

## EARLY OUTCOME AFTER HEART VALVE REPLACEMENT IN PATIENTS WITH SEVERE REDUCTION OF LEFT VENTRICULAR EJECTION FRACTION

Nguyen Duc Hien<sup>1</sup>, Tran Thanh Thai Nhan<sup>1</sup>, Nguyen Thuc<sup>1</sup>,  
Nguyen Thi Cuc Nhat<sup>1</sup>, Le Quang Thuu<sup>1</sup>, Tran Hoai An<sup>1</sup>

---

### ABSTRACT

**Objectives:** Evaluate the early outcome after heart valve replacement in patients with severe reduction of left ventricular ejection fraction.

**Results:** 57 patients with heart valve replacement and LVEF < 40% were enrolled in the study. Mean age was 45.68 ± 10.97 yrs. 47.36% had both aortic and mitral valve replacement, 24.56% mitral valve replacement, and aortic valve replacement in 28.08%. 66.67% NYHA class III-IV. ICU stay in 9.29 days. Mean inotrope use time was 8.46 days. Operative mortality was 7.02%. Heart chambers size reduced well postoperative with gradual improvement of LVEF.

**Conclusion:** Heart valve replacement in patients with severe left ventricular dysfunction, although having higher risk of mortality and morbidity, is a method of choice which improves symptoms and LV function, and reduces mortality.

**Key words:** heart valve replacement, left ventricular ejection fraction

### I. INTRODUCTION

Although aortic and mitral valve surgery have been performed since early 1960s, but until 1970s, mortality was still high with limited late results [9]. Meanwhile, there was less understanding about basic factors effecting postoperative mortality.

One of the controversial risk factors in trials during a long time is reduction of left ventricular ejection fraction (LVEF). Operation in patients with severe reduction LV function, which is showed by low LVEF, has been studied for a long time, but early mortality and late outcome was still differ from authors.

In Vietnam, research on heart valve replacement in patients with reduction of LV function has not been found in literature. So, there are existing controversy in surgical indication for this high risk group as well as longterm prognosis. Many patients refused surgery because of complication and high mortality. Furthermore, poor financial status as well as low education level, made many patients come to find medical assistance too late so that their diseases were at advance stage with severe reduced LVEF, which caused high surgical risk.

The objective of this study was to evaluate early outcome after heart valve replacement in patients with low LVEF.

---

1. Cardiovascular Centre - Hue Central hospital

**Corresponding author:** Nguyen Duc Hien  
Email: ndhien1979@gmail.com; Tel: 0914173567  
**Received:** 7/3/2017; **Revised:** 25/4/2017;  
**Accepted:** 19/6/2017

## II. SUBJECTS AND METHOD

**2.1. Subjects:** 57 patients with heart valve replacement (mitral and/or aortic valve), with preoperative LVEF <40% at Hue Central Hospital from 1/2014 to 6/2016.

Included criteria:

- Age >16 yrs, who was operative with one or two valve replacement, with LVEF on echo <40%.

Exclusion:

- Heart valve replacement with CABGs
- Heart valve replacement with bioprosthesis valve
- Tricuspid or pulmonary valve replacement
- Aortic surgery
- Patients with low LVEF due to dilated cardiomyopathy or other non-heart causes.

**2.2. Method:** A prospective study, patients were operated under cardiopulmonary by pass with hypothermia at body temperature 32°C. Warm blood cardioplegia solution was used antegrade and continuously retrograde via coronary sinus. All patients were replaced one or two mechanical valve (St. Jude or ATS). Inotrope was used postoperatively when needed, echo data was collected to compare with pre-op data.

## III. RESULTS

57 pts with 1 or more valve lesions, with preoperative LVEF <40% were enrolled. Mean age was 45, most of them had severe heart failure with 66.67% at NYHA class III, IV (table 1).

Table 1: Preoperative characteristics

	Min	Max	Mean
Age	18	66	45.68 ± 10.97
LV diastolic diameter (mm)	50	71	59.87 ± 5.9
LV systolic diameter (mm)	41	58	49.17 ± 5.7
LVEF(%)	32	39	37.7 ± 1.56
PAPs (mmHg)	25	60	37.8 ± 10.35

In this study, all included patients had low LVEF, mean LVEF was 37.7 ± 1.56%. All heart chambers were dilated due to severe heart failure. Most patients have AF (75.44%).

Table 2: Operative characteristics

CBP time (min)	Min: 82 Max: 134	Mean: 95.28 ± 12.07
Mechanical valve replacement	100%	
Tricuspid valve repair	57.89%	

TV repair was indicated when TR >2/4, with right atrium dilation.

Table 3: Postoperative characteristics

	Min	Max	Mean
ICU stay (days)	5	22	9.29 ± 1.6
Inotrop use duration (days)	5	22	8.46 ± 1.51

All patients were replaced with mechanical heart valve, concomitant TV repair if TR >2/4 (57.89%). ICU stay was 9 days with mean inotrope use was 8 days.

In this group, there were 4 deaths due to acute heart failure postoperatively. All these cases started with acute heart failure with severe reduction of LVEF, low unstable blood pressure which lead to acute renal failure then multiple organs failure.

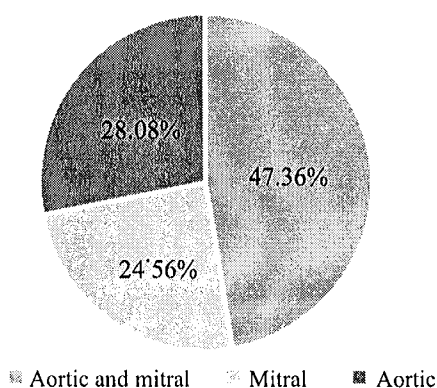


Chart 1: Percentage of valve lesion

Table 4: Postoperative results

	Min	Max	Mean
LV diastolic diameter (mm)	42	63	59.87 ± 5.9
LV systolic diameter (mm)	36	51	46.5±6.04
LVEF (%)	24	56	42.41±1.52
PAPs (mmHg)	25	30	25.7±1.8

Table 5: Complications

Complications	N	%
Bleeding need re-exploration	3	5.26
Pneumothorax	2	3.5
Hemothorax	2	3.5
Sternal infection	0	0
Acute renal failure	4	7.02
Mortality	4	7.02

Most of the complications were bleeding need re-exploration, pneumothorax, hemothorax. All complications were managed well.

Table 6: Comparison of pre and post-operative echo data

	Preop	Postop	p
LV diastolic diameter (mm)	59.87 ± 5.9	55.76±4.53	0.0235
LV systolic diameter (mm)	49.17 ± 5.7	46.5±6.04	0.0235
LVEF (%)	37.7 ± 1.56	42.41±1.52	0.2394
PAPs (mmHg)	37.8 ± 10.35	25.7±1.8	0.01

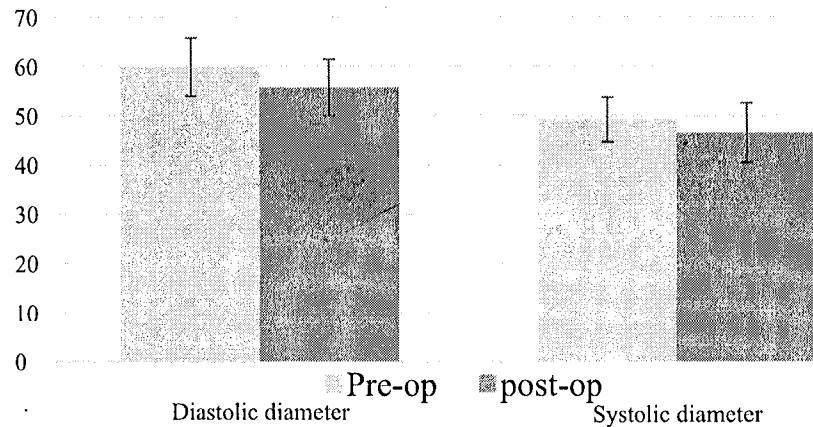


Chart 2: Comparison of heart chamber size pre and post operatively

#### IV. DISCUSSION

Patients with valvular heart diseases and markedly reduced LVEF can have severe symptoms but some of them are still asymptomatic. These patients usually had higher early and late mortality risk and the percentage of post operative heart failure are also higher than those with better LVEF. In patients with reduced LV function, some research showed that mortality ranged from 8% to 21% in aortic stenosis patients, and 6% to 12% in aortic regurgitation. Until now, there are no consensus on the indication for these severe patients, so there is no proper recommendation. However, there are still trials indicating that although with high operative risk and mortality, but the results were still good and longterm outcome was acceptable.

The purpose of this study is to evaluate early outcome after mechanical valve replacement in patients with low LVEF, base on that results, we can have more precise indications and to recommend our patients. This is high risk group, with high demand in technique as well as appropriate strategy to gain good outcome. These patients often need longer intubation time, longer ICU stay and inotrope use. In this study, mean ICU stay was  $9.29 \pm 1.6$  days, mean inotrope use was  $8.46 \pm 1.51$  days. Moreover, hospital mortality in our result was still in the same range as other trials. In heart valve replacement, death is usually due to low cardiac output and multiple organ failure. Sharony et al. showed that mean hospital stay was 12 days, acute renal failure was 3.2%.

Table 7: Mortality in some studies

Authors	N	LVEF (%)	Mortality (%)
Neale Smith (1978)	19	$37 \pm 0.02$	21
David E.P. (2000)	55	$22.2 \pm 6.2$	18
Chaliki (2002)	43	$28 \pm 5$	14
Ram S. (2003)	416		10.1
Onorati (2014)	81	$\leq 35$	8.6
Bishay (2000)	44	$28 \pm 6$	2.3
<b>Our result</b>	<b>57</b>	<b><math>37.7 \pm 1.56</math></b>	<b>7.02</b>

One of the most important thing in open heart surgery in patients with low LVEF is myocardial protection. Without proper protection technique, weak hearts will worsen and lead to fatal consequences such as longer ICU stay, more inotrope use, more complications like

pneumonia, acute renal failure, infection... and death. In this study, we use warm blood cardioplegia which is more physiologic and protective. Furthermore, we use antegrade and continuous retrograde infusion technique that continuously protect the heart during operation

time, contributing to better heart recovery. Our mean CBP time was  $95.28 \pm 12.07$  min, this was not a long time which help our patients recovered better. Sharony showed that mean CBP time in AVR was 137 min.

In our result, all heart chamber size reduced significantly after surgery, which indicated that the hearts were not dilated anymore and contractility would be better. Bishay showed that systolic and diastolic heart diameter were all reduced postoperatively in patients with mitral replacement and low LVEF. Diastolic size reduced from 65mm to 57mm, systolic size from 50mm to 46mm.

LVEF also increased after operation, although without statistically signification, maybe because of small size of data. According to Czer et al. there was a significant improvement of LV function after AVR. PAP also reduced postoperatively. Bishay et al. also showed that LVEF increased

from 28% to 36% after valve replacement. Mitral posterior leaflet preservation in MVR was proved to help maintain LV shape, increase LVEF.

In our study, morbidity was low with only 5.25% bleeding need reexploration, 3.5% pneumothorax, 3.5% hemothorax, no sternal infection. In Ram Sharony's study, there were 3.8% bleeding, 2.2% sternal infection. All these percentage was low and caused minor risk to patients.

So, our patients have demonstrated that early result was optimistic although preoperative risk was high.

## V. CONCLUSION

Heart valve replacement in patients with severe reduction of LVEF, although having high morbidity and mortality risks, is the method of choice which help improve symptoms and heart function, contributing to reduce mortality due to advanced heart failure.

## REFERENCE

1. Bishay E.S, McCarthy P.M, Delos M. Cosgrove, Katherine J. Hoercher (2000), "Mitral valve surgery in patients with severe left ventricular dysfunction", *European Journal of Cardio-thoracic Surgery* 17 (2000) 213±221.
2. Brogan W.C. III, Grayburn P.A., Lange R.A. et al (1993), "Prognosis after valve replacement in patients with severe aortic stenosis and a low transvalvular pressure gradient", *J Am Coll Cardiol* 21:1657-1660.
3. Chaliki H.P. (2002), "Outcomes after Aortic valve replacement in patients with severe aortic regurgitation and markedly reduced left ventricular function", *Circulation*, 106, 2687-2693.
4. Czer G. et al (2013), "Aortic Valve Replacement or Heart Transplantation in Patients With Aortic Stenosis and Severe Left Ventricular Dysfunction", *Transplantation Proceedings*, 45, 364-368.
5. David E.P, Paul A.T. (2000), "Aortic valve replacement in patients with aortic stenosis and severe left ventricular dysfunction", *Arch Intern Med*, 160, 1337- 1341.
6. Neale S. et al, (1978), "Severe aortic stenosis with impaired left ventricular function and clinical heart failure: results of valve replacement", *Circulation*, 58, 255- 264.
7. Onorati F. et al (2014), "Effect of severe left ventricular systolic dysfunction on hospital outcome after transcatheter aortic valve implantation or surgical aortic valve replacement: Results from a propensity-matched population of the Italian OBSERVANT multicenter study", *The Journal of Thoracic and Cardiovascular Surgery*, 147 (2), 568- 575.
8. Ram S., Eugene A.G, et al. (2003), "Aortic valve replacement in patients with impaired ventricular function", *Annals of thoracic surgery*, 75, 1808- 1814.
9. Turina J., Stark T., et al. (1999) "Predictors of the long-term outcome after combined aortic and mitral valve surgery", *Circulation*, 100 [suppl II], 48-53.

## **SURGERY FOR MITRAL REGURGITATION: UP TO DATE**

Van Hung Dung<sup>1</sup>

### **ABSTRACT**

**Objectives:** In recent years, what alter for mitral valve repair? We summarize new advances in mitral valve repair on the world and present results of isolated mitral valve repair at Ho Chi Minh Heart Institute.

**Methods:** Search and analyse all data collect in American and Europe Cardiac Surgery Journal and perform retrospective study in all cases of mitral valve repair from 1993 to 2015 at Ho Chi Minh Heart Institute.

**Results:** Trends in isolated mitral regurgitation surgery has changed in recent years:

- Early surgery and expand the indication in young patient without symptom.
- New generation rings have more physiologic and more compatible with any types of MR.
- With new techniques (such as artificial chordal, posterior leaflet widening...) make increasing the possibility of valvular repair.

We divided the study group in 2 stage, 1<sup>st</sup> stage :1993 to 2003 and 2<sup>nd</sup> stage: 2004 to 2015.

- About etiology of MR: in 2<sup>nd</sup> stage, rate of RHD decrease significantly.  
( 54.7% vs 84.8%,  $p < 0.001$ ) meanwhile rate of degenerative and ischemic MR increase important.
- About mean age: in 2<sup>nd</sup> stage, mean age was increase significant ( $p < 0.01$ ).
- Proportion of valve repair increases by years: 1<sup>st</sup> stage : 80.3% lower than 2<sup>nd</sup> stage: 89.1%.
- Redo for recur MR: 2<sup>nd</sup> stage (1.07%) versus 1<sup>st</sup> stage (3.06%) that proved all technique applied have improved.
- Operative mortality still have low although the type of IMR were more diversified.

### **Conclusion:**

- The surgical tendency to preserve valves is expanding with some new technologies and new-generation valve rings.
- At the HCM Heart Institute, the rate of valve repair is increasing with the pathology more and more diverse but the results are very good.

**Key word:** Isolated mitral regurgitation (IMR)

### **I. BACKGROUND**

Mitral valve repair was begun in 1950-1960's decade but fast developed in 1970 decade by Pr.Alain Carpentier 's researches and the others pioneers such as Carlos Duran, Harvey Feigenbaum... With the development of both

as supporting facilities and material have created favorable conditions for the restoration of mitral valve. We conducted this study with the aim of updating mitral valve repair methods in recent years and evaluating mitral repair results at the HCM Heart Institute.

1. HCM Heart Institute

**Corresponding author:** Van Hung Dung  
Email: vhdung2004@yahoo.com ; Tel: 0917882488  
**Received:** 21/1/2017; **Revised:** 25/5/2017;  
**Accepted:** 19/6/2017

## II. PATIENTS AND METHODS

### 2.1. Subjects

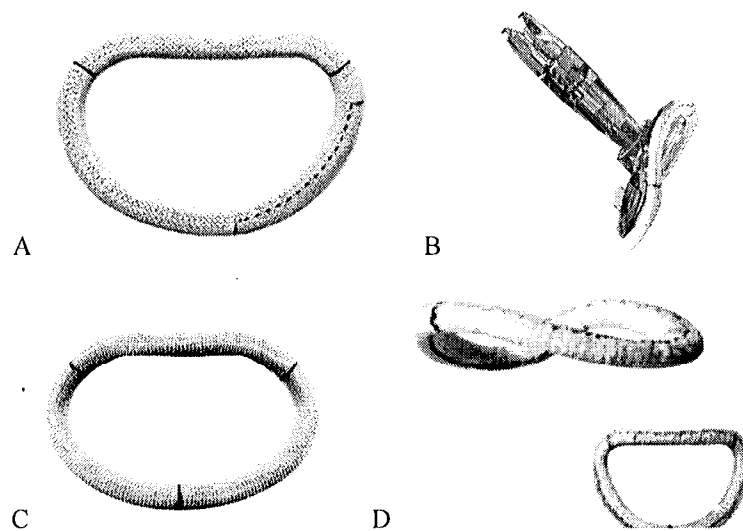
- We retrospectively all patients undergoing mitral repair surgery from 1993 to 2015 at the Heart Institute of Ho Chi Minh City. To serve the purpose of our research, we divided it into two stage: stage 1, from 1993 to 2003 and stage 2, from 2004 to 2015.

### 2.2. Methods

- We used keyword at mention before and found 15 articles published in journals such as “The Annals of Thoracic Surgery”, “The Journal of Thoracic and Cardiovascular Surgery”, “European Journal of

Cardio Thoracic Surgery” ... Analyse and statistics show that new trends in mitral valve surgery are as follows :

- Early surgical indication especially in patients with functional mitral regurgitation (MR) [2], [13]
- Indications of mitral surgery was open widely [1], [6], [10], [13]
- Combination of many supportive treatments for mitral surgery [5], [10], [15]
- Widely applied minimally invasive surgery for mitral valve repair [14], [15], [17] .



Picture 1: Some type of new ring  
A,C: IMR ETlogix ring , Profile 3D ring for ischemic MR  
B,D: CE Physio II ring, SJM rigid saddle ring for degenerative MR

## III. RESULTS

- Retrospective study on 2146 isolated mitral valve regurgitation patients at the Heart Institute of Ho Chi Minh city from 1993 to 2015.

The study data is summarized in the following table:

Table 1: Data characteristics of patients

Data Stage	M age	Wo	NMR (N)	Op. Mort.	Re do	Cause of MR				
						RHD	Degen.	EB	Congenital	Ische.
1993-2003	28	536	817 (1017)	14 1.7%	25	693	73	13	22	16
2004-2015	45.5	572	1214 (1368)	22 1.8%	13	652	238	47	65	212

Subgroup surgery for the following causes in table 2

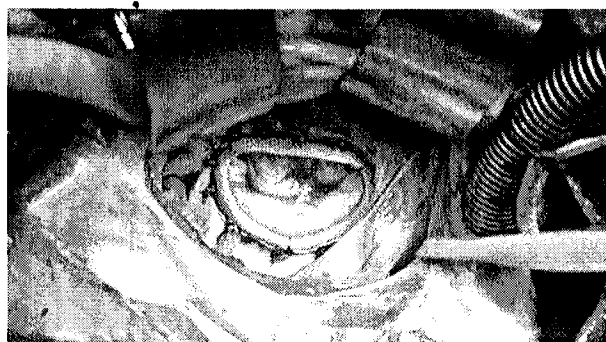
Table 2: Rate of redo under the cause

Stages	Redo	Cause of MR				
		RHD	Degene.	EB	Congenit.	Ischem.
1993-2003	25 (3.06%)	3%	2.7%	7.7%	0	0
2004-2015	13(1.07%)	1.5%	1.1%	2.1%	0	0

And the ability to repair the valve success by the cause were as follows

- Stage 1: The rate of mitral valve repair is 80.3% and the second stage is 88.7%.

- The rate of successful repairing by cause, stage 1 compared with the stage 2 is 81.2% compared to 85.6% (rheumatic); 93.6% vs. 99% (degeneration); 65% vs. 53.5% (infectious endocarditis) and 95.6% vs. 98.5% (congenital). Except for the rate of mitral valve repair caused by infectious endocarditis is lower because in the later stage we recommend surgery sooner while the lesion is hot and diffuse so the valve conservation capacity is lower. Remaining, these rates all increase, proving the vanishing technique is getting better and better.



Picture 2: CE Physio II ring

#### IV. DICUSSION

##### 4.1. Indication of surgery for MR

It seems that in recent years the look on surgical indications for severe MR has changed. Classical standards, such as heart failure or symptomatic levels, left ventricular dysfunction, and pulmonary hypertension, are still applied but widespread. Enriquez-Serano cited six reasons for early surgery for organic MR in which emphasis early surgery to relieve complications of severe MR, and surgery

was an option that could not be replaced at the time of its appearance[13]. R. Bonow also required early surgery for patients with symptomatic MR, or severe left ventricular dysfunction, especially in patients with degenerative valve disease due to new techniques and surgical results better [4]. Evidence for this, statistics on 14,604 patients in the United States, V. Badhwar showed that the actual survival rate after 10 years in patients after valve reconstruction surgery was 57.1%, this number is equal with population with the same age class [3]. Gammie's statistics on 910 hospitals in the United States in 2009 showed that the rate of mitral valve repair increased from 51% to 69% ( $p < 0.0001$ ) that proved benefits of early surgery [9].

##### 4.2. About the new technical methods to be applied

Thanks to a deeper understanding of the anatomy, the physiology and mechanism of MR leads to the application of new techniques in valve repairing. Typically, MR is caused by breaking chordae could be repair by many techniques. The introduction of PTFE artificial ligaments (Gore-tex CV4) has solved most of the cases in the past its have to replace the valve by rupturing too many chords. Ibrahim has been counting more than 40 reimplantation techniques as a technical alternative to traditional Carpentier techniques (partial removal of the valve and transference of the chord). Artificial ligament is the solution to simplify the search and replace of broken or absence chordae, this technique is reproducible and safe, especially for the case rupture many chordae of both valves. Castillo reports that nearly 100% of cases of degeneration MR can be repairing due to artificial ligaments [6]. However, the authors emphasized that the more technique is, the easier it would be to make mistakes



or abuse if not properly analyzed the mechanism of the lesion. Another striking step is the application of all these new techniques to mitral valve repair through minimally invasive techniques as well as robotic surgeries [17]. This top-notch combination brings the picture of artistic perfection of cardiac valve surgery.

### 4.3. About the results of HCM Heart Institute

The results of statistics have shown:

- The cause of MR was markedly changed: the rate of rheumatic decreased (54.7% vs. 84.8%,  $p < 0.001$ ), the rate of degeneration and ischemia MR increased sharply (8.9% vs. 19.6%,  $p < 0.01$  and 2% vs. 17.4%). This can be explained from two points of view: rheumatic disease rates in the community have decreased and people's wellbeing and lifespan have increased.

- According to general trend, valve conservation rate is increased in later stages thanks to newly applied techniques and improved skills. Based on Carpentier's techniques plus experience and application of new techniques, we have been able to successfully repair in almost MR cases. This success is also due to the more accurate diagnosis of echocardiography, especially the trans-esophageal echocardiography (TEE), which helps to accurately determine the mechanism of MR as well as the immediate examination of results before weaning

from CPB. Therefore, we performed routine TEE from 2006, thereby reducing the rate of residual leakage after surgery. Currently, conventional 3D and TEE 3D is gradually replacing the 2D ultrasound due to the accuracy in the diagnosis of the mechanism and the cause of MR. In difficult cases or severe MR due to multiple mechanisms of association, the role of 3D TEE to perform before weaning of CPB is really useful and necessary. And also, the development of new cardioplegia liquid helps to prolong protective myocardium, a prerequisite for the surgeon to be confident in investing time in valve repair is much longer if compared to valve replacement. In this study, recurrence rate in the second stage was only 1.07% compared to 3.06% in the first stage, and the rate was reduced in all three groups thanks to the completion of the valve repairing skills as well as promote the companion role of echocardiography in mitral valve surgery.

### V. CONCLUSION

- The surgical tendency to preserve valves is expanding with some new technologies and new-generation valve rings.

- At the HCM Heart Institute, the rate of valve repair is increasing with the pathology more and more diverse but the results are very good.

### REFERENCES

1. DH. Adams, R Rosenhek, and V Falk. Degenerative mitral valve regurgitation: best practice revolution. *Eur Heart J* 2010; 31: 1958– 967.doi:10.1093 /eurheartj/ ehq222.
2. MA. Acker, MK. Parides, LP. Perrault, AJ. Moskowitz, AC. Gelijns, P Voisine, et al. Mitral-Valve Repair versus Replacement for Severe Ischemic Mitral Regurgitation. *N Engl J Med* 2014;370:23-32. DOI: 10.1056/NEJMoa1312808.
3. V. Badhwar, ED. Peterson, JP. Jacobs, X.He, JM. Brenan, SMO'Brien et al. Longitudinal outcomes of isolated mitral repair in older patients: results from 14,604 procedures performed from 1991 to 2007. *Ann Thorac Surg* 2012;94:1870-9.
4. RO. Bonow. Chronic Mitral Regurgitation and Aortic Regurgitation Have Indications for Surgery Changed ? *J Am Coll Cardiol* 2013;61:693–701.
5. J.Braun, A.Ciarka, MI.M. Versteegh, V. Delgado, E.Boersma, HF. Verwey. Cardiac support device, restrictive mitral valve annuloplasty, and optimized medical treatment: A multimodality approach to nonischemic cardiomyopathy. *J Thorac Cardiovasc Surg* 2011;142:e93-100.
6. JG. Castillo, AC. Anyanwu, V Fuster, and DH. Adams. A near 100% repair rate for mitral valve prolapse is achievable in a reference center:

- Implications for future guidelines . *J Thorac Cardiovasc Surg* 2012;144:308-12.
7. JG. Castillo, AC. Anyanwu, A.El - Eshmawi, DH. Adams.All anterior and bileaflet mitral valve prolapses are repairable in the modern era of reconstructive surgery. *Eur. J Cardio Thorac Surg* 2014;1: 39-45.
  8. L.Conradi, H.Treede, H. Reichenspurner . Recent advances in surgical and percutaneous mitral valve therapies - implications of an integrated approach to mitral regurgitation. *EMJ Int Cardiol.* 2014;1:44-51.
  9. JS Gammie, S Sheng, BP Griffith, ED Peterson, JS Rankin et al.Trends in mitral valve surgery in the United States : results from Society of Thoracic Surgeons Adult Cardiac Database. *Ann Thorac Surg* 2009;87:1431-9.
  10. Donald D. Glower. Surgical Approaches to Mitral Regurgitation. *J Am Coll Cardiol* 2012;60:1315-2.
  11. M.Ibrahim, C .Rao, T. Athanasiou. Artificial chordae for degenerative mitral valve disease: critical analysis of current techniques. *Interac Cardiovasc Thorac Surg* 2012;15:1019-1032.
  12. JS. Rankin, MA. Daneshmand, CA. Milano, JG. Gaca, DD. Glower, PK. Smith. Mitral valve repair for ischemic mitral regurgitation: review of current techniques. *Heart, Lung and Vessels.* 2013; 5(4): 246-251.
  13. M Enriquez-Sarano, Thoralf M. Sundt III. Is early surgery recommended for mitral regurgitation? . *Circulation.* 2010;121:804-812.
  14. RM Suri, Dphil, HM Burkhardt, RC Daly, JA Dearani, SJ Park et al.Robotic mitral valve repair for all prolapse subsets using technique identical to open valvuloplasty. Establishing the benchmark against with percutaneous interventions should be judged. *J Thorac Cardiovasc Surg* 2011;142:970-9.
  15. YJ. Woo, and AB. Goldstone. The contemporary evolution of mitral valve surgery. *J Thorac Cardiovasc Surg* 2016;151:7-9.
  16. Văn Hùng Dũng. Hở van hai lá bẩm sinh đơn thuần: từ chẩn đoán đến điều trị phẫu thuật. *Y học thành phố HCM, tập 16 phụ bản của số 1, năm 2012, trang 377-382*
  17. JA Wolfe, SC. Malaisrie, RS Farivar, JH. Khan, WC. Hargrove, MG. Moront, et al. Minimally Invasive Mitral Valve Surgery II. Surgical Technique and Postoperative Management. *Innovations* 2016; 11 : 251-259.