Original Article on Cardiac Surgery

Video assistance in mitral surgery: reaching the "Thru" port access

Francesco G. Irace[1], David Rose[2], Riccardo D'Ascoli[3], Federica Caldaroni[1], Ines Andriani[1], Fernando Piscioneri[1], Piergiusto Vitulli[4], Matteo Piattoli[5], Luigi Tritapepe[5], Ernesto Greco[1]

[1]Department of Cardiovascular, Respiratory, Nephrological, Anesthesiological, and Geriatric Sciences, Policlinico Umberto I, Sapienza University of Rome, 00161 Rome, Italy; [2]Department of Cardiothoracic, Lancashire Cardiac Centre, Blackpool Victoria Teaching Hospital, Blackpool FY3 8NR, UK; [3]Department of Cardiac Surgery, Ospedale dell'Angelo, Mestre, 30174 Venice, Italy; [4]Department of Medico-Surgical Sciences and Biotechnologies, Sapienza University of Rome, 04100 Latina, Italy; [5]Department of Anesthesiology and Intensive Care, Sapienza University of Rome, Rome, Italy

Contributions: (I) Conception and design: FG Irace, L Tritapepe, E Greco; (II) Administrative support: I Andriani, F Caldaroni, P Vitulli, M Piattoli; (III) Provision of study materials or patients: D Rose, R D'Ascoli, F Caldaroni, E Greco; (IV) Collection and assembly of data: F Piscioneri, P Vitulli, M Piattoli, I Andriani; (V) Data analysis and interpretation: None; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Dr. Francesco G. Irace. Department of Cardiovascular, Respiratory, Nephrological, Anesthesiological, and Geriatric Sciences, Policlinico Umberto I, Sapienza University of Rome, Viale del Policlinico 155, 00161 Rome, Italy. Email: francesco_irace@hotmail.it.

Background: Minimally invasive and video assisted mitral valve surgery has been used widely since beginning of 20th. Different reduced surgical approaches allowed replacing or repairing a mitral valve sparing sternal incision. Nevertheless the most used strategy has been in the last years the right mini thoracotomy and the extra thoracic cardiopulmonary bypass (CPB). The main goal is avoiding sternal approach for mitral valve procedures and improve postoperative course of the patients. Some postoperative complication likes blood loss, need for transfusion, prolonged intubation and infection has been reduced using this alternative technique. A special advantages has been reported in elderly or high risk patients and in redo cases.

Methods: Several cardiac centres using videoscopy and a revolutionary set up for CPB management and aortic occlusion have adopted the approach. The team approach, including surgeon, anaesthesiologist, nurse, cardiologist and perfusionist, is crucial for a safe and effective realization of this surgical strategy. The proper use of catheters and Seldinger skilfulness, and the guidance of trans-esophageal echocardiography (TEE) during the procedure are two milestones of this technique. A careful and progressive learning curve is required for all the components of the team. In fact some peculiarity likes modified surgical instruments, 3D and Full HD video assisted view, percutaneous canulation for CPB and myocardial protection, etc., make this procedure challenging for all members of the operative room (OR) team.

Results: Our favourite set-up include right mini thoracotomy in the IV intercostal space, femoral vein and arterial canulation and an additional venous cannula in the superior vena cava for the drainage of the upper part of the body. Aortic occlusion is achieved usually using an endo-aortic clamp positioned by means of continuous and careful TEE guidance. A mitral valve procedure is realized by direct or video guided view; using adapted and shaft instruments or special atrial retractors all standard techniques are used in this setting.

Conclusions: The literature reports and our published results showed the technique is safe, easy to replicate and allows an excellent rate of valve repair even in more complex patients.

Keywords: Mitral disease; videoscopy; minimally invasive; team work

Received: 14 September 2015; Accepted: 15 September 2015; Published 28 October 2015.
doi: 10.3978/j.issn.2221-2965.2015.10.01
View this article at: http://dx.doi.org/10.3978/j.issn.2221-2965.2015.10.01

Introduction

Mitral valve surgery has been in evolution for the last 2 to 3 decades. Minimally invasive techniques have been popularized ever since the success of laparoscopic surgery. Similarly minimally invasive mitral valve surgery (MIMVS) is becoming more popular because of better visualization of the valve, safety in redo—surgeon and patient's choice. MIMVS outcomes are comparable with median sternotomy in many centres.

Is difficult to define which was the first non-conventional minimally invasive surgical procedure, but since the first decade of 20th century pioneers begun to perform surgery via a laparoscopic and endoscopic approach (1). For several years mini-invasive surgery was only a prerogative of gynecologic and general surgery, but in the last two decades also thoracic, vascular and cardiac surgery became familiar with these techniques.

After it had been demonstrated that the port-access approach for mitral valve was feasible in canine model and cadavers. In 1996, Pompili *et al.* in circulation (2) first reported the experience of port-access mitral valve replacement, using single lung ventilation, cardiopulmonary bypass (CPB) was established through the femoral vessels and an endo-aortic balloon catheter (Endo-Clamp) was used for cardioplegia delivery and root venting. The increased interest in minimally invasive surgery (MIS) is, of course, due to the more fascinating cosmetic results, the smaller incision and minor general trauma; this seems to particularly important in a world population becoming older and more frail. A more complex patient, a more complex instruments and need for special monitoring, characterizes MIS. Our experience (3-7) in this field concern a relative young technique, which introduces MI video-assisted surgery in cardiac surgery, especially in mitral valve surgery. About mitral valve operations, the aims of a less invasive procedure, through a video-assisted or video-guided mini-thoracotomy approach (4-6 cm), are the overall reduction in surgical trauma, a major increase in patient comfort, minor morbidities and shorter in-hospital stay, besides the remarkable cosmetic advantages.

Patient selection and preoperative management

In high volume centers, in which mitral valve operations are routinely performed through a minimally invasive approach, theoretically almost all patients could undergo the procedure. In our experience we occasionally request a pre-operative computed tomography (CT) scan in order to assess the aorta and femoral vessels, along with the routine examinations required for cardiac surgery such as coronary angiogram (preferable via radial artery), chest X-ray, lung function test and carotid Doppler. As can be easily understood patient with extensive calcification of the aorta or of the femoral arteries are excluded for the MI approach, as well as patient with small or very tortuous femoral vessels are not good candidate for this approach. Slim and fit patients are ideal candidates to start a MI program, but obesity does not represent a contraindication to the procedure.

Literature results showed (8,9) that a MIS is as safe as traditional surgery, granting fewer blood transfusions; fewer wound infections and pulmonary complications, and faster recovery as well as better cosmetic results. In addition, despite initial report of slightly more frequent cerebral events after MIS, recently a group (4) reported in a multi institutional analysis similar results in terms of overall complications comparing with standard procedures. For those reasons, patients with chronic pulmonary impairment, redo, and Jehovah witness could benefit from MIS. In addition is fundamental to not create an excessive expectation, or fear, in patients, showing the real benefits of the technique and discussing with them the preferable approach. Finally, most important, is the organization and coordination of a specific team, trained in MIS, and indicating peculiar roles and responsibility.

Technologies

To summarize the main changes in MIS are a sternal sparing incision, and this is achieved via a right anterior thoracotomy and a femoral cannulation for CPB. MI mitral valve surgery is an "ultra-specialized" field, in which is required a specific surgeon training and a rigorous team approach. Most of these issues depend of the complex technological devices and tools used in this setting. Particularly video assistance is helpful during operation through very small incision. High definition and inclusive 3D visualization is used with 5 or 10 mm optics. Wider view of the surgical field is achieved with 30° or even 120° camera (10). Special surgical tools, like curved atrial retractor, during such approach allow optimal visualization of the mitral valve both by direct or video assisted vision. Trans-esophageal echocardiography (TEE) is routinely used in cardiac surgery to assess ventricular function pre and post-CPB, prosthetic valves and conduit performance, assist the surgeon during de-airing maneuvers. During MIS, his use

Figure 1 Removal of a left atrial thrombus simulating an atrial myxoma associated to a mitral valve annuloplasty for a type I mitral regurgitation uniportal (13).
Available online: http://www.asvide.com/articles/699

is mandatory representing the surgeon "eye" in evaluating everything he cannot see directly: aortic wall quality and thickness, mediastinal vessels, ventricular filling, results of the repair or replacement. Furthermore, when using Endo-Clamp, use of TEE is required to assess correct balloon positioning and inflating, and adequate aortic clamping. In-Vivo Optical Spectroscopy (INVOS) is routinely used in MI approach to monitor brain oxygenation and the anesthetist and perfusionist should promptly address possible changes in this parameter.

Surgical technique

Different surgical approaches have been described (8,11,12) such as partial sternotomy, parasternal incision, but finally mini-thoracotomy with different CPB set up is the most commonly used approach. This could be summarized in four groups:

- Full extra-thoracic CPB with external trans-thoracic aortic clamping;
- Full extra-thoracic CPB with endo-aortic clamping;
- Central arterial cannulation with external trans-thoracic aortic clamping;
- Central arterial cannulation with endo-aortic clamping.

Minimally invasive and video assisted surgery is performed mainly for mitral valve pathologies. Atrial tumors, thrombus or atrial septal defects (ASD) can also be operated using such techniques like tricuspid valve pathology. Our video shows the removal of a left atrial thrombus simulating an atrial myxoma associated to a mitral valve annuloplasty for a type I mitral regurgitation (*Figure 1*).

In our experience, the standard preoperative work-up used for conventional valve surgery also should be performed for minimally invasive valve surgery. Under general anesthesia, the patient is positioned in the supine position, with slight elevation (30°) of the right hemi thorax. All patients are ventilated with a double-lumen endotracheal tube. Monitoring includes double side arterial lines and use of TEE. Next, a venous cannula (14-20 Fr) is placed percutaneously by the anesthetist through the internal jugular vein into the superior vena cava, under transesophageal echocardiographic guidance. The surgeon exposes femoral vessels through a 3-4 cm incision in the groin, the side is decided according to the CT scan finding of the bigger femoral vessels, and alternatively the Sonosite could be used to assess the dimensions of the femoral vessels. If dimensions are similar we preferably use the right groin, furthermore if both dimensions are not ideal a bilateral arterial cannulation can be performed in order to have two accesses, one for the aortic cannula and the second for endo-balloon insertion. A 5-6 cm right mini-thoracotomy (working port) and two additional ports are made; the technique is described elsewhere (5,14,15). After patient heparinization, femoral vessels are cannulated using Seldinger technique and under TEE guidance; the endo-aortic balloon catheter is pushed from the groin, under TEE guidance, in the ascending aorta just above the sinotubular junction. Endoclamp™ or today Intraclude™ is a three-lumen catheter with an elastomeric balloon near its tip for occluding the ascending aorta in order to partition the aortic root from arterial circulation. The large central lumen of the catheter attends two functions: delivery of cardioplegic solution to the aortic root during occlusion and venting of fluid and air from the aortic root. CPB is instituted and, under TEE monitoring to avoid balloon migration, the endo-aortic balloon is progressively inflated, carefully checking its position at the level of the sino-tubular junction. Moreover, any blood pressure modification through the arterial line suggesting partial or transient occlusion of the arterial branches of the arch can be promptly detected. Initially the balloon is inflated using an amount of saline solution proportional (1:1) to the diameter of the sino-tubular junction. The pressure originated inside the balloon is continuously monitored by perfusionists and is usually around 350/400 mmHg. During operation, this pressure progressively reduce of 10-20% due to change of temperature of the balloon and the reduced stiffness of the aortic wall. No additional volume of saline is needed if the heart is asystolic and the field is

dry. Immediately thereafter antegrade cardioplegic solution is administered. The adhesion of the balloon with the aortic wall is crucial for equilibrium of the device. At this time, a balance should be achieved between distal aortic pressure, driven by arterial cannula inflow, and aortic root pressure originated by cardioplegia or by the still existing ejection from the heart. In some cases (trivial aortic regurgitation or inadequate drainage of the left ventricle) adenosine injection in the aortic root can be used to stop the heart and make easier the endo-clamping. In addition, to optimize left ventricular drainage during endo-clamping an endo-pulmonary Vent Catheter®, previously inserted by anesthesiologist, can be used. During surgery, continuous TEE monitoring is recommended, as it is able to provide an optimal monitoring of venous cannula position, de-airing maneuvers and, of course, an assessment of valve function after the operation. Other monitoring tools include near-infrared spectroscopy (NIRS) (INVOS) or transcranial Doppler, for the same purpose, always useful in cardiac surgery, but in this case fundamental to detect any balloon migration prone to occlude the ostia of supraortic branches with a subsequent impairment of cerebral blood flow. Once the surgical procedure has been completed, the balloon is deflated and partially withdrawn. Aortic venting is achieved through the same catheter. When CPB is finished, the device is fully removed through the arterial cannula. A major concern of using this device is the reduction of the arterial cannula lumen after his introduction and during flow. This is unusual with a 23 Fr cannula but can occur with the 21 Fr one. Sometime the possible consequence of its employment is an elevated pressure on the line of arterial perfusion (>250 mmHg). This is especially true in small and elastic femoral arteries, like in small young women or in patients with arterial atherosclerosis of the iliac femoral tree. If pressure reach 300 mmHg during full flow of CPB, a contra-lateral arterial cannulation, even with a small cannula (18-19 Fr), is indicated and a Y line perfusion is institute.

Heart "surgical" team

In this complex context, the operatory theater is the meeting place for several specialized figures and a "team approach" is essential. The professionals involved are:

- Surgeon
- Anesthesiologist
- Perfusionist
- Nurse

The surgeon is the pivot of the team. He has the important role of coordinating all the other members of the team, delivering specific tasks. He has to be trained into mitral valve traditional surgery, experience in video-assisted procedure and its instruments is crucial, and he should have experience in percutaneous procedures. In order to reach the level of independent operator a learning curve is necessary, and accepting that every surgeon is different from the other, we can estimate that almost 100 cases performed should be performed to be confident with the technique. The anesthetist plays an essential role; he is required to perform selective single lung intubation and jugular vein cannulation in order to establish CPB. Furthermore, in addition to conventional surgery, in the minimally invasive approach, we routinely use the INVOS to monitor the brain oxygenation and changes in these parameters have to be addressed by the anesthetist along with the perfusionist. At the time of the vessels cannulation and particularly endo-balloon inflation is crucial a perfect visualization of the vessels and ascending aorta in order to assess the position of the balloon and manage possible displacements. Direct heart visualization during MIS operation is impossible through such small access and TEE managed by anesthesiologist is vital. Any modification in ventricular size or performance need to be detected by TEE and proper management introduced. At the time of weaning from CPB is important to assess air bubble inside the heart, and the results of the mitral repair or replacement. The perfusionist is required at all time to carefully participate to the operation beside his specific task. He had to monitor all the pressure lines and take action in case of changes. The pressures usually monitored are bilateral arterial line, aortic root, endo-balloon and cardioplegia delivery. Particularly during endo-balloon inflation, his role is crucial. As previously mentioned the correct position of endo-balloon and his stability in contact with aortic wall required special attention by all team. In addition, very often an active venous drainage is required, and for this reason, the perfusionist has to be confident with this technique. The scrub nurse should be confident with endoscopic surgery (optical instruments etc.) and be trained in de-airing the endo-balloon before establishing CPB. In addition, she/he will support actively the surgeon and perfusionist during management of all pressure line preparation and check. To successfully create such a team is important to have people able to coordinate and accept responsibility, creating enthusiasm and initiative, having clear and logical objectives. Any component should understand and have clear his role and be empowered

according to his skills and ability.

Acknowledgements

None.

Footnote

Conflicts of Interest: Professor Ernesto Greco has consulted for Edwards Lifesciences on minimally invasive valve surgery and holds a patent concerning minimally invasive access (No. US D701,305 S). The other authors have no conflicts of interest to declare.

Ethical Statement: The study was approved by the ethnical committee. Written informed consent was obtained from the patient. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

References

1. Vecchio R, MacFayden BV, Palazzo F. History of laparoscopic surgery. Panminerva Med 2000;42:87-90.
2. Pompili MF, Stevens JH, Burdon TA, et al. Port-access mitral valve replacement in dogs. J Thorac Cardiovasc Surg 1996;112:1268-74.
3. Misfeld M, Borger M, Byrne JG, et al. Cross-sectional survey on minimally invasive mitral valve surgery. Ann Cardiothorac Surg 2013;2:733-8.
4. Casselman F, Aramendi J, Bentala M, et al. Endoaortic Clamping Does Not Increase the Risk of Stroke in Minimal Access Mitral Valve Surgery: A Multicenter Experience. Ann Thorac Surg 2015;100:1334-9.
5. Greco E, Barriuso C, Castro MA, et al. Port-Access cardiac surgery: from a learning process to the standard. Heart Surg Forum 2002;5:145-9.
6. Greco E, Zaballos JM, Alvarez L, et al. Video-assisted mitral surgery through a micro-access: a safe and reliable reality in the current era. J Heart Valve Dis 2008;17:48-53.
7. Speziale G, Nasso G, Esposito G, et al. Results of mitral valve repair for Barlow disease (bileaflet prolapse) via right minithoracotomy versus conventional median sternotomy: a randomized trial. J Thorac Cardiovasc Surg 2011;142:77-83.
8. Mohr FW, Falk V, Diegeler A, et al. Minimally invasive port-access mitral valve surgery. J Thorac Cardiovasc Surg 1998;115:567-74; discussion 574-6.
9. Modi P, Hassan A, Chitwood WR Jr. Minimally invasive mitral valve surgery: a systematic review and meta-analysis. Eur J Cardiothorac Surg 2008;34:943-52.
10. Greco E, Mestres CA, Cartañá R, et al. Video-assisted cardioscopy for removal of primary left ventricular myxoma. Eur J Cardiothorac Surg 1999;16:677-8.
11. Casselman FP, Van Slycke S, Wellens F, et al. From classical sternotomy to truly endoscopic mitral valve surgery: a step by step procedure. Heart Lung Circ 2003;12:172-7.
12. Cosgrove DM 3rd, Sabik JF, Navia JL. Minimally invasive valve operations. Ann Thorac Surg 1998;65:1535-8; discussion 1538-9.
13. Irace FG, Rose D, D'Ascoli R, et al. Removal of a left atrial thrombus simulating an atrial myxoma associated to a mitral valve annuloplasty for a type I mitral regurgitation uniportal. Asvide 2015;2:123. Available online: http://www.asvide.com/articles/699
14. Chirichilli I, D'Ascoli R, Rose D, et al. Port Access (Thru-Port System) video-assisted mitral valve surgery. J Thorac Dis 2013;5 Suppl 6:S680-5.
15. Marullo AG, Irace FG, Vitulli P. Recent Developments in Minimally Invasive Cardiac Surgery: Evolution or Revolution? BioMed Research International. [In Press].

doi: 10.3978/j.issn.2221-2965.2015.10.01
Cite this article as: Irace FG, Rose D, D'Ascoli R, Caldaroni F, Andriani I, Piscioneri F, Vitulli P, Piattoli M, Tritapepe L, Greco E. Video assistance in mitral surgery: reaching the "Thru" port access. J Vis Surg 2015;1:13.

