Role of Three Dimensional Echocardiography in Detection of Left Ventricular Mechanical Dyssynchrony in Patients with Severe Primary Mitral Regurgitation

Thesis Submitted for Partial Fulfillment of Doctorate Degree in Cardiology

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2014

Dedication and Acknowledgments

I would like to dedicate this thesis dissertation to my mother who provided me with passionate and love and was a source of inspiration throughout my life. To my wife who provided me with great support and encouragement to finish my work in a warm atmosphere. Without her tolerance and enthusiasm I wouldn't have completed much of my career achievement.

I would like to thank **Dr. Wafaa Elaroussy**, professor of cardiovascular medicine, for her contributed ideas, feedback and advice. I am really grateful. Without these guidance and unlimited help, this work would not come to light. I am so much obliged to **Dr. Mohammad Abdelghany**, professor of Cardiology, Cairo University for his continuous guidance and supervision, valuable advices and encouragement during this work. To him I extend my sincere thanks. He taught me a lot, not only in cardiology but also in life.

I am greatly indebted to **Dr. Azza Farrag**, professor of cardiovascular medicine, for her endless efforts, inspirational instruction and guidance from the formative stages of the thesis to the final draft. I believe that without her continued support and counsel I wouldn't have completed this work.

Finally, special thanks to my colleagues and co-workers who aided me during data collection and provided me with invaluable cooperation.

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Role of three dimensional echocardiography in detection of left ventricular mechanical dyssynchrony in patients with severe primary mitral regurgitation

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Abstract

Purpose: We studied various tissue Doppler imaging (TDI) and three dimensional echocardiographic (RT3DE) parameters that might predict left ventricular (LV) mechanical dyssynchrony in patients with severe primary mitral regurgitation (MR).

Methods: The study included 65 patients with severe primary mitral regurgitation; 34 (mean age 30.4 ±8.0 years) had rheumatic etiology and 31(mean age 32.9±12.6 years) patients diagnosed as mitral valve prolapse. All patients were in normal sinus rhythm. In addition, 22 (mean age 28± 6.1 years) age and gender matched healthy subjects were studied and served as a control group. All the studied population underwent history taking, clinical examination and ECG. Detailed transthoracic echocardiogram (TTE) was done. Tissue Doppler imaging (TDI) was performed to determine left ventricular systolic dyssynchrony by measuring Ts-SD (SD of time to peak myocardial systolic velocity during the ejection period). Real time 3D echocardiography (RT3DE) was performed to assess global left ventricular ejection fraction (LVEF) and the systolic dyssynchrony index (SDI).

Results: There was significant difference between the three groups and also between RHD and MVP groups regarding Ts-Dif, Ts-SD, corrected Ts-SD and corrected Ts-Dif (p=0.000). These indices were significantly lower in MVP patients compared to patients with RHD. Also There was significant differences between RHD and MVP groups regarding $Tmsv_{12}$-SD% and $Tmsv_{6}$-SD% (p=0.037, 0.022 respectively). There was a significant difference between RHD and MVP regarding $Tmsv_{6}$-Dif% (p=0.036). Pearson correlation coefficients showed significant correlation between $Tmsv_{16}$-SD% and LVESV (r=0.409, p=0.016) and negatively correlated with 2D ejection fraction (r=-0.580, p=0.000) and with 3D EF(r=-0.404 , p=0.018) in RHD patients. The $Tmsv_{16}$-SD%, $Tmsv_{12}$-SD% and $Tmsv_{6}$-SD% were negatively correlated with EF 3D (r=-0.371, p=0.04) (r=-0.542 p=0.002) and

(r=-.0.622 p=0.000) respectively in MVP patients.

Conclusion:

There is mechanical systolic dyssynchrony in patients with severe MR due to rheumatic etiology when compared with MVP patients.

LIST OF ABBREVIATIONS

AF	Atrial Fibrillation
AHA	American Heart Association
AR	Aortic regurgitation
AS	Aortic stenosis
ASE	American society of echocardiography
BMI	Body mass index
BSA	Body surface area
CHF	Congestive heart failure
CMR	Cardiac Magnetic Resonance
CRT	Cardiac resynchroniztion therapy
CWD	Continuous wave Doppler
Diff	Maximal difference
ECG	Electrocardiogram
EDV 3D	End diastolic volume by three dimensional echocardiography
EF	Ejection fraction
EROA	Effective regurgitant orifice area
ESV 3D	End systolic volume by three dimensional echocardiography
FS	Fraction shortening
H	Height
HCM	Hypertrophic cardiomyopathy
HF	Heart Failure
IE	Infective endocarditis
IVSd	Interventricular septum dimension
LA	Left atrium
LAA	Left atrial area
LBBB	Left bundle branch block
LV	Left ventricle
LVDVI	Left ventricular end diastolic volume index
LVEDD	Left ventricular end diastolic dimension
LVEF	Left ventricular ejection fraction
LVESD	Left ventricular end systolic dimension
LVEDV	Left ventricular end diastolic volume
LVESV	Left ventricular end systolic volume
LVH	Left ventricular hypertrophy
LVM	Left ventricular mass
LVMD	Left ventricular mechanical dyssynchrony
LVMI	Left ventricular mass index
LVSVI	Left ventricular end systolic volume index
MR	Mitral regurgitation
MS	Mitral stenosis
MVA	Mitral valve area

Mvo2	Myocardial oxygen consumption
MVP	Mitral valve prolapsed
NYHA	New York Heart Association
PASP	Pulmonary artery systolic pressure
PISA	Proximal isovelocity surface area
PWd	Posterior wall dimension
RF	Rheumatic fever
RF	Regurgitant fraction
RHD	Rheumatic heart disease
RT3DE	Real time Three-dimensional echocardiography
RV	Right ventricle
RVol	Regurgitant volume
RWT	Relative wall thickness
SD	Standard deviation
SDI	Systolic dyssynchrony index
SV	Stroke volume
TDI	Tissue Doppler imaging
TEE	Transesophageal echocardiography
Tmsv	Time from QRS onset to minimal systolic regional volume
TR	Tricuspid regurgitation
Ts	Time from QRS onset to peak systolic tissue velocity
TTE	Transthoracic echocardiography
TVI	Time–velocity integral.
VC	Vena contracta
VCF	Velocity of circumferential fiber shortening
VTC	Volume-time curves
W	Weight

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INTRODUCTION

Left ventricular dyssynchrony refers to uncoordinated ventricular movement which may occur during ventricular contraction (systolic dyssynchrony) or during relaxation (diastolic dyssynchrony). Systolic dyssynchrony can be defined as uncoordinated timing of contraction in different segments of the myocardium. Systolic dyssynchrony in patients with heart failure and depressed ejection fraction (EF) has been investigated extensively in recent years after development of cardiac resynchronization therapy (CRT).

The presence of mechanical dyssynchrony in patients with normal EF has not been directly examined, but there have been two published studies that are relevant to this topic. In the first report, the presence of dyssynchrony in patients with congestive heart failure (CHF) and EF >40 was investigated. That study showed that systolic dyssynchrony is not uncommon[1]. In the second study, the presence of a prolonged QRS duration was associated with worse outcome in patients with CHF and normal EF[2]. In addition, there are few studies that have examined the degree of systolic and diastolic dyssynchrony in patients with diastolic dysfunction and normal EF together with the effect of medical and non-medical treatment. Those studies evaluated patients with coronary artery disease[3], aortic stenosis[4], hypertrophic cardiomyopat[5,6] and hypertension[7].

A more recent study concluded that left ventricular function is affected not only by a depressed contractile status of the myocardium, abnormal loading conditions or both, but also by disturbed synchrony of myocardial walls[8] and that persistent mechanical dyssynchrony contributes to progressive ventricular remodeling and impaired systolic left ventricular function[9].

Very few studies reported mechanical dyssynchrony in patients with primary mitral regurgitation. To our knowledge, only one study investigated the effect of primary mitral regurgitation on left ventricular synchrony[10]. Severe mitral regurgitation promotes left ventricular dilatation and eccentric remodeling[11]. In patients with RHD, left ventricular scaring and fibrosis due to rheumatic pathology may be responsible for

some degree of dyssynchronization. A condition that may not present in patients with mitral valve prolapse (MVP).

AIM OF THE WORK

1- Evaluation of mechanical dyssynchrony in patients with different etiologies of primary mitral regurgitation.

2- Comparison between patients with rheumatic heart disease and patients with mitral valve prolapse as regards the degree of systolic dyssynchrony.

3- Utilization of different echocardiographic methods used to assess mechanical dyssynchrony, and applying this to patients with rheumatic or degenerative mitral regurgitation.

CHAPTER 1

PRIMARY MITRAL REGURGITATION

Causes and Pathology

The mitral valve apparatus involves the mitral leaflets, chordae tendineae, papillary muscles, and mitral annulus. Abnormalities of any of these structures may cause mitral regurgitation (MR)[12]. The major causes of MR include mitral valve prolapse (MVP), rheumatic heart disease, infective endocarditis, annular calcification, cardiomyopathy, and ischemic heart disease (Table 1). Less common causes of MR include collagen vascular diseases, trauma, the hypereosinophilic syndrome, carcinoid, and exposure to certain drugs.

Table 1 Causes of Chronic Mitral Regurgitation[13]

Chronic
Inflammatory
• Rheumatic heart disease • Systemic lupus erythematosus • Scleroderma
Degenerative
• Myxomatous degeneration of mitral valve leaflets (Barlow click-murmur syndrome, prolapsing leaflet, mitral valve prolapse) • Marfan syndrome • Ehlers-Danlos syndrome • Pseudoxanthomaelasticum • Calcification of mitral valve annulus
Infective
• Infective endocarditis affecting normal, abnormal, or prosthetic mitral valves
Structural
• Ruptured chordae tendineae (spontaneous or secondary to myocardial infarction, trauma, mitral valve prolapse, endocarditis) • Rupture or dysfunction of papillary muscle (ischemia or myocardial infarction)

• Dilation of mitral valve annulus and left ventricular cavity (congestive cardiomyopathies, aneurysmal dilation of the left ventricle) • Hypertrophic cardiomyopathy • Paravalvular prosthetic leak
Congenital
• Mitral valve clefts or fenestrations • Parachute mitral valve abnormality in association with: Endocardial cushion defects Endocardialfibroelastosis Transposition of the great arteries Anomalous origin of the left coronary artery

Abnormalities of Valve Leaflets

Mitral regurgitation caused by involvement of the valve leaflets occurs in many situations[14]. Mitral regurgitation in patients with chronic rheumatic heart disease is a consequence of shortening, rigidity, deformity, and retraction of one or both mitral valve cusps and is associated with shortening and fusion of the chordae tendineae and papillary muscles. Mitral valve prolapse involves both leaflets and chordae and is usually associated with annular dilation. Infective endocarditis can cause MR by perforating valve leaflets; vegetations can prevent leaflet coaptation, and valvular retraction during the healing phase of endocarditis can cause MR. Destruction of the mitral valve leaflets can also occur in patients with penetrating and nonpenetrating trauma. Mitral regurgitation associated with drug exposure also results from anatomic changes in the valve leaflets[15,16,17].

Abnormalities of the Mitral Annulus

These include congenital malposition of the muscles, absence of one papillary muscle, resulting in the so-called parachute mitral valve syndrome, and involvement or infiltration of the papillary muscles by a variety of processes, including abscesses, granulomas, neoplasms, amyloidosis, and sarcoidosis[18].