. In reoperative cases, mediastinal scar retraction may render adequate exposure of the mitral valve lengthy and technically challenging. Taking into account that reoperation rates are steadily increasing due to the aging of the population and the long-term structural deterioration of mechanical and biological prosthesis, in the future cardiac surgeons will have to face reoperative mitral valve surgery more and more often than in the past.

To avoid the complications of sternal re-entry and to obtain adequate mitral exposure antero-lateral thoracotomy has been suggested by some authors . This approach bears the advantage of avoiding dissection of the retrosternal adhesions, but nevertheless implies a dissection of the ascending aorta for aortic cannulation (if femoral cannulation is not elected) and aortic cross clamping. De-airing also remains a problem.

In recent years minimally invasive Port-Access technique has increasingly gained more popularity in mitral valve surgery. Many centers have adopted video-assisted port-access mitral surgery as their routinary approach . At our center we have begun using Heart-Port technique in 1997 and 677 mitral valve surgery have been performed ever since. Aim of this study is to analyze our experience with the Heart-Port technique in mitral valve surgery in patients who already underwent at least one previous cardiac operation.

Patients and Methods

From 1997 to January 2007, 677 consecutive mitral valve operations have been performed at our center using Port-Access video-assisted right mini-thoracotomy. Among these, 241 (35.6 %) were performed on patients who had undergone one or more previous cardiac surgery procedures: 183 patients had one previous cardiac surgery; 41 had two previous operations; 13 had three previous cardiac surgeries

and 3 had four previous operations. The patients can be roughly divided into four categories: group I (previous surgery on the mitral valve either alone or in combination with aortic and/or tricuspid valve procedures) 52%, group II (previous surgery on the aortic valve and/or ascending aorta) 13%, group III (previous coronary artery surgery ± aortic and/or mitral valve) 31%, group IV (miscellaneous cardiac surgery) 4%.

All patients underwent operation using Port-Access platform with the surgical approach through a right minithoracotomy (6±1, 4 – 10 cm skin incision) conducted through the fourth intercostal space across the anterior axillary line. Using the soft tissue retractor the surgical port has been exposed and a rib retractor inserted to obtain a mild rib spreading (about 5-7 cm). In no instances any rib resection was performed. In case of pleural adhesions, the lung was partially separated from the thoracic wall by electro-cautery dissection, just enough to uncover the lateral surface of the pericardium. To implement the vision of adhesions and subsequently of the mitral valve an Olympus® endoscope was inserted in an accessory port created below the working port.

Arterial cannulation was obtained by using both the femoral Endo-Cardio Pulmonary By-pass (CPB) (Heartport, Inc, Redwood City, CA) system (129 cases; 53.5 %) and more recently the Endo-Direct (Heartport, Inc, Redwood City, CA) aortic system (112 cases; 46.5 %). Venous return was routinely obtained with a double (jugular and femoral) cannulation. Jugular cannulation was always obtained percutaneusly using a 17 Fr cannula. Femoral cannulation was performed percutaneously in all cases of simultaneous Endo-Direct aortic cannulation. In case of Endo-CPB femoral arterial cannulation, a minimal (3 cm) groin incision was necessary to uncover the anterior wall of the femoral vessels and both arterial and femoral cannulation was directly performed using Seldinger technique through two 4-0 prolene purse strings.

The technique of direct aortic cannulation with the Endo-Direct system has been previously described by other authors. A 8 mm port is created in the first or second right intercostal space. Two purse-string closed with two teflon pledgets are sutured on the right lateral aspect of the ascending aorta as close to the innominate artery branching as possible. Cannulation is then obtained by a single manouvre with the

Heartport cannula. The peculiarity of this cannula is the presence of a retractile blade on its tip, allowing a safe single-punch introduction of the cannula.

Aortic clamping and cardioplegia delivery were obtained using the Heartport endo-clamp, inserted through the side arm of the femoral or aortic cannula. Position of the balloon was controlled by means of transesophageal echocardiography (TEE). Use of radioscopic techniques was not necessary in any case.

After CPB institution, the pericardium was opened 3 to 4 cm above the phrenic nerve and adhesion of the pericardium with the right atrium and the ascending aorta were taken down, with a limited dissection to expose the superior and inferior vena cava and the interatrial groove. In no instances a dissection of the anterior surface of the heart was necessary.

At this stage aortic clamping was obtained by inflating the balloon with 15 to 35 cc of saline solution to reach an endo-balloon pressure of 300-400 mmHg. When the clamping was obtained a bolus of 4 mg of adenosine was administered through the endo-ballon line into the aortic root to stop the heart and then quickly cardioplegia was infused. CPB temperature was usually maintained in the range of 28-32 degrees. A lower temperature (24 - 26 degrees) was sometime required in case of graft patency to avoid the heart restart beating.

Left atrium was accessed with a traditional paraseptal incision. The Heartport atrial retractor was then inserted through a 5 mm stab incision in the 4th or 5th intercostal space just laterally to the left internal mammary pedicle. The retractor was then stabilized with a Codman retraction system. Exposure of the mitral valve was satisfactory in all cases and the mitral operation was then performed as usual with the visual aid of the Olympus® endoscope. In 11 cases (4.6%) surgical treatment of atrial fibrillation was associated using either crioablation or microwave devices.

At the end of the mitral operation, the left atrium was closed with a running suture of 3-0 prolene. De-airing of the cavities was obtained venting both the left atrium and the aortic root through suction on the endo-balloon cardioplegia line; the operating bed was tilted to the left head-up and a gentle external cardiac massage was applied from outside to squeeze the air through the left atrium and the aortic root. Aortic declamping was obtained by slowly deflating the endo-clamp, maintainig active suction on the

cardioplegia line. If pacing of the heart was needed, pacing wires were positioned on the surface of the right or left ventricle, adding a further limited dissection from the pericardium.

After weaning from CPB, arterial aortic or femoral cannulas were removed tying the purse-strings and venous cannulas, if percutaneous, pulled-out and then manual compression was applied.

After checking hemostasis, the pericardium was closed over the right atrium and two thoracic drains positioned through the endoscope port and the Endo-Direct port when present. The ribs were re-approached with a 5 flexidene stitch and the thoracic wound was closed by layers.

Results

The population of patients was very heterogeneous and generally no exclusion criteria were applied. Preoperative characteristics and echocardiographic parameters are summarized respectively in table 1 and 2, mitral valve diseases at the hospitalization are listed in table 3. Direct cannulation of the aorta did not result in any complication. Complications occurred only during femoral artery cannulation: 5 cases required the positioning of an additional cannula in the opposite femoral artery due to high resistance on the arterial line; 1 case was complicated by iatrogenic damage of the femoral artery and in 1 patient the aorta was dissected by retrograde flow. Mean CPB time was 117±46 minutes and the endo-clamp time 71±31 minutes. In 6/241 cases (2.5%), surgery was performed under ventricular fibrillation without clamping the aorta due to myocardial preservation concerns (2 cases) and difficulty in gaining the correct position of Endo-clamp in the ascending aorta of patients with peripheral arterial cannulation (4 cases).

Of the 241 patients 91 and 65 underwent previous mitral valve replacement and repair, respectively. The remaining 85 patients underwent other cardiac surgeries (CABG, aortic valve surgery, etc). In 158 cases the mitral valve was replaced whereas in 56 repaired, 21 mitral prosthesis were reattached and in 6 cases prosthesis' toilette was performed. In 64 of the 91 patients who underwent previous mitral valve replacement it was necessary to replace the prosthesis again. Among 65 patients previously treated with mitral valve repair, only 3 were re-repaired, whereas in 62 cases the mitral valve was replaced. In the group of patients operated for cardiac diseases other than mitral valve defects (n =

85), 32 and 53 underwent mitral valve replacement and repair, respectively. Considering these results, the percentage of patients with a native valve receiving mitral valve repair is 37%. This percentage rises to 65% if patients who had previously undergone mitral valve repair were not considered for re-repair. The complete list of the operations performed is shown in table 4. In 13 out of 241 patients (5.4%) an additional procedure was associated: 5 tricuspid valve replacements, 5 tricuspid valve repairs, 2 atrial septal defect closures and 1 bypass grafting (right internal mammary artery to right coronary).

In two cases (0.8%) conversion to sternotomy was necessary because of 1 case of aortic dissection and 1 case of left ventricle free wall rupture. The aortic dissection was caused by retrograde flow, presumably due to a jet lesion originating in the femoral artery.

Median ICU stay was 24 hours, median mechanical ventilation support was 12 hours and median blood loss from chest drains was 450 mL. During the first post-operative day, 17 patients (7.0%) required surgical revision because of bleeding (12 pts), extracorporeal membrane oxigenator (ECMO) positioning due to low cardiac output (2 pts), right femoral artery occlusion (1 pt), removal of a pulmonary vent entrapped into the atrial suture (1 pt) and repair of right atrium-left ventricle fistula (1 pt).

In the post-operative period 46 cases of atrial fibrillation (AF) occurred in patients that were in sinus rhythm (SR) at the hospitalization. Among these, 30 patients spontaneously recovered to SR. The remaining 16 were treated with intravenous administration of amiodarone and DC shock (1 to 5 times): 9 eventually returned to SR, 6 of them were discharged from the hospital in AF and in 1 case implantation of a pace-maker was necessary due to complete atrio-ventricular block occurrence.

Ninety five patients (39%) presented with pre-operative AF (64 permanent, 31 paroxysmal); 11/95 (9 parossistic and 2 permanent AF) were treated with crioablation or microwave surgical ablation (pulmonary veins encircling and left atrial appendage exclusion only) and 7 of them were discharged in SR. Major postoperative complications occurred in 53/241 patients (22%): 25 patients suffered from neurological injury, 12 patients required surgical revision for bleeding, 9 patients had respiratory failure, 2 patients experienced low cardiac output syndrome which required the positioning of an external circulatory support, 3 patients had of multi organ failure, 1 had cardiac arrest and 1 acute myocardial infarction. In 14

out of 25 cases the neurological injury was considered a major event characterized by permanent damage; the remaining 11 cases spontaneously recovered with a complete regression of the symptoms and/or signs. Of the above mentioned neurological complications, 18 occurred during the surgical procedure; 6 of them were directly related to the Port Access technique (3 cases of difficult venous drainage, 1 case of high resistance in the cardio-pulmonary bypass circuit that required a new arterial cannulation, 1 endo-aortic balloon displacement and 1 balloon rupture). The remaining 12 cases were not strictly correlated to the adopted technique (1 cardiac ruptures, 1 aortic dissection and 10 unknown events probably amenable to cerebral malperfusion or air/atheroma embolization). The seven post-operative events were related to 1 anoxic arrest and 6 unknown occurrences. There was no statistical difference in the occurrence of neurologic events between femoral (15/129, 11.6%) and direct aortic cannulation (10/112, 8.9%; p=NS).

Blood-culture resulted positive, during the post-operative course, in 9 patients (3.7 %), successfully treated with antibiotic therapy. Only 4 patients (1.6%) experienced major wound infections.

Median hospital stay was 8 days and the overall hospital mortality 4.9% (12/241 pts). The causes of death were mainly related to severe heart failure and poor cardiac output with consequent multi organ failure (7 cases), 1 aortic dissection and 4 cases of sepsis associated with acute renal failure and respiratory insufficiency.

Comment

The results of this study suggest that minimally invasive right antero-lateral thoracotomy using Port-Access technique may represent an efficient and safe approach for patients requiring mitral operation and who had previous sternotomy.

Division of the sternum is primarily a blind procedure and carries an increased risk of injury of major cardiac structures in the presence of adhesions between the posterior table and the innominate vein, right ventricle and extracardiac conduits or grafts . Some parts of the mitral valve, especially the annulus of the anterior leaflet, the postero-medial commissure and papillary muscle may require direct mobilization of the valve for optimal exposure. This may be difficult in reoperations because of adhesions that fix the

left ventricle and mitral annulus to the posterior pericardium. Port-Access video-assisted mini-thoracotomy has several advantages over sternotomy: it avoids injury to the heart, phrenic nerve, great vessels, patent vascular grafts and dissection of the anterior mediastinum with less intra-operative and post-operative bleeding . It also allows a better surgical exposure of all the mitral valve components with only a moderate retraction. From the right chest, the mitral valve can be easily approached in all cases, the great distance to the valve can be overcome by the use of longer surgical instruments. In addition this approach is highly suitable to observe valve pathology and function, while providing quick and simple control of the results in case of surgical repair. From the same side it is also possible to reach and control superior and inferior venae cavae and to enter the right atrium for additional right heart procedures. Treatment of AF with different devices and different lesion set is also possible, even if it requires more extensive dissection of adhesions.

Minimal surgical dissection can prevent excessive bleeding and transfusion requirement. In addition this mini-invasive technique bears less tissue trauma with less post-operative pain . Earlier mobilization is also possible because of a greater stability of the bony thorax. The short post-operative ventilation time, ICU and hospital stay seem to be related to the mini-invasive nature of this technique with a resultant earlier recovery of this patients population.

Differently from what described by Burfeind et al. , in our experience, the CPB and aortic clamp time was acceptable and comparable to the operative results reported by other authors . These times are also shorter than those published by some authors in mitral valve re-operation performed through a median sternotomy. This data are encouraging considering that additional cardiac procedures were associated to mitral valve surgery.

In this study few patients were treated for atrial fibrillation. This can be explained by the fact that Port-Access technique allows to re-operate on mitral valve with very limited dissection of adhesions. On the other hand, AF treatment requires more estensive isolation of cardiac structures that may void the advantages provided by this minimally invasive approach. Patients with AF were treated with crioablation

or microwave ablation by an intra-cardiac approach that permits to prevent wider dissections, however, with the risk of damaging other adherent structures or organs such as the esophagus and the phrenic nerve.

The occurrence of neurologic events was 10%. Svensson et al. reported 7.5% of strokes in patients who underwent a right thoracotomy. There are few factors that may account for the frequent occurrence of stroke in our experience. First, in re-do patients mediastinal adhesions may keep the left ventricle apex tilted upwards to the outflow tract. This can lead to some air bubbles trapping. Yet, along the way, we learned some tricks: as it is not possible to manually vent the heart from inside the chest, we now de-air the left ventricle by shaking and squeezing the chest of the patients, under a careful transesophageal ultrasound monitoring. Moreover, the patient's head is lifted up and the operative table is turned leftwards. By doing so, we have been able to progressively reduce the incidence of stroke to 0% in the last 2 years.

The percentage of mitral valve repair is low in our series. However, this is in part due to the 91 patients who had undergone previous mitral valve replacement. Bearing this in mind, the percentage of patients with a native valve receiving mitral valve repair is about 37%. This percentage rises to 65% if we exclude from a re-repair procedure the patients who had previously undergone mitral valve repair. The concern about the presence of damaged tissues that can limit the durability of a new repair, may prevent the use of conservative techniques. In addition, some authors suggested that failed mitral valve repair should be treated by replacement and in the study published by el Asmar et al. only 15% of the patients underwent re-repair procedures. Also, at the beginning of our experience, the initial learning curve presumably affected the type of surgery performed, being mitral valve replacement favored over repair, especially when complex mitral valve repair was requested.

In our series only one case (0.4%) of aortic dissection occurred during the positioning of the endovascular balloon through the peripheral cannula. Other authors reported an higher rates of this particularly serious complication (2.5- 4.0%) . There were only 2 conversions to median sternotomy because of to the above mentioned aortic dissection (1 case) and of massive bleeding due to left ventricle free wall rupture (1 case).

At the beginning of our experience we always used peripheral cannulation, whereas currently we prefer to cannulate centrally. Patients selection is not performed in regards to central cannulation. Only those patients with obvious contraindications such as severe ascending aorta atherosclerosis, chest deformity or pneumonectomy with inability to maintain single lung ventilation were excluded. The direct cannulation of the aorta, as described by Glower et al. , allows to perform minimally invasive valve surgery with the Heart-Port technique in patients with severe atherosclerotic disease of the femoral vessels and/or the descending aorta, thus overcoming the contraindications previously defined by other authors . The direct aortic cannulation with the Endo-Direct cannula should also provide a better stability of the endo-clamp and a lower risk of balloon migration. The availability of different cannulation approaches allows us to overcome most of the contraindications to this technique.

In our experience, hospital mortality rate (4.9%) was comparable to the data reported in the US STS database for mitral valve surgery after previous cardiac procedures (5.6%). Moreover, these results favourably compare with those of other studies in which mitral valve reoperations were performed either through a right thoracotomy or a median sternotomy . In 1998, Mohr et al. published a disappointing initial experience with the Port-Access approach for mitral valve surgery with high mortality and morbidity rates , even if those authors subsequently have presented better results. A long standing experience along with proper clinical and surgical training, specific anesthesiological intra-operative management allowed us as other authors to achieve acceptable mortality rate.

The limitation to the use of this surgical approach are mainly related to a prolonged learning curve that can increase the risk of patients at new centers and to the cost of the devices. Embolism of air remains a concern when left cardiac cavities are opened. Careful de-airing, by means of aortic and left atrium vents, removed only after disappearance of echocardiographic signals of air bubbles, along with gentle external squeezing of the heart, can reduce this risk. Moreover the operating field can be continuously flooded with carbon dioxide (CO2) using a special throcar that allows the insertion of both the videoscope and the CO2 line.

This overview of our experience did not attempt to analyze post-hospitalization outcomes and follow-up. The purpose was to show the surgical results achieved at our institution and to demonstrate the feasibility of the Port-Access procedure in a non-selected population of patients previously submitted to one or more cardiac surgical procedures. An extensive analysis of the post-hospitalization period and follow up is mandatory in order to define the real long term benefits to patients.

In conclusion, our experience demonstrates that minimally invasive mitral valve surgery in reoperative procedures can be performed safely with several advantages: a very low rate of wound infections, short ICU and hospital stay. The possibility to extend the indication also to patient previously ineligible for this type of surgery can lead to a more extensive use of the Port Access technique. These reasons have contributed to make this technique the treatment of choice for mitral valve reoperations in our practice.

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Table 1. *Patients pre-operative characteristics.*

Characterisctics	
Age (y)	61 ± 11 (27 – 80)
Female Sex	107/241 (44.4%)
Hight (cm)	166 ± 8 (148 – 191)
Body Weight (Kg)	68.2 ± 12.3 (35 – 110)
Mean NYHA class	2.9 ± 0.7 (1 – 4)
Mean Euroscore	7.4 ± 3.7 (1 – 14)
Atrial Fibrillation	95/241 (39.4%)
REDO	241/677 (35.6%)
1st REDO	183/241 (76%)
2nd REDO	41/241 (17%)
3rd REDO	13/241 (5.4%)
4th REDO	4/241 (1.6%)

Results are given as means ± SD and range where shown. NYHA: New York Heart Association.

Table 2. *Pre-operative echocardiographic parameters of patients*

Echocardiographic Parameters	
LVDTD (mm)	55.9 ± 10.4 (39 – 90)
LVSTD (mm)	38.7 ± 10.3 (14 – 79)
IVS (mm)	10.5 ± 1.9 (7 – 16)
PW (mm)	10.2 ± 1.7 (5 – 16)
LA (mm)	52.9 ± 11.4 (32 – 100)
LVEF (%)	49.7 ± 13.3 (16 – 79)
RSVP (mmHg)	44.9 ± 15.5 (14 – 85)

Results are given as means ± SD and range where shown. LVTDD, Left Ventricle Telediastolic Diameter; LVTSD, Left Ventricle Telesystolic Diameter; IVS, Interventricular Septum; PW, Posterior Wall; LA, Left Atrium; LVEF, Left Ventricular Ejection Fraction; RVSP, Right Ventricular Systolic Pressure.

Table 3. *Mitral valve diseases (at the hospitalization)*

Mitral Valve Disease	
Stenosis	17/241 (7.0%)
Regurgitation	112/241 (46.5%)
Combined Mitral Stenosis/Regurgitation	21/241 (8.7%)
Mechanical Prosthesis Dysfunction	46/241 (19.2%)
Biological Prosthesis Dysfunction	13/241 (5.4%)
Mechanical Prosthesis Detachment	28/241 (11.6%)
Biological Prosthesis Detachment	2/241 (0.8%)
Prosthesis Thrombosis	2/241 (0.8%)

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Table 4. *Type of surgical procedures performed.*

Surgical Procedures	
MV Replacement	149/241 (61.8%)
MV Re-Replacement	64/91
MV Repair	52/241 (21.6%)
MV Replacement + TV Replacement	5/241 (2.1%)
MV Replacement + TV Repair	4/241 (1.6%)
MV Repair + TV Repair	1/241 (0.4%)
MV Repair + ASD closure	2/241 (0.8%)
MV Repair + 1 CABG	1/241 (0.4%)
Prosthesis Reattachement	21/241 (8.7%)
Prosthesis Toilette	6/241 (2.5%)

MV, Mitral Valve; TV, Tricuspid Valve; ASD, Atrial Septal Defect; CABG, Coronary Artery Bypass Grafting.