SUNTEXT REVIEWS

SunText Review of Cardiovascular Sciences

Open Access
Review Article
Volume 1:1

Current Trends and Future Prospect of Treatment of Mitral Valve Disease: Role of Interventional Cardiologists and Cardiac Surgeons

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Received date: 30 September 2021; **Accepted date:** 20 October 2021; **Published date:** 11 October 2021

Citation: Anisuzzaman M, Hosain N, Rashid Z and Ferdous S (2021). Current Trends and Future Prospect of Treatment of Mitral Valve Disease: Role of Interventional Cardiologists and Cardiac Surgeons. SunText Rev Cardiovasc Sci 1(1): 107.

Abstract

The treatment of mitral valve disease is rapidly changing. The excellent results and success rates of mitral valve repairs for primary mitral regurgitation were just a prelude. The cases of mitral valve replacement with both bioprosthetic and mechanical prosthetic valves, has produced good long-term results still having a lot of problems. The introduction of Minimally Invasive Cardiac Surgery, endoscopic systems and Robotics has eliminated the need for sternotomy. At the same time these have reduced the access to the mitral valve via small incision only, maintaining excellent long-term results comparable to traditional techniques. Similarly, recent interventional procedures can offer treatment options to high-risk patients. With new technologies, instrumentation and devices, the treatment of mitral valve disease will remain in focus for the year to come.

Keywords: Mitral valve; MICS; MACS

Introduction

The first successful valve surgery of any kind, a mitral valve repair (blind mitral commissurotomy) was performed at Peter Bent Brigham Hospital (now Brigham and Women's Hospital) in Massachusetts, USA by Dr Elliot C. Cutler in a young girl comatose from low cardiac output with rheumatic mitral stenosis in 1923 [1,2]. In 1925, Sir Henry S. Souttar performed the first finger fracture of mitral stenosis. After the Second World War, Dr. Dwight E. Harken (famous for removing shell fragments lodged in soldiers' hearts) at the Peter Bent Brigham Hospital, performed a large series of closed mitral valvuloplasties for mitral stenosis. He worked very closely with Dr. Laurence B. Ellis, a cardiologist there. This exemplifies the concept that mitral valve problems are best treated by a team involving cardiac surgeons, cardiologists and cardiac anesthesiologists working together [3]. The first open mitral valve repair for mitral insufficiency was performed by Dr. C W Lillehei at the University of Minnesota in 1957 [4]. Dr. Dwight C. McGoon of the Mayo Clinic reported the nouvelle techniques of valve repair to repair a ruptured cord in the posterior leaflet in a 1960 issue of Journal of Thoracic and Cardiovascular surgery [5]. The first artificial mitral valve was implanted by Dr. Nina Starr Braunwald in 1960 at the National Institute of Health that was a homemade device and never produced commercially. The first commercially successful valve was revolutionized by Dr. Albert Starr and his collaborator M. Lowell Edwards at the University of Oregon in the early 1960s. The misconceptions of deleterious effect of valve surgery on left ventricle of the 1970s was changed by the demonstration of the importance of the mitral apparatus in maintaining good left ventricular function after mitral valve surgery by Dr. Miller and colleagues at Stanford University[6,7]. In 1980s, there was an increased incidence of mitral valve repair and Dr. Alain F. Carpentier of the University of Paris outlined the pathophysiological classification of mitral valve lesions and provided the tools for collaborative work of cardiologists, cardiac surgeons and cardiac anesthetists. But, the recurrence of regurgitation was a problem and Dr. Carlos M. G. Duran pioneered flexible ring as a solution. Patients with regurgitant myxomatous mitral valves that underwent repair with ring had a recurrence rate of 3.6% (Figures 1 and 2).

But repair without ring had a recurrence rate of 15%. The development of treatment for mitral valvular disease behind the iron curtain during 60 covers another interesting chapter. Until recently many of these stories were not known to the Western world d ue to censorship and language barrier. The first valvular prosthesis in USSR was implanted by a Ukrainian surgeon Nikolai Mikhailovich Amosov. In 1965 he also developed a valve made of antithrombotic materials. He was also famous for his writings. His famous novel Mysli i serdce (Thoughts and heart) is actually based on the story of the first valve implantation. This amazing book has been translated in more than 30 different languages. It's a must read for any cardiac surgeon. Anticoagulation has always been an issue with the mechanical valves. Daily intake of anticoagulants and regular checking of prothrombin time made life difficult for the valve recipients. One solution of this problem was implanting biological valves. Various bioprosthetic devices were designed and marketed for implantation in the mitral position incorporating porcine, bovine, equine tissue. These valves had excellent hemodynamic properties and didn't require anticoagulation, but the long term durability has been a major concern. These valves tend to degenerate and a difficult second redo surgery for replacing the degenerated valve is often warranted.

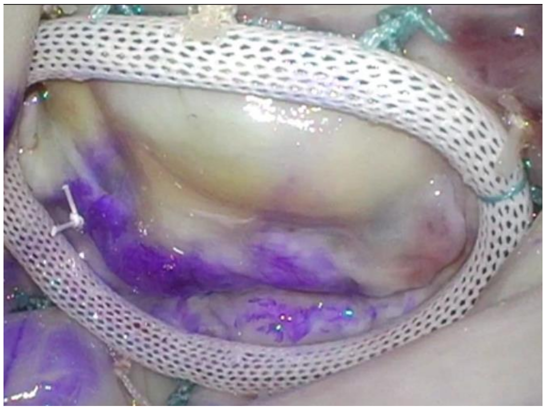

Figure 1: *Mitral valve repair with Annuloplasty ring.*

Figure 2: *Mechanical and bioprosthetic valve.*

Minimal access mitral surgery

Since the first mitral valve repair procedure for mitral stenosis, mitral valve surgery has been evolving rapidly. Prosthetic mitral valves have been developed for mitral valve replacement, which can be performed using transcatheter access. Similarly, mitral valve repair has progressed form closed commissurotomies to open complex mitral valve repairs using artificial cordaes and rings. Access to the mitral valve is achieved through small incisions with the use of endoscopes and robotic systems, thus avoiding sternotomy.

Endoscopic minimal access mitral surgery

Endoscopic minimal access mitral surgery was introduced in 1996. It incorporates the use of endoscope and instruments specially designed to minimize surgical trauma caused by the conventional access to the mitral valve through the median sternotomy as much as possible. In a typical setting, the patient is connected with the cardiopulmonary bypass circuit through the peripheral vessels. For venous drainage, internal jugular and femoral veins are used, and for arterial access the femoral artery is typically cannulated. The aorta is then clamped with the use of either a cross-clamp or an endoballoon, which acts as an occlusion device. Cardioplegic solution is then instilled into the coronary arteries and the heart is arrested in a similar manner to conventional procedures. The mitral valve is access from a right lateral minithoracotomy (4-6cm) or even a right peri-areolar incision. Visualization and exposure of the mitral valve is optimized with the use of endoscopes, which can provide two-dimensional (2D) or three-dimensional (3D) images. With the use of thoracoscopic instrumentation, the mitral valve is assessed and repaired with contemporary techniques, which include ring implantation, artificial chordal replacement, leaflet resection etc. From the same minimal access, mitral valve can be replaced with a mechanical or a biological prosthesis. Many concomitant procedures can also be performed using the above set-up, including tricuspid valve surgery, atrial septal defect closure, relief of hypertrophic obstructive cardiomyopathy, excision of masses such as myxomas, atrial fibrillation surgery and closure of left atrial appendage [8]. From the description above, one can understand why the phrase "minimal access mitral surgery" is better suited to these techniques, as opposed to the term "minimal invasive mitral surgery". Despite the fact that access is minimal, the procedure to the heart itself has a similar degree of "invasiveness" to conventional mitral surgery performed through a median sternotomy.

Robotic mitral surgery

Robotic systems mainly consist of a console and a robotic cart. Through small incisions, robotic instruments and endoscopes are introduced to the chest cavity and the operation is performed by the operating surgeon unscrubbed, controlling the robotic instruments from a distance. The main advantages of robotic implementation include superior 3D visualization, elimination of tremor, seven angles of freedom for the instruments (compared to four in endoscopic access). However, it involves a loss of tactile feedback for the surgeon and higher cost when compared to endoscope or traditional access mitral surgery [9]. Establishment of cardiopulmonary bypass and cardiac arrest is similar between endoscopic and robotic mitral surgery, with similar incisions and identical possibilities for concomitant procedures. Therefore, robotic mitral surgery can also be classified as “minimal access”. The robotic system that has been used most in cardiac surgery worldwide is the da Vinci family from Intuitive Surgical (Sunnyvale, CA, USA). First applications for mitral operations started in 1998 and since then there has been a gradual adaptation in many centres in Europe and the USA. Currently, over 100 robot-assisted mitral procedures per year are taking place in Europe and over 1700 in the USA. The main limitation of further expansion is the increased cost and steeper learning curve of robotic training compared to endoscopic [10].

Contraindications of minimal access mitral surgery

Minimal access mitral surgery, despite being technically more demanding and having a learning curve, offers the complete range of surgical options for the treatment of mitral valve disease. There are however, a few contraindications and limitations to minimal access approaches. Pleural adhesions and history of extensive radiation to the chest could complicate the entrance to the chest cavity and access to the heart. As single lung ventilation is required until cardiopulmonary bypass is stablished, patient with poor lung function or inability to tolerate single lung ventilation should be excluded from these techniques. Patients with peripheral vascular disease and aortic regurgitation should also be excluded, and chest deformities such as pectus excavatum can make access very difficult. Minimal access robotic mitral surgery is also associated with increased operation times compared to conventional sternotomy approach, leading some surgeons to avoid minimal access surgery in patients with many comorbidities or reduced left ventricular function who may benefit from a quicker operation.

Outcomes of minimal access mitral surgery

The short and long term data for conventional mitral valve surgery, and more specifically mitral valve repair through sternotomy approach, demonstrate excellent results. The STS database revealed a 1.2% mortality for isolated mitral valve repairs, which is further reduced to 0.6% when the patients are asymptomatic. Reports of long-term outcomes show freedom from reoperation which reaches 95% in 15 years and survival similar to a control population when the procedure is carried out early and the patient is in NYHA class I or II. These excellent results serve as a bench mark to which minimal access mitral procedures should be compared. Reports and meta-analysis that compare traditional and minimal access endoscopic techniques demonstrate less pain, improved cosmesis, reduced blood transfusions, reduced wound infections, less incidence of atrial fibrillation, and reduced ventilation time, intensive care length of stay and hospital length of stay for minimal access surgery. In a large series, the mortality rate remained low (1.1%) and in 95% mitral valve repair was feasible with a 94% freedom from reoperation at 15 years. Robotic mitral surgery has demonstrated similar excellent outcomes with mortality rates of <1% despite the fact that cross-clamp and cardiopulmonary bypass times were slightly longer [9]. In hospital morbidity for endoscopic minimal access mitral surgery procedures has been low. Conversion to sternotomy has been reported to be as low as 2%, incidence of stroke 0.3%, myocardial infarction 0.6%, new-onset atrial fibrillation 17%, need for permanent pacemaker implantation 2.3%, renal insufficiency 2.6% and wound infection 0% [11]. The above results show excellent perioperative mortality, morbidity, and long-term outcomes of minimal access mitral surgery. However, there are currently no randomized control trials with enough power to demonstrate significant superiority of these techniques when compared to conventional sternotomy mitral surgery.

Other minimal invasive mitral valve procedure

Technological advances in transcatheter aortic valve replacement (TAVR) have also been implemented to the mitral valve. Transcatheter mitral valve replacement procedures have been introduced, which are performed in centres experienced in TAVR. These procedures aim to replace the mitral valve using a catheter delivery system without the need for cardiopulmonary bypass or cardiac arrest. Four different systems have currently been implemented into humans; they are all still under clinical investigation and are not available commercially. These are the CardioAQ (Edwards Lifesciences, Irvine, CA, USA), TendyneTM (Tendyne Inc. [now Abbott], Roseville, MN, USA), TiaraTM (Neovasc Inc., Richmond, BC, Canada) and the Twelve valve (Medtronic, Minneapolis, MN, USA). All these valves are delivered through the apex of the heart following a small left anterior thoracotomy, with the exception of the CardioAQ valve which is designed also to be delivered trans-femorally and trans-septally. There are anatomical and morphological limitations which make transcatheter mitral valve replacement more complex compared to TAVR. There is however, increased interest from the industry as more devices are currently under development [12]. Minimal invasive chordal replacement techniques have recently become commercially available. The Neocord (Neocord, Inc., St.

Louis Park, MN, USA) is a device which introduces artificial chordae's from the cardiac apex and secures them at the edge of the posterior mitral leaflet. The other end is then tied at the epicardial surface of the left ventricle, with chordal length adjustment happening in real time with a beating heart under echocardiographic guidance. Long-term results are awaited from this exciting new technique. Finally, interventional cardiologists have an armamentarium of innovative therapies for the treatment of mitral regurgitation. These techniques are the Mitraclip (Abbott Vascular, Santa Clara, CA, USA), mitral annular remodeling devices and ventricular remodeling devices. The MitraClip is by far the one that has been most extensively implanted and investigated. First implantations took place in 2003, and CE mark and FDA approval was granted in 2008 and 2013, respectively. This device, inspired by the surgical edge-to-edge repair initially described by Alfieri, is a clip which is introduced through a femoral vein and advanced to the mitral valve through the atrial septum. Under echocardiographic and fluoroscopic imaging, the clip is deployed to grasp anterior and posterior mitral valve leaflets, which results in increased coaptation and reduced regurgitation. The procedure is performed typically by interventional cardiologists without any use of cardiac arrest or cardiopulmonary bypass and is effective in high and prohibitive risk patients suffering from primary and secondary mitral regurgitation. Results from the randomized control trial EVEREST II were promising, despite the fact that a recurrence in mitral regurgitation was observed in 25% of the patients in one year. Furthermore, the randomized COAPT trial recently published results that demonstrate reduced rates of hospitalizations and death, as well as improved quality of life and functional capacity for symptomatic patients suffering from secondary mitral regurgitation and heart failure. These patients were receiving maximum tolerated optimum medical therapy and were also treated with MitraClip. As other studies, such as the MITRA-FR, found no benefit for patients suffering from secondary mitral regurgitation treated with MitraClip, we can therefore assume that there is need for further evidence with regards to indications of MitraClip implantation [13].

Conclusions

The treatment of mitral valve disease is evolving rapidly. The excellent long-term results of conventional mitral surgery can now be achieved through smaller incisions by using endoscopic and robotic techniques. For high risk and inoperable patients, minimal invasive transcatheter therapies are currently available and many others are under development. These offer the cardiac surgeon and interventional cardiologist a choice of different approaches to meet each and every patient's needs.

References

1. Cohn LH, Soltesz EG. The evolution of mitral surgery: 1902-2002. Am Heart Hosp J. 2003; 1: 40-46.
2. Cutler EC, Levine SA. Cardiotomy and valvulotomy for mitral stenosis; experimental observations and clinical notes concerning an operated case with recovery. Boston Med Surg J. 1923; 188: 1023-1027.
3. Ellis LB, Harken DE. Closed valvuloplasty for mitral stenosis. A twelve-year follow-up study of 1571 patients. N Engl J Med. 1964; 270: 643-650.
4. Lillehei CW, Gott VL, Dewall RA. Surgical correction of pure mitral insufficiency by Annuloplasty under direct vision. J Lancet. 1957; 77: 446-449.
5. McGoon DC. Repair of mitral insufficiency due to ruptured chordae tendineae. J Thorac Cardiol Surg. 1960; 39: 357-362.
6. Hansen DE, Cahill PD, DeCampli WM. Valvular-ventricular interaction: importance of the mitral apparatus in canine left ventricular systolic performance. Circulation. 1986; 73: 1310-1320.
7. Thoughts on the experiment. Nikolay Amosov. 27: 2018.
8. Glauber M, Miceli A. State of the art for approaching the mitral valve; sternotomy, minimal invasive or total endoscopic robotic. Eur J Cardiothorac Surg. 2015; 48: 639-641.
9. Bush B, Nifong LW, Alwair H, Chitwood WR Jr. Robotic mitral valve surgery-current status and future directions. Ann Cardiothorac Surg. 2013; 2: 814-817.
10. Pettinari M, Navarra E, Noirhomme P, Gutermann H. The state of robotic cardiac surgery in Europe. Ann Cardiothorac Surg. 2017; 6: 1-8.
11. Casselman FP, Van Slycke S, Wellens F, DeGeest R, Degrieck I, Van Praet F, et al. Mitral valve surgery can now routinely be performed endoscopically. Circulation. 2003; 108: 1148-1154.
12. Merwe JVD, Casselman F. Mitral valve replacement-current and future perspectives. Open J Cardiovasc Surg. 2017; 9.
13. Feldman T, Kar S, Elmariah S, Smart SC, Trento A, Siegel RJ, et al. Investigators. Randomized comparison of percutaneous repair and surgery for mitral regurgitation: 5-year Results of EVEREST II. J Am Coll Cardiol. 2015; 66: 2844-2854.