Mitral valve surgery (MVS) has continuously evolved over the past decades. Indications, repair techniques and surgical approaches represent the most important revolutions of the MVS.

Mitral valve replacement has been considered the treatment of choice for mitral valve disease for many decades. Despite initial criticisms, repair is now considered the standard of care of most mitral valve diseases as a number of studies have demonstrated its superiority over replacement, in terms of mortality, morbidity and long-term results, while reducing the risk of infective endocarditis, thromboembolism events and bleeding complications related to anticoagulation [1, 2].

Median sternotomy is the common surgical approach for heart surgery. It provides excellent exposure to the heart and great vessels, allows central arterial and venous cannulation for cardiopulmonary bypass and guarantees a good myocardial protection. The operation can be performed precisely and expeditiously and if complications occur, the surgeon may have direct access to the heart. MVS has been performed through median sternotomy for more than 30 years and the clinical outcomes have significantly improved in the past years, despite gradual increase in patient age and overall risk profile. Recent data reported from STS database showed an overall operative mortality for isolated mitral valve repair of 1.2% and a 0.6% in asymptomatic patients [3]. Freedom from reoperation is very high in the setting of degenerative mitral valve disease, as Carpentier et al. have demonstrated a freedom from reoperation of 95% at 15 years [4]. Despite these excellent results, less-invasive procedures have been developed as an alternative to the conventional technique to reduce the surgical trauma and preserve the same quality, safety and efficacy of the full sternotomy approach.

The term 'minimally invasive' refers to a small chest wall incision that does not include a full sternotomy [5]. The most common minimally invasive MVS (MIMVS) approach is the right minithoracotomy, followed by the lower ministernotomy. Potential benefits of the MIMVS approach are less surgical trauma and postoperative pain, better respiratory function due to the preservation of the sternum, faster recovery and better cosmesis. Compared with conventional procedure, several meta-analyses have shown that MIMVS is associated with low mortality and excellent postoperative outcomes [6, 7]. Specifically, MIMVS has the advantage of reducing bleeding, blood product transfusion, atrial fibrillation, sternal wound infection, ventilation times, intensive care unit, hospital length of stay as well as to reduce the time to return to normal activity. These benefits are even more evident in the setting of redo surgery [8]. At the last EACTS meeting held in Milan, we presented our 10-year experience on over 1600 patients undergoing MIMVS for any mitral valve disease, showing an overall mortality rate of 1.1%, a 95% rate of mitral valve repair in the setting of degenerative mitral valve disease and a freedom from reoperation of 94% at 10 years (Fig. 1). Despite these excellent results, many criticisms still remain regarding MIMVS. Traditionalists have claimed that MIMVS is technically more complex, requires dedicated instruments and reduces the rate of mitral valve repair. Despite the learning curve (generally at least 25 cases), results from experienced centres have confirmed that right minithoracotomy or ministernotomy approach is a safe and reproducible technique, can be taught successfully to cardiac trainees and enable excellent repairs, even in the setting of mitral valve Barlow disease [9-11]. A second criticism is related to morbidities associated with peripheral arterial cannulation in terms of neurological events, pseudoaneurysm and wound infections. In a meta-analysis of over 12,000 patients, Cheng et al. concluded that MIMVS was associated with higher incidence of stroke, aortic dissection and groin complications and phrenic nerve palsy [7]. We previously highlighted the importance of antegrade perfusion and the use of a CO2 line in reducing neurological complications and postoperative delirium [12]. Our preference is the direct aortic cannulation, which allows a more direct and physiological flow to the brain and reduces morbidities related to the groin cannulation. In addition, the use of direct aortic clamping in favour of balloon endoclamp has definitively reduced the rate of aortic dissection. To avoid phrenic nerve palsy, it is mandatory to identify the phrenic nerve after thoracotomy and the pericardium should be opened at least 3–4 cm above it. Third criticism is related to the cost of the surgical instrumentation and optical devices. Although these devices are more expensive and are not required in standard sternotomy, the low rate of complications and the faster recovery associated with the minimally invasive procedures.
should translate in less use of rehabilitation resources and therefore lower costs.

Finally, it has been advocated that the real advantage of the MIMVS is related to the improved cosmetic results rather than better clinical outcomes, as the majority of published studies are retrospective and the few randomized trials are unpowered and have shown no superiority over standard sternotomy [6, 7]. However, the opportunity to perform a well-designed prospective randomized trial with an appropriate sample size is very difficult because MIMVS has been shown to be at least equivalent to the standard approach, and patients now prefer less-invasive procedures.

Totally endoscopic robotic MVS represents the final iteration of MIMVS.

Improvements in endoscopic technologies, surgical instrumentations as well as the advances in cardiopulmonary perfusion, myocardial protection and anaesthetic techniques have facilitated the development of totally endoscopic robotic surgery. The term ‘totally endoscopic’ refers to incisions no larger than the port for a 0.5- to 1.0-cm endoscope [13]. Despite this definition, many surgeons consider totally endoscopic a small minithoracotomy without rib spreading. In almost 1000 patients undergoing surgery, Taylor and Vanermen showed excellent results, performing video-directed minimally invasive mitral valve repair; however, a 4-cm thoracotomy incision was still required [14]. To avoid misunderstanding, Chitwood and Rodriguez proposed a minimally invasive cardiac surgery classification based on four levels of technical complexity: (i) direct vision comprising a mini-incision of 10–12 cm; (ii) video-assisted procedures comprising a microincision of 4–6 cm; (iii) video-directed and robotic-assisted comprising a microincision of 4–6 cm or port incision of 1 cm; (iv) robotic telemanipulation comprising a port incision of 1 cm [15].

Initially, robotic technology emerged in the form of a voice-controlled robotic arm referred to as AESOP 3000 (automated endoscopic system for optimal positioning; Computer Motion, Inc., Santa Barbara, CA, USA). In 1997, Mohr et al. first used this technology to perform a mitral valve repair through a 4-cm right thoracotomy; 6 months later, Chitwood routinely adopted AESOP 3000, performing more than 800 robotic assisted MVS in 10-year period [15].

The next step beyond robotic camera manipulation was to use robotic arms controlled by a surgeon from a remote console (telemanipulation). In 1998, Carpentier and Mohr performed the first mitral valve repairs using an early prototype of the da Vinci Model (Intuitive Surgical, Inc., Sunnyvale, CA, USA), reporting favourable experiences. Nowadays, da Vinci Model is the most common system used worldwide and consists in a remotely controlled servo where a surgeon, assisted by a 3D visualization, operates from a console (away from the patient) and manipulates several robotic arms inserted into the chest wall via several ports. Advantages of this device compared with video-assisted camera are the 7 degrees of freedom (4 degrees of freedom for endoscopic instruments), which emulate the human wrist activity in the X–Y–Z axes, ambidexterity, tremor filtration and avoidance of the fulcrum effect associated with long-shafted endoscopic instruments [15]. Experienced robotic surgeons have demonstrated that the standard surgical mitral valve repair techniques may be safely replicated using robotic technology and allow effective repair of all types of leaflet prolapse (Fig. 2) [16]. Patient selection is paramount for success in robotic heart surgery. Relative contraindications are pleural adhesions, previous right pulmonary surgery, poor pulmonary function, poor ventricular function, aortic regurgitation and pectus excavatum.

Compared with conventional MVS, a recent meta-analysis on six retrospective studies demonstrated that patients undergoing robotic MVS had superior perioperative survival, a trend of lower incidence of stroke and shorter hospitalization and a similar high rate of mitral valve repair, although cardiopulmonary and cross-clamp times were longer [17]. Despite the low number of patients and the patient selection in the robotic group, this study revealed that a successful robotic programme is possible in highly specialized mitral valve repair centres in the presence of a huge cooperation among surgeons, echocardiographists, anaesthesiologists, perfusionists and operating room nurses. Limitations related to the use of robotic surgery are the prolonged operative times associated with the procedure, the need of a distinct learning curve inherent to the complexity of the system and the lack of haptic feedback in favour of ocular tactility. Finally, the extensive cost of the robot system and its instruments makes the totally endoscopic robotic MVS not suitable for all cardiac centres.
MIMVS through either video-assisted/directed or totally endoscopic robotic surgery is a safe approach associated with excellent outcomes in terms of mortality, morbidity and long-term results. In the setting of degenerative mitral valve disease, rate of mitral valve repair and freedom from reoperation at 10 years is very high and equivalent to those repairs performed through median sternotomy. Owing to these outstanding results, we strongly believe that any kind of minimally invasive MVS approach will become the new conventional technique for approaching the mitral valve.

Current guidelines advise performing early mitral valve repair in asymptomatic patients with chronic severe mitral valve regurgitation in cardiac surgery centres, where the likelihood of a successful and durable repair without residual mitral regurgitation is >95% with an expected mortality rate of <1% (Class IIa) [18]. The MIMVS and durable repair without residual mitral regurgitation is >95% in patients with previous sternotomy: a single institution experience with 173 patients. J Thorac Cardiovasc Surg 2014;148:2763–8.


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REFERENCES


