Video-Assisted Mitral Surgery through a Micro-Access: A Safe and Reliable Reality in the Current Era

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Background and aim of the study: **Minimally invasive mitral valve surgery was introduced into clinical practice during the mid 1990s. The clinical benefits of the technique, namely a reduction of surgical trauma, increased patient comfort and shorter hospital stay, are achieved by using a video-assisted, mini-thoracotomy approach rather than a standard median sternotomy. Herein is described the authors' experience with video-assisted mitral surgery through a micro-access.**

Methods: **Between September 2003 and September 2006, 100 patients (mean age 65.7 years; range: 16-84 years; 29 aged >75 years) underwent video-assisted port-access mitral valve surgery through a 4- to 6-cm anterior mini-thoracotomy. Mitral valve repair was carried out in 36 patients (36%) and mitral valve replacement (MVR) in 64 (64%) for degenerative (n = 54), rheumatic (n = 44), functional (n = 1) or infective disease (n = 1). Redo procedures were performed in 14 patients.**

Results: **Peripheral extra-thoracic cardiopulmonary bypass (CPB) was used in all cases, and Endoclamp occlusion of the ascending aorta in 94%. The median intensive care unit and hospital stays were 20.0 ± 30.8 h and 7.0 ± 5.9 days, respectively. Hospital mortality was 4% (n = 4). No patient required conversion to sternotomy. Five patients (5%) underwent minimally invasive surgical revision for bleeding, and one patient (1%) had an early reoperation for MVR during the immediate postoperative course due to failure of a mitral valve repair. There were no perioperative myocardial infarctions, permanent strokes, major vascular complications, or peripheral ischemic events. Among the patients, 63% had no complications at all during the postoperative course, and no wound infections were observed.**

Conclusion: **Video-assisted mitral surgery through a micro-access may be performed safely, at low risk of morbidity and mortality, and with results and quality standards similar to those reported for a sternotomy approach. Of note, older patients may be successfully treated using this technique.**

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The growing interest in minimally invasive cardiac mitral valve surgery (MIC-MVS) is due mainly to the significant improvements in the quality of life of the patients following surgery. At the present authors' institution, MIC-MVS consists of a right anterior mini-thoracotomy (4-6 cm), videoscopy, femoral access for extracorporeal circulation and, in the majority of patients, aortic endoclamping. However, a number of slightly different techniques have been reported, with various degrees of success (1-3). The study aim was to review the authors' three-year experience with port-access mitral surgery, and to establish the safety and reliability of the technique.

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Clinical material and methods

Patients

The records of 100 patients (64 females, 36 males; mean age 65.7 years; range: 16 to 84 years) undergoing video-assisted port-access mitral surgery at the authors' institution were reviewed. Twenty-nine of the patients (29%) were aged >75 years. All patients with mitral valve disease (with or without associated tricuspid valve regurgitation) who met the inclusion criteria were included in the series. The exclusion criteria were peripheral vascular disease, previous right lung surgery or evidence of right pleural adhesions, obesity, and a transverse diameter of the sinotubular junction of the ascending aorta >35 mm. In total, mitral valve repair was performed in 36 patients and mitral valve replacement (MVR) in 64, while an associated tricuspid valve repair was carried out in 11 cases. Details of

Table I: Mitral valve diagnoses and pathologies identified in patients (n = 100).

Diagnosis/Pathology	No. of patients
Diagnosis	
Mitral regurgitation	61
Mitral stenosis	18
Double lesion	21
Pathology	
Degenerative	54
Annular dilatation	7
Posterior leaflet prolapse	21
Anterior leaflet prolapse	2
Bileaflet prolapse	3
Rheumatic	44
Chronic endocarditis	1
Functional	1

Table II: Operative techniques employed among patients (n =100).

Operative techniques	No. of patients
Valve replacement	64
Mechanical	63
Bioprosthesis	1
Valve repair	36
Annuloplasty and posterior leaflet partial resection	19
Annuloplasty	7
Annuloplasty and edge-to-edge	3
Posterior leaflet partial resection	2
Annuloplasty and commissurotomy	2
Annuloplasty and cleft closure	2
Commissurotomy	1
Tricuspid valve annuloplasty-associated	11

the valve pathologies are listed in Table I.

Redo operations were performed in 14% of cases, and the mean logistic EuroSCORE was 7.1%. Sixty-two percent of the patients were in NYHA functional class III/IV, and atrial fibrillation was present in 55%. All patients but 11, had a left ventricular ejection fraction (LVEF) ≥50% (the mean LVEF was 65%, and mean left ventricular end-diastolic volume 75.2 ml), and all but underwent surgery on an elective basis. Details of the operative techniques are listed in Table II.

Surgical technique

The patient was positioned in a supine position with slight antero-positioning of the right chest, in order to obtain optimal exposure for the right anterior minithoracotomy. Bilateral radial arterial cannulation and single intermittent lung ventilation was used. External paddles for electric defibrillation were placed in all patients. For the induction of anesthesia, a 14/17 Fr cannula (DLP Cannula, Medtronic) was introduced percutaneously through the right jugular vein into the superior vena cava, under 1 mg/kg heparinization and transesophageal echocardiography (TEE) control. An skin incision (4-6 cm) was made in the right inframammary groove in order to open the working port through the fourth intercostal space (Fig. 1). A medium Soft Tissue Retractor (STR; Cardiovations, Ethicon Inc.) was used and, when necessary, an additional pediatric Finocchietto ribs retractor. A 10-mm port was created in the third right intercostal space on the anterior axillary line to allow positioning of the zero-degree, 10-mm axial camera. A third 1-mm port was created parasternally to introduce the handle of the left atrial retractor (Cardiovations, Ethicon Inc.) and a Blake 19 Fr (Cardiovations) pericardial drainage tube after the procedure. A fourth 5-mm port was positioned in the fifth right intercostal space to allow introduction of the CO_2 line and the atrial venting cannula (DLP Cannula, Medtronic) during surgery, and the pleural drainage tube at the end of surgery. A 2-cm incision was made in the inguinal groove.

Cardiopulmonary bypass (CPB) was established via the right femoral vessels. Bicaval drainage was used in all cases. The introduction of a venous 22/25 Fr cannula (Cardiovations) for cannulation of the inferior vena cava was performed using the Seldinger technique under TEE guidance. Special care was taken to avoid contact between the tip of the cannula and the interatrial septum to improve venous return. Active venous drainage with a vacuum or centrifugal pump was not used for any patient. A Y-shaped arterial (ER Cardiovations) cannula of 21 or 23 Fr was introduced into the femoral artery using a small transverse arteriotomy. When CPB achieved full flow, an endoclamp (EC 101; Cardiovations) was introduced through the side-arm of the cannula and advanced, under TEE guidance, to the ascending aorta 4 cm distal to the aortic valve. The pericardium was entered 2 cm anterior to the phrenic nerve using a T-inverted incision. Optimal vision of the left atrium was achieved by using pericardial retraction stitches anchored to the chest wall. The balloon was then inflated according to the size of the aorta at the sinotubular junction (1 mm:1 ml) and anterograde cool blood cardioplegia delivery commenced. The left atriotomy was constructed and a vent positioned on the atrial floor. An atrial retractor was

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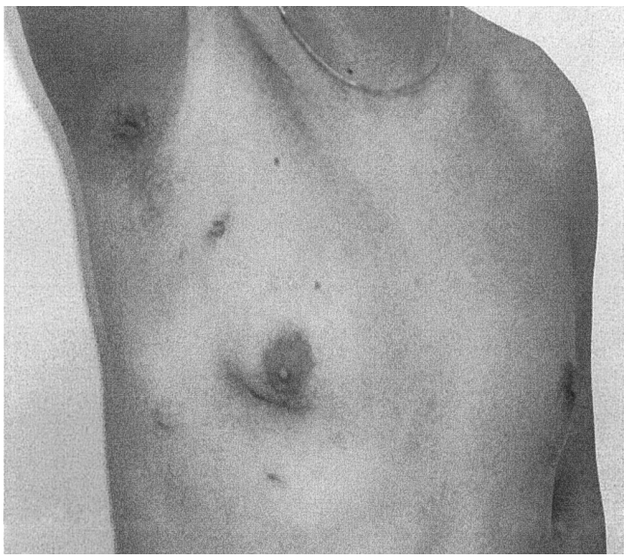

Figure 1: The micro-access scar in the right inframammary groove.

inserted, taking care to choose the appropriate size, and keeping it at least 2 cm away from the anterior leaflet of the mitral valve. The valve was either repaired or replaced according to the standard technique.

On completion of the mitral surgery, a Foley catheter was positioned through the valve for de-airing, and the left atrium was closed. When a tricuspid valve repair was carried out, the inferior vena cava was snared with a double elastic vessel-loop and the venous return from the superior vena cava was avoided by an external bulldog clamp positioned just below the tip of the jugular venous cannula. An epicardial pacing wire was placed in the right ventricular wall. The aorta was unclamped with deflation of the endoclamp and, after recovery of a normal rhythm, the patient was weaned from CPB and the femoral cannulas removed. A curved 28 Fr drainage tube and 19 Fr flexible tube were inserted into the pleural and pericardial spaces. After careful hemostasis and local infiltration of 20 ml 0.5% bupivacaine solution, the mini-thoracotomy and groin incisions were closed.

Table III: Technical complications among patients (n = 100).

Complication	No. of patients
Difficult cardioplegic perfusion	2
Femoral artery repair	2
No endoclamp progression	1
Endoclamp perforation	1

During the postoperative course, the patient was (if possible) extubated within the first 3 h, and early mobilization was achieved on the following day. The chest drains were not withdrawn before the second postoperative day in order to avoid the development of late pleural effusion and to allow complete lung expansion.

Results

The mean total duration of the operation and mean surgical time were 327.8 ± 40.7 min and 197.8 ± 35.2 min, respectively. The mean CPB and mean cross-clamp times were 116.5 ± 22.54 min and 79.4 ± 17.35 min, respectively, and the median intensive care unit and median hospital stays 20.0 ± 30.8 h and 7.0 ± 5.9 days, respectively.

Minor intraoperative technical complications occurred in six patients (Table III), and were mainly related to the endoclamping and cannulation procedures. In all cases surgery was completed as the port-access technique never required conversion to sternotomy. The endoclamping technique was used in 94 patients, while a transthoracic clamp (Cygnet; Novare, Surgical Systems) was used in four cases, and Portaclamp® and hypothermic ventricular fibrillation in one patient each.

The overall mortality was 4% (n = 4). Two of these patients (aged 78 and 82 years) died as a result of abdominal complications requiring laparotomy on the sixth and seventh postoperative days, respectively, related to mesenteric ischemia and gastroesophageal ulceration. The third patient (aged 68 years) had a cardiac arrest in the ward, and required cardiopulmonary resuscitation 48 h after surgery, but died on postoperative day 3. The fourth patient, an 82-year-old man, was in cardiac failure, had undergone preoperative intra-aortic balloon pumping (IABP), and had a history of renal failure, left ventricular dysfunction and multiple coronary artery bypass grafting eight years previously. He underwent MVR for acute mitral regurgitation on hypothermic ventricular fibrillation (left interior mammary artery to left anterior descending patent), but died on the fifth postoperative day from multiple organ failure.

Five patients (5%) required re-exploration for bleeding. Bleedings from the port incisions were responsible for postoperative blood loss requiring reoperation. In all cases the bleed was controlled through the same incisions with the support of videothoracoscopy. The clinical postoperative major complications are listed in Table IV.

There were no cases of major vascular complication. In two patients a patch closure of the femoral arteriotomy was required due to the small caliber of the ves-

Table IV: Clinical postoperative major complications among patients (n = 100).

Complication	No. of patients
Death	4
Urgent postoperative MVR	1
Acute renal failure	3
Revision for bleeding	5
Prolonged ventilation	1
Transient ischemic attack	3
Myocardial infarction	0
Stroke	0

MVR: Mitral valve replacement.

Table V: Clinical postoperative minor complications among patients (n = 100).

Complication	No. of patients
Atrial fibrillation	14
Pacemaker	3
Pleural effusion	2
Subcutaneous chest emphysema	2

sel. No major complications such as arterial dissection or rupture, or limb ischemic events were encountered. Neither were any perioperative myocardial infarctions, permanent strokes, or deep venous thrombosis identified. Transient ischemic neurological complications occurred in 3% of the patients, in one of whom IABP was used postoperatively, while pacemaker implantation for heart block was necessary in three patients. There was one case of early reoperation due to acute failure of mitral repair on the first postoperative day. This patient underwent urgent reoperation through an enlarged thoracotomy, and an uneventful MVR was subsequently performed.

Clinical minor complications (Table V) mainly included atrial fibrillation which was treated successfully with electric cardioversion in one case, and in 13 patients with medical treatment. No thoracic wound infections or complications were identified.

The mean follow up period was 20.9 months (range: 1 to 37 months), during which time three patients required reoperation due to endocarditis of the mechanical mitral prosthesis (at six months), to hemolysis secondary to perivalvular leak (at four months), and to mitral regurgitation after annuloplasty (at four months). All but two patients were in NYHA functional class I or II at the follow up examination.

Discussion

The growing popularity of MIC-MVS is strongly related to the mini-thoracotomy as the ideal approach (4,5), as this provides - even with a very limited incision of 4-6 cm - a straight access to the left and right atria, and also helps to reduce surgical trauma. This not only provides a cosmetic advantage over a median sternotomy but also maintains the integrity of the chest cage, thereby improving and hastening postoperative recovery. Although the majority of studies have reported that MIC-MVS may be performed both safely and effectively, only one prospective randomized trial has compared MIC surgery versus conventional mitral valve surgery (6). Hence, much of the data available are obtained from retrospective clinical, non-randomized trials.

The patient's quality of life and postoperative pain have been evaluated in many studies (1). For example, Walther and colleagues (7) showed, in comparison with a sternotomy approach, lower pain levels of the MIC-MVS group. A better stability of the bony thorax also led to an earlier mobilization of the patient, and a rapid return to daily activities. Yamada et al. (8) reported data in agreement with those of Walther. In recent years, several groups have demonstrated good clinical outcomes among patients undergoing MIC surgery. In 2001, Cohn (9) and Schroeyers et al. (10) each examined about 300 patients undergoing MIC surgery, and highlighted a similar mortality when compared to the standard sternotomy approach, as well as shorter intensive care unit and hospital stays. In the same year, the present authors reported their experience at the Hospital Clinic of the University of Barcelona, where 129 patients underwent MIC surgery (11). The reported mortality for mitral valve surgery was 2.2%, and the incidence of neurological events 0.7%. In 2002, Grossi et al. (12) reported on their experience with 714 patients, and concluded that MIC surgery was a reproducible technique with late outcomes comparable to those of conventional surgery. The reported mortality was 1.1%, while at follow up echocardiography 89.1% of those patients undergoing mitral valve repair had none or only trace residual mitral valve regurgitation. In the same year, Onnash et al. (13) studied 449 patients and reported a mean survival at two years of 96.3%. In 2003, Casselman et al. (14) published results on 306 patients, with a hospital mortality of 1%, postoperative morbidity including re-exploration in 8.5% of cases, new-onset atrial fibrillation in 17%, and pacemaker implantation in 2.3%. Previously, Vanermen

and colleagues (4) had suggested that, for MIC surgery to be safely performed, the surgeons would be required to follow a distinct learning curve. In 2005, Dogan et al. (15) reported the only prospective randomized trial comparing MIC surgery with conventional mitral valve surgery, wherein 40 elective patients with mitral valve disease were prospectively randomized to undergo minimally invasive or conventional mitral valve surgery. In this study, the markers of myocardial and cerebral damage, as well as pulmonary and neuropsychological tests, did not show any statistically significant difference between groups. However, in the minimally invasive group a high rate of intraoperative, procedure-related problems was observed.

In the present series, 100 patients have undergone video-assisted mitral valve surgery through a minimal access since 2003. Currently, this approach is used routinely in most patients with mitral valve disease, with the exception of those in whom peripheral arteriosclerosis is present or previous right lung surgery has been performed. Extreme obesity is also an absolute contraindication to such an approach. A redo operation where tricuspid valve repair is indispensable is a relative contraindication because of the required snaring of the venae cavae. As the present authors had gained previous experience with this technique elsewhere, no learning curve was involved, and therefore the patients were not selected with regards to age, severity of illness, or NYHA functional status. Although the mean logistic EuroSCORE was 7.1%, it was in general only those patients in an elective status who were operated on using this approach.

Since the introduction of minimally invasive, video-assisted mitral valve surgery, the risk of related complications has been the main reason for its limited use in Europe. This has been based largely on the need for femoral cannulation, the reduced access to the surgical field, and the complexity of video assistance. In addition, the use of specialized surgical instruments and management of the Endoclamp requires ad hoc training. It is clear that a learning curve is both necessary and difficult, and should involve the entire operating theater team. However, the initial negative experience reported by some authors may be related predominantly to inexperience in using the Seldinger technique and TEE control during cannulation and Endoclamp positioning, or to the poor quality of the material used during the early days of the study. A direct surgical view through a small port is difficult and may be imperfect, and hence the use of videothoracoscopy is, in the present authors' opinion, mandatory. The main benefit is the possibility of improving the lighting inside the thorax and heart, and to allow video-guided surgery when necessary. Initially, the surgeon may find video-assisted surgery very difficult to perform, mainly because of the two-dimensional vision and a lack of depth and tactile feed-back perception. Nevertheless, progress is generally rapid during the learning period, and the surgeon soon becomes familiar with the video assistance. In the authors' opinion, knot pushing remains the 'Achilles' heel' of the technique in mitral surgery because it is time-consuming and sometimes difficult to perform due to a lack of feed-back. However, a wider use of automatic sutures will most likely improve this aspect of the procedure.

Currently, the minimal approach is used in elderly patients (29% of the present cohort were aged >75 years), and takes into consideration the advantage of reducing trauma and improving mobilization soon early after surgery.

Among the present patients, transient or permanent neurological complications showed a low incidence (3% transient ischemic attacks, 0% stroke), which may reflect the minimal contact of the ascending aorta due to endoclamp use, while endoluminal occlusion may reduce the risk of plaque rupture. Although, during many years, endo-aortic occlusion with the endoclamp has been considered a risk for vascular complications, if correctly used it offers a typical 'no-touch aorta technique'. A video-assisted view of the surgical field can also avoid unexpected material embolism during the procedure, and allows careful clearing of the cardiac cavity. External transthoracic cross-clamping of the aorta (using a Chitwood clamp) represents an excellent and valid option for clamping the ascending aorta, and this has been used in patients where progression of the endoclamp was complicated. Indeed, its use is advocated when the endoclamp cannot be introduced due to small femoral vessels (high pressure in the arterial line) or atherosclerotic disease, or where the size of the ascending aorta at the sinotubular junction exceeded 30 mm and endoclamp stability would be expected to be poor. External clamping is difficult and may even be dangerous in the case of pericardial adhesions due to pericarditis or previous surgery, or when a wide pulmonary artery is present. In addition, it makes necessary an extra cannulation site in the ascending aorta for the delivery of cardioplegia. Previously, migration of the endoclamp to the aortic arch has been described, but this may be only a temporary occurrence during cardioplegia delivery when the balloon is not yet stable in the ascending aorta. TEE control and the monitoring of bilateral arterial pressure is mandatory for this reason. During the procedure, migration is unlikely due to the arterial flow from the groin pushing the endoclamp towards the heart. However, migration of the balloon to the valve is possible if it is not tightly secured when the correct position is achieved.

Although others prefer central aortic cannulation,

the present authors still advocate a femoral approach for arterial perfusion, since access to the ascending aorta may be difficult through a small fourth intercostal entrance. A wider incision, inclusive of a rib resection, may be required in this case, thus reducing the advantages of a port-access approach.

A relatively high incidence of reintervention for postoperative bleeding (4-13%) has been observed elsewhere; this is usually related to small hemorrhagic spots from the thoracic wall, and may be the consequence of a limited view of the surgical field. In the present study the incidence of such a complication was reduced (to 5%) by paying careful attention to hemostasis on completion of the procedure, and using videoscopy to check inside the chest. It was also recommended that the chest tubes be kept in situ for at least two days during the postoperative course in order to reduce the incidence of late pleural effusion.

In conclusion, video-assisted mitral valve surgery through a micro access is both safe and reliable, and today its use represents the standard in several centers worldwide. Different opinions persist, however, with regards to occluding the aorta and delivering cardioplegia based on experience, personal preference, and cost. Nevertheless, familiarity with different methods should be encouraged in order to select the best approach in terms of patient anatomy and specific situations that might arise during surgery. Notably, a careful and meticulous learning curve, coupled with teamwork, is mandatory in order to avoid technique-related complications during the early stages of this surgical experience.

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