

***Clinical and Echocardiographic Correlates of
Postoperative LV Function after Mitral Valve Surgery
in Patients with Severe Mitral Incompetence***

*A Thesis Submitted for Partial Fulfillment of Master Degree of
Cardiology*

Presented By

**Mohamed A. Adel Abdelwahab.
M.B.B.CH**

Under the Supervision of

Dr. ZeinabAttiaAshour, MD
Professor of Cardiology, Cairo University

Dr. Ahmed HussienGaafer, MD
Assistant Professor of Cardiothoracic surgery, Cairo University

Dr. HussienHeshmatKasem, MD
Lecturer of Cardiology, Cairo University

Cardiology Department
Faculty of Medicine
Cairo University
2012

Acknowledgment

First and foremost, I feel always deeply indebted to ALLAH, the Most Gracious and the Most Merciful.

I would like to express my deepest gratitude and cardinal appreciation to Prof. Dr. ZeinabAshour, who kindly supervised and motivated the performance of this work.

I am greatly honored to express my deep thankfulness to Dr. Ahmed Gaafer, for his continuous support.

Sincere appreciation is extended to my advisor Dr. HussienHeshmat for his excellent guidance and for devoting part of his precious time to help me in the completion of this work.

I am very grateful to all my staff members and my colleagues in the Cardiology department, particularly Dr. Dina Osama for her help and support throughout the course of the work. She kindly performed most of the echocardiographic examination. Also great thanks to Dr. Ahmed Shehata who help me a lot in making the statistics.

Finally, I am most grateful to my parents for their patience and everlasting support.

*Mohamed A. Abdelwahab
Cairo
2012*

Abstract

Background: Severe mitral regurgitation (MR) is associated with reduced afterload and overestimated ejection fraction (EF). Correction of MR may result in significant decline of EF in some patients.

Aim: Determine the predictors of postoperative decline of EF in patients with severe MR after mitral valve surgery.

Methods: From April 2011 to April 2012, we prospectively recruited 30 consecutive patients with isolated primary severe MR who had successful mitral valve surgery (repair in 19 patients including 10 patients with rheumatic etiology and replacement with mechanical prosthesis with chordal preservation in the remaining patients). Clinical data were collected including the presence of atrial fibrillation (AF) and functional capacity using 6-minute walk test (6MWT). Echocardiography was done to study the left ventricular (LV) volume, EF, and left atrial volume. We performed pulsed wave tissue Doppler imaging (TDI) to measure lateral mitral annulus peak S wave velocity and myocardial performance index (MPI). Follow up echocardiogram was done two months after surgery to assess postoperative EF. Patients with post-operative EF<50% (Group I) were compared with patients with post-operative EF ≥50% (Group II) using independent sample T test for continuous variables and Chi square test for categorical variables.

Results: The mean age of patients was 33±12.7 years and 63.3% were females. The cause of MR was rheumatic in 20 patients, myxomatous in 10 patients. The effective regurgitant orifice area was 0.46±0.17 cm². The pre-operative biplane EF was 63±6.7%. Compared to Group II, patients in Group I (n=9) had significantly more AF (p=0.008), shorter 6MWT distance (p=0.009), larger LV end-systolic volume (p=0.047), larger LA volume index (p=0.008) and lower pre-operative EF

($p=0.004$). However, the TDI peak S wave velocity and MPI were not different between the two groups ($p=0.06$ & $p=0.27$ respectively). Multiple linear regression analysis using stepwise technique showed that the preoperative biplane EF and the 6-minute walk distance are independent predictors of postoperative EF $<50\%$ with p value 0.007 & 0.013 respectively. The receiver operating characteristic (ROC) curve analysis showed that a pre-operative biplane EF $< 61\%$ has 76.2 sensitivity & 78% specificity and a 6-minutes walk distance <245 meters has 87.5% sensitivity & 75% specificity to predict a post-operative LV EF $<50\%$.

Conclusion: Pre-operative LV biplane EF $<61\%$ and 6-minute walk distance <245 meters are independent predictors of postoperative LV systolic dysfunction (EF $<50\%$) after mitral valve surgery for severe mitral regurgitation.

Key word;

- Sever Mitral incompetence
- Left Ventricular ejection Fraction
- 6. Minulue Walk test – Mitral Valve Surgery

List of Contents

Acknowledgment	II
Abstract	III
List of Contents	V
List of Figures	VIII
List of Tables	XI
List of Abbreviations	XII

Introduction and Aim of work	1
Review of Literature	
Chapter 1: Anatomy of the Mitral Valve	4
The Left atrial Wall	4
The Leaflets.	5
The commissures	9
The Annulus	11
The Chordae Tendineae.	13
The Papillary Muscles and Left Ventricular Wall	15
Over view of Mitral Valve Function	17
Chapter 2: Pathophysiology of mitral incompetence	19
Determinants of Mitral Regurgitant Volume.	19
Left Ventricular Compensation	21
Left Atrial Compliance	24
Coronary Blood Flow in Mitral Incompetence	25
Left Ventricular Pressure-Volume Loop	26
Normal LV pressure-volume loop	26
LV pressure-volume curve in mitral incompetence	28
Assessment of Hemodynamics of Mitral Incompetence	29

Exercise hemodynamics	30
Hemodynamic consequences of vasoactive drugs in MR	31
Chapter 3: Guidelines in the Management of	
Mitral Incompetence	33
Indications for Transthoracic Echocardiography	34
Indications for Trans-esophageal Echocardiography	35
Indications for Cardiac Catheterization	35
Management	36
Medical therapy	36
Indications for mitral valve operation	37
Chapter 4: Echocardiographic Assessment of Mitral	
Incompetence	44
1. Role of Two-dimensional Echocardiography	44
2. Doppler Methods in Evaluation of Mitral	
Incompetence	45
3. Integrative Approach for Assessment of Mitral	
Incompetence severity	57
Chapter 5: Echocardiographic Quantification of Left	
Sided Chambers	61
Left Ventricular Quantification	61
Left ventricular size	61
Left ventricular global systolic function	66
Tissue Doppler imaging	69
Left ventricular shape and geometry	74
Left Atrium Quantification	80
Left atrium size	80
Patients and Methodology	82
Results	88
1. Baseline clinical characteristics	88
2. Baseline echocardiographic characteristics	89
3. Echocardiographic changes after surgery	91
4. Univariate analysis	89
5. Multivariate analysis	98
6. ROC curve analysis	108
	109

Discussion	112
Clinical Implications	130
Limitations	131
Summary &Conclusions	132
References	134
Appendix	146

List of Figures

Figure	Title	Page
Figure 1	Effect of left atrial dilatation on mitral regurgitation	5
Figure 2	Anatomic-clinical nomenclature of scallops	6
Figure 3	Zone of coaptation	8
Figure 4	Coaptation depth and tenting area	9
Figure 5	Anatomy of the anterior and posterior commissures of the mitral valve	10
Figure 6	The Commissural area	10
Figure 7	Surgical anatomy of the mitral annulus with important surrounding structures	13
Figure 8	The chordae tendineae	14
Figure 9	Subvalvular apparatus of the mitral valve	15
Figure 10	An open mitral valve	16
Figure 11	Forces acting on mitral valve	18
Figure 12	Pathophysiology of mitral incompetence	23
Figure 13	Normal LV pressure volume curves	26
Figure 14	Pressure volume curve in chronic MR	29
Figure 15	Hemodynamic tracing in severe MR with IV sodium nitroprusside infusion	32

Figure	Title	Page
Figure 16	Management strategy for patients with chronic severe mitral regurgitation	43
Figure 17	Color flow recording of the 3 components of the true mitral regurgitant jet	46
Figure 18	Examples of color flow recordings of different mitral regurgitation (MR) lesions	47
Figure 19	Steps of assessment of MR severity by PISA method	51
Figure 20	Calculation of mitral regurgitant volume and regurgitant fraction by pulsed Doppler	54
Figure 21	Continuous wave Doppler and pulmonary vein flow by pulsed wave Doppler in mitral regurge	55
Figure 22	Two-dimensional guided M-mode echocardiogram of the left ventricle (LV) at the papillary muscle level	62
Figure 23	Method for determining the left ventricular volume from the rule of disks or Simpson rule	65
Figure 24	Modified biplane Simpson's method to measure LV volumes	65
Figure 25	Calculation of the left ventricular dP/dt from the continuous wave Doppler mitral regurgitation spectral signal	66
Figure 26	Method of calculating the left ventricular dP/dt by Doppler echocardiography	68
Figure 27	PW-TDI from the septal corner of the mitral annulus	70
Figure 28	Relation between Doppler transmitral flow and Doppler tissue imaging	74
Figure 29	Myocardial fiber orientation	75
Figure 30	Left ventricular sphericity index	77

Figure	Title	Page
Figure 31	Linear relation of LVEF and LV twist& apical rotation	78
Figure 32	The parabolic relation between LV sphericity index and peak LV apical rotation & twist	79
Figure 33	Measurement of left atrial (LA) volume from area-length method	81
Figure 34	Echocardiographic change in LVEDD before and after surgery	91
Figure 35	Echocardiographic change in LVESD before and after surgery	92
Figure 36	Echocardiographic change in LVEDV before and after surgery	93
Figure 37	Echocardiographic change in LVESV before and after surgery	93
Figure 38	Echocardiographic change in LVEF before and after surgery	94
Figure 39	Echocardiographic change in LA volume before and after surgery	95
Figure 40	Rhythm distribution among the two study groups	98
Figure 41	Distribution of the NYHA classes among the two study groups	99
Figure 42	Mean 6-minute walk distance in the two study groups	100
Figure 43	Mean left ventricular ejection fraction in the two study groups	101
Figure 44	Mean left ventricular end systolic volume index in the two study groups	102
Figure 45	Mean left atrial volume index in the two study groups	103
Figure 46	ROC curve of preoperative ejection fraction	110
Figure 47	ROC curve of 6-minute walk distance	111

List of Tables

Table	Title	Page
Table 1	Qualitative and quantitative parameters useful in grading mitral regurgitation severity	56
Table 2	Echocardiographic and Doppler parameters used in the evaluation of mitral regurgitation severity: Utility, advantages, and limitations	59
Table 3	Application of specific and supportive signs, and quantitative parameters in the grading of mitral regurgitation severity	60
Table 4	Baseline clinical characteristics	88
Table 5	Cross tabulations; Etiology of MR & Type of mitral valve surgery	89
Table 6	Baseline echocardiographic characteristics	90
Table 7	Echocardiographic changes after mitral valve surgery	97
Table 8	Comparisons between the 2 groups regarding the clinical characteristics	104
Table 9	Comparisons between the 2 groups regarding the echocardiographic characteristics (chamber quantification)	106
Table 10	Comparisons between the 2 groups regarding the echocardiographic characteristics (MR severity assessment)	108

List of Abbreviations

ACC: American College of Cardiology
ACE: Angiotensin Converting Enzyme
AF: Atrial Fibrillation
AHA: American Heart Association
CW: Continuous Wave
CR: Contractile Reserve
EF: Ejection Fraction
EROA: Effective Regurgitant Orifice Area
ESWS: End Systolic Wall Stress
FAC: Fractional Area Change
FS: Fractional Shortening
IVCT: Isovolumic Contraction Time
IVRT: Isovolumic Relaxation Time
LA: Left Atrium
LV: Left Ventricle
LVEDA: Left Ventricular End Diastolic Area
LVESA: Left Ventricular End Systolic Area
LVEDD: Left Ventricular End Diastolic Diameter
LVESD: Left Ventricular End Systolic Diameter
LVEDV: Left Ventricular End Diastolic Volume
LVESV: Left Ventricular End Systolic Volume
LVOT: Left Ventricular Out flow Tract

LVPV: Left Ventricular Pressure Volume
LVSI: Left Ventricular Sphericity Index
MR: Mitral Regurgitation
MPI: Myocardial Performance Index
NYHA: New York Heart Association
PASP: Pulmonary Artery Systolic Pressure
PCWP: Pulmonary Capillary Wedge Pressure
PH: Pulmonary Hypertension
PW: Pulsed Wave
ROC: Receiver Operating Characteristic Curve
RV: Regurgitant Volume
Sm: Myocardial Systolic Wave Velocity
TDI: Tissue Doppler Imaging
VC: Vena Contracta
2D: Two Dimensions
3D: Three Dimensions
6-MWT: Six Minute Walk Test

Introduction

Before the 1990s, most clinicians viewed mitral regurgitation (MR) as a relatively benign condition, and surgery was reserved for patients who were severely symptomatic or failed medical management. Reluctance to proceed with operation was related to the likelihood of prosthetic valve replacement and to the notion that asymptomatic patients with severe MR were a stable compensated group with negligible risk of serious complications, including sudden death.^{1&2}

Nowadays it becomes well known that MR is a progressive disease, with an average increase of 7.5ml per year for regurgitant volume and 5.9 mm² per year for the effective regurgitant orifice area,³ as well as progressive left ventricular (LV) remodeling, leading eventually to the development of LV dysfunction, which may be irreversible.

Evaluation of LV systolic function in chronic severe MR is challenging due to increased preload and reduced afterload as left ventricle empties into low impedance left atrium, consequently the ejection fraction (EF) remains higher than normal during compensated phase of chronic MR. Thus, ejection indices such as ejection fraction (EF) in patients with severe MR cannot be considered reliable measures of left ventricular contractile function, as it remains within the normal range despite contractility is already becoming impaired. Also Symptoms often occur late in chronic MR, most likely as a result of the compliance properties of the left atrium that allow it to accommodate large volumes of blood without a significant rise in pressure. Another major concern for patients with asymptomatic severe MR is the risk of sudden cardiac death, with an absolute risk of 1–2.5% over 6years.

Introduction & Aim of work

The major determinants of sudden cardiac death in degenerative MR are LV dysfunction, redundant leaflets and severe MR.⁴

For the above reasons and due to significant improvements in surgical technique with a lower perioperative mortality and better long-term outcome of valve repair, the current trend is early surgical correction in patients with severe mitral regurgitation.