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

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Abstract

Background: Re-do 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 centre 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 cardio-pulmonary bypass time and endo-clamp time were 117 ± 46 min and 71 ± 31 min, 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 (one case) and left ventricle free wall rupture (one case). Median intensive care unit stay was 24 h, median mechanical ventilation time was 12 h; median hospital stay was 8 days. Bleeding requiring surgical revision occurred in 12 patients (4.9%). Hospital mortality was 4.9% (12/241 patients).

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 re-do surgery.

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Keywords: Minimally invasive surgery; Re-operation; Mitral valve; Thoracotomy; Heart valve

1. Introduction

Re-operative mitral valve procedures performed through longitudinal median sternotomy are characterised 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 re-operative cases, mediastinal scar retraction may render adequate exposure of the mitral valve lengthy and technically challenging. Taking into account that re-operation rates are steadily increasing due to the ageing of the population and the long-term structural deterioration of mechanical and biological prosthesis, in the future, cardiac surgeons will have to face re-operative mitral valve surgery much more often than in the past.

To avoid the complications of sternal re-entry [1—3] and to obtain adequate mitral exposure, antero-lateral thoracotomy has been suggested by some authors [4—8]. 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 [9,10].

In recent years, minimally invasive port-access technique has increasingly gained popularity in mitral valve surgery. Many centres have adopted video-assisted port-access mitral surgery as their routine approach [4,11]. At our centre, we have begun using heart-port technique in 1997, and 677 mitral valve surgery have been performed ever since. The aim of this study is to analyse our experience with the heart-port technique in mitral valve surgery in patients who already underwent at least one previous cardiac operation.

2. Patients and methods

From 1997 to January 2007, 677 consecutive mitral valve operations have been performed at our centre 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 three had four previous operations. Patients who underwent previous cardiac surgeries can be roughly divided into three categories: group I (combined or isolate mitral valve replacement: 91/241 – 38%), group II (combined or isolate mitral valve repair: 65/241 – 27%) and group III (other previous cardiac procedures not on mitral valve: 85/241 – 35%).

All patients underwent operation using port-access platform with the surgical approach through a right mini-thoracotomy (6 ± 1, 4- to 10-cm skin incision) conducted through the fourth intercostal space across the anterior axillary line. Using the soft-tissue retractor, the surgical port was exposed and a rib retractor inserted to obtain a mild rib spreading (about 5–7 cm). No rib resection was performed in any of the cases. 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 improve 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 bypass (endo-CPB) (Heartport, Inc., Redwood City, CA, USA) system (129 cases; 53.5%) and more recently the Endo-Direct (Heartport, Inc., Redwood City, CA, USA) aortic system (112 cases; 46.5%). Venous return was routinely obtained with a double (jugular and femoral) cannulation. Jugular cannulation was always obtained percutaneously 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 were 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 [12,13]. An 8-mm port is created in the first or second right intercostal space. Two purse-string sutures 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 manoeuvre with the Heart-port 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 Heart-port endo-clamp, inserted through the side arm of the femoral or aortic cannula. Position of the balloon was controlled by means of trans-oesophageal echocardiography (TEE). Use of radioscopic techniques was not necessary in any case.

After CPB institution, the pericardium was opened 3–4 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 inter-atrial groove. No dissection of the anterior surface of the heart was necessary in any of the cases.

At this stage, aortic clamping was obtained by inflating the balloon with 15–35 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-balloon 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 °C. A lower temperature (24–26 °C) was sometimes required in case of graft patency to avoid the heart to restart beating. In case of previous coronary artery bypass grafting (CABG), we did not detect the position of previous grafts nor were the left/right internal mammary artery (LIMA/RIMA) grafts clamped. Cardioplegia was always delivered into the aortic root (except in six cases performed under VF), and retrograde heart perfusion has never been used in this series. In case of patent grafts, the combination of VF and moderate hypothermia ensured an efficient and safe myocardial protection.

Left atrium was accessed with a traditional para-septal incision. The Heart-port atrial retractor was then inserted through a 5-mm stab incision in the fourth or fifth intercostal space just laterally to the left internal mammary pedicle. The retractor was then stabilised 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 by 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, maintaining 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 cannuas were removed by tying the purse-strings and venous cannuas, if percutaneous, pulled-out and then manual compression was applied.

After checking haemostasis, 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 5/0 flexidene stitch and the thoracic wound was closed by layers.

2.1. Statistical analysis

Data are presented as mean ± standard deviation (SD), median (range) or frequencies (percentage). Patients’ characteristics of the femoral and direct aortic cannulation groups were compared with Student’s t-test. The relationship between the above-mentioned groups was analysed by Pearson’s chi-square tests. Statistical significance was accepted for P values <0.05.

3. Results

The population of patients was heterogeneous and generally no exclusion criteria were applied. Preoperative
Atrial fibrillation 95/241 (39.4%)
Mean additive Euroscore 7.4
Body weight (kg) 68.2
York Heart Association.
71
Prosthesis thrombosis 2/241 (0.8%)
Mechanical prosthesis detachment 28/241 (11.6%)
Biological prosthesis dysfunction 13/241 (5.4%)
Mechanical prosthesis dysfunction 46/241 (19.2%)
Combined mitral stenosis/regurgitation 21/241 (8.7%)
Regurgitation 112/241 (46.5%)
Stenosis 17/241 (7.0%)
Mechanical prosthesis dysfunction 46/241 (19.2%)
Biological prosthesis detachment 28/241 (11.6%)
Biological prosthesis detachment 2/241 (0.8%)
Prosthesis thrombosis 2/241 (0.8%)

Characteristics and echocardiographic parameters are summarised, respectively, in Tables 1 and 2, mitral valve diseases at hospitalisation are listed in Table 3. No statistical difference has been observed between femoral and direct aortic cannulation with regard to all preoperative patient characteristics, echocardiographic parameters and operative data (data not shown). Direct cannulation of the aorta did not result in any complication. Complications occurred only during femoral artery cannulation: five cases required the positioning of an additional cannula in the opposite femoral artery due to high resistance on the arterial line; one case was complicated by iatrogenic damage of the femoral artery and in one patient the aorta was dissected by retrograde flow. Mean CPB time was 117 ± 46 min and the endo-clamp time 71 ± 31 min. In six out of 241 cases (2.5%), surgery was performed under ventricular fibrillation without clamping the aorta due to myocardial preservation concerns (two cases) and difficulty in gaining the correct position of endoclamp in the ascending aorta of patients with peripheral arterial cannulation (four cases). Operative data are summarised in Table 4.

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; in 21 cases mitral prosthesis were re-attached and in six 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 three 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 receiving mitral valve repair is 62%. Patients with no previous cardiac surgery on the mitral valve (n = 85) were not considered for mitral repair in case of advanced mitral valve endocarditis (six of 85) and calcified-rheumatic mitral degeneration of the leaflets (13 of 85). In case of degenerative (21 of 85) or ischaemic (45 of 85) mitral valve disease, mitral valve repair rate has been 71% and 84%, respectively. 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: five tricuspid valve replacements, five tricuspid valve repairs, two atrial septal defect closures and one bypass grafting (right internal mammary artery to right coronary).

In two cases (0.8%) conversion to sternotomy was necessary because of one case each of aortic dissection and 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 h, median mechanical ventilation support was 12 h and median blood loss from chest drains was 450 ml. During the first postoperative day, 17 patients (7.0%) required surgical revision because of bleeding (12 patients), extracorporeal membrane oxygenator (ECMO) positioning due to low cardiac output (two patients), right femoral artery occlusion (one patient), removal of a pulmonary vent entrapped into the atrial suture (one patient) and repair of right atrium—left ventricle fistula (one patient).

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

Ninety-five patients (39%) presented with preoperative AF (64 permanent, 31 paroxysmal); of these, 11 (nine paroxysmic and two permanent AF) were treated with crioablation or microwave surgical ablation (pulmonary veins encircling and left atrial appendage exclusion only) and seven of them were discharged in SR.
Table 4
Type of surgical procedures performed and operative data.

<table>
<thead>
<tr>
<th>Previous operation</th>
<th>Surgical procedures</th>
<th>Percentage of MV repair</th>
</tr>
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<tbody>
<tr>
<td>Combined or isolated MV replacement 91/241 (38%)</td>
<td>62/91 MV re-replacement alone</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>2/91 MV re-replacement + TV replacement</td>
<td></td>
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<tr>
<td></td>
<td>21/91 prosthesis reattachment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6/91 prosthesis toilette</td>
<td></td>
</tr>
<tr>
<td>Combined or isolated MV repair 65/241 (27%)</td>
<td>59/65 MV replacement alone</td>
<td>4.6%</td>
</tr>
<tr>
<td></td>
<td>3/65 MV replacement + TV repair</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3/65 MV re-repair alone</td>
<td></td>
</tr>
<tr>
<td>Others (CABG, aortic valve surgeries, etc.)</td>
<td>49/85 MV repair alone</td>
<td>62% (over all)</td>
</tr>
<tr>
<td>85/241 (35%)</td>
<td>28/85 MV replacement alone</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3/85 MV replacement + TV replacement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1/85 MV replacement + TV repair</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2/85 MV repair + ASD closure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1/85 MV repair + TV repair</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1/85 MV repair + CABG</td>
<td></td>
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</tbody>
</table>

Operative data

- CPB duration (min) 117 ± 46 (105; 45—405)
- Endo-clamp duration (min) 71 ± 31 (65; 0—175)
- Surgery under VF 6/241 (2.5%)
- Conversion to sternotomy 2/241 (0.8%)

MV, mitral valve; TV, tricuspid valve; ASD, atrial septal defect; CABG, coronary artery bypass grafting; CPB, cardio-pulmonary bypass; VF, ventricular fibrillation; MR, mitral regurgitation.

In the postoperative period, 14 (5.8%) patients suffered from major neurological injury, 12 (4.9%) required surgical revision for bleeding, nine (3.7%) had respiratory failure, two (0.8%) experienced low cardiac output syndrome which required the positioning of an external circulatory support, three (1.2%) had of multi-organ failure, one (0.4%) had cardiac arrest and one (0.4%) acute myocardial infarction. In 11 cases (4.5%), a minor neurologic event occurred and patients spontaneously recovered with a complete regression of the symptoms and/or signs. Of the above-mentioned major and minor neurological events, 18 occurred during the surgical procedure; six of them were directly related to the port-access technique (three cases of difficult venous drainage, one case of high resistance in the CPB circuit that required a new arterial cannulation, one endo-aortic balloon displacement and one balloon rupture). The remaining 12 cases were not strictly correlated to the adopted technique (one cardiac rupture, one aortic dissection and 10 unknown events probably amenable to cerebral malperfusion or air/atheroma embolisation). The seven postoperative events were related to one anoxic arrest and six unknown occurrences. Postoperative complications are listed in Table 5. There was no statistical difference in the occurrence of neurologic events between femoral (15 of 129, 11.6%) and direct aortic cannulation (10 of 112, 8.9%; p = NS).

During the postoperative course, blood culture was positive in nine patients (3.7%), and they were successfully treated with antibiotic therapy. Only four patients (1.6%) experienced major wound infections.

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

4. Comment

The results of this study suggest that minimally invasive right anterolateral 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 [2]. Some parts of the mitral valve, especially the annulus of the anterior leaflet, the postero-medial commissure and the papillary muscle may require direct mobilisation of the valve for optimal exposure. This may be difficult in re-operations 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 postoperative bleeding [10,14]. 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 vena cava 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 minimally invasive technique bears less tissue trauma with less postoperative pain [15]. Earlier mobilisation is also possible because of a greater stability of the bony thorax. The short postoperative ventilation time, ICU and hospital stay seem to be related to the minimal invasive nature of this technique with a resultant earlier recovery of this patient population.

Differently from what is described by Burfeind et al. [5], in our experience, the CPB and aortic clamp time was acceptable and comparable with the operative results reported by other authors [4,14]. These times are also shorter than those times published by some authors [16,17] in mitral valve re-operation performed through a median sternotomy. These data are encouraging considering that additional cardiac procedures were associated with mitral valve surgery.

In this study, few patients were treated for AF. This can be explained by the fact that port-access technique allows to operate on mitral valve with very limited dissection of adhesions. However, AF treatment requires more extensive isolation of cardiac structures, and this can be extremely dangerous in up to four re-do operations in patients especially with chronically enlarged left atrium. In fact, the decision not to treat AF was taken in those patients (84/95 — 88%) with an extremely enlarged left atrium (LA > 60 mm). Patients with AF were treated with cryoablation or microwave ablation by an intra-cardiac approach that allows prevention of wider dissections, however, with the risk of damaging other adherent structures or organs, such as the oesophagus and the phrenic nerve.

The occurrence of neurologic events was 10%. Svensson et al. [16] 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 trapping of some air bubbles. 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 trans-oesophageal 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. We honestly report all the neurological events occurred in our patients. Fourteen patients experienced a major neurologic event (5.8%). This still higher percentage was reached at the very beginning of our experience, also the preoperative non-selection of patients to be operated with this technique, especially those in which a femoral endo-clamp and retrograde perfusion were used, can explain these events. A careful preoperative evaluation of the aorta, iliac and femoral arteries with either CT scan, angiography is mandatory to reduce at the minimum the risk of retrograde mobilisation of thrombus or atheromatous plaques.

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 receiving mitral valve repair is 62%. In addition, in case of degenerative and ischaemic mitral valve disease, in valves previously not operated (85), the percentage is 71 and 84, respectively. This confirms that when possible a mitral valve repair has been performed. For the remaining cases, those who underwent mitral repair previously, 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 [18,19] and in the study published by el Asmar et al. [20] only 15% of the patients underwent re-repair procedures. Furthermore, at the beginning of our experience, the initial learning curve presumably affected the type of surgery performed, being mitral valve replacement favoured 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 higher rates of this particularly serious complication (2.5—4.0%) [21,22]. There were only two conversions to median sternotomy because of the above-mentioned aortic dissection (one case) and massive bleeding due to left ventricle free wall rupture (one case).

At the beginning of our experience we always used peripheral cannulation, whereas currently we prefer to cannulate centrally. Patients’ selection was not performed with regard 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. [12], 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 [5]. 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 contra-indications 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 re-operations were performed either through a right thoracotomy [16,17,23,24] or a median sternotomy [9,16]. 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 [22], even if those authors subsequently have presented better results. A long-standing experience along with proper clinical and surgical training, specific anaesthesiological intra-operative management allowed us, similarly to other authors [4,7], to achieve acceptable mortality rate.

The limitations to the use of this surgical approach are mainly related to a prolonged learning curve that can increase the risk of patients at new centres 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 trocar that allows the insertion of both the videoscope and the CO₂ line.

This overview of our experience did not attempt to analyse post-hospitalisation 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-hospitalisation period and follow-up is mandatory to define the real long-term benefits to patients.

In conclusion, our experience demonstrates that minimally invasive mitral valve surgery in re-operative 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 those patients 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 re-operations in our practice.

References