Assessment of the Left Atrial Function by Speckle Tracking Echocardiography in Patients with Mitral Valve Disease

THESIS

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Abstract

Background: The different effects of pressure and volume overloads on left atrial (LA) deformation are not well established. **Aims:** To compare the effects of mitral stenosis (MS) and mitral regurgitation(MR)on LA deformation using two-dimensional speckle tracking echocardiography (STE).**Methods**: Thirty patients with isolated moderate to severe MS, 30 patients with isolated moderate to severe MR and normal left ventricular ejection fraction (LVEF) ($\geq$ 55%) and 30 healthy controls were compared using one way analysis of variance (ANOVA) test with post-hoc multiple two-group comparisons.LA reservoir strain was calculated as peak systolic atrial longitudinal strain (PALS), LA reservoir strain rate (SR S) as peak systolic positive value, LA conduit SR (SR E) as the early diastolic negative peak, and LA contractile SR(SR A) as the late diastolic negative peak with QRS onset as the reference point. The time from QRS onset to peak systolic longitudinal strain (TTP strain), peak SRS (TTP SRS), peak SRE (TTP SRE) and peak SRA (TTP SRA) were also calculated**.** The average PALS, different average SR and different time intervals were calculated as the average of LA 6 equidistant segments in the four-chamber view. **Results:** By ANOVA, there was a statistically significant difference between the LA average PALS (p=0.000), SRS (p=0.000), SRE (p=0.000), SRA (p=0.000), TTP strain (p=0.008), and TTP SRE (p=0.006) of the 2 patient groups and controls. By post-hoc analysis, the LA average PALS, SRS, SRE and SRA were significantly lower in MS patients (all p=0.000) and in MR patients (all p=0.000) compared to controls. TTP SRE was significantly shorter in MR patients compared to controls (p=0.02). LA average PALS was significantly higher in MR compared to MS patients (p=0.02).The average SRS, SRE and SRA were however similar in MS and MR patients. The TTP strain and TTP SRE were significantly shorter in MR compared to MS patients (p=0.007 and p= 0.01, respectively). Significant inverse correlations were noted between the LA volume index (LAVI) and average PALS (r= -0.47, P=0.01), SRS (r= -0.45, P=0.01), SRE (r= -0.59, P=0.001) and SRA (r= -0.4, P=0.03) in MR patients and between LAVI and average SRS (r= -0.51, P=0.004) in MS patients. **Conclusion:** The LA PALS, TTP strain, and TTP SRE can differentiate between volume overloaded and pressure overloaded LA. Pressure overload seems to have a more pronounced effect on LA mechanics.

Key words: left atrium, speckle tracking, mitral stenosis, mitral regurgitation, strain, strain rate.

List of Contents

List of Abbreviations

2D	Two Dimensional
A	Maximum velocity of late mitral filling.
ACC	American College Of Cardiology
AF	Atrial Fibrillation
AHA	American Heart Association
AR	Aortic regurgitation
AV	Atrioventricular
AVB	Atrioventricular bundle
AVN	Atrioventricular node
BMI	Body Mass Index
BSA	Body Surface Area
CAD	Coronary Artery Disease
CHF	Congestive heart Failure
CMR	Cardiac Magnetic Resonance
CS	Coronary Sinus
CT	Computed tomography
CV	Cardiovascular
CVD	Cardio-Vascular Diseases
Cx	Circumflex coronary artery
DE-MRI	Delayed Enhancement Magnetic Resonance Imaging
DSE	Dobutamine Stress Echocardiography
E	Maximum velocity of early mitral filling

ECG	Electrocardiogram
EDD	End Diastolic Diameter
EDV	End Diastolic Volume
Ees	Left atrial end systolic elastance
EF	Ejection Fraction
E_{LV}	Left ventricular elastance
ESD	End Systolic Diameter
ESV	End Systolic Volume
FO	Fossa Ovalis
FPS	Frame Per Second
HF	Heart Failure
HR	Heart Rate
IE	Infective Endocarditis
IVC	Inferior Vena Cava
LA	Left Atrium
LAA	Left Atrial Appendage
LAD	Left Anterior Descending coronary artery
LAV	Left Atrial Volume
LAVI	Left Atrial Volume Index
LV	Left Ventricle
LVEF	Left Ventricular Ejection Fraction.
MI	Myocardial Infarction
MR	Mitral Regurgitation
MRI	Magnetic resonance imaging

MS	Mitral Stenosis
MV	Mitral Valve
MVA	Mitral Valve Area
MVD	Mitral Valve Disease
MVP	Mitral Valve Prolapse
NS	Non Significant
NT pro-BNP	N-terminal pro-brain natriuretic peptide
NYHA	New York Heart Association
PA	Time interval between beginning of p-wave on ECG and A-wave of atrial tissue velocity
PAC	Premature atrial contractions
PACS	Peak Atrial Contraction Strain
PAF	Paroxysmal Atrial Fibrillation
PALS	Peak Atrial Longitudinal Strain
PE	Pulmonary Edema
PWT	Posterior Wall Thickness
PW-TDI	Pulsed-Wave Tissue Doppler Imaging.
RA	Right Atrium
RCA	Right Coronary Artery
RF	Rheumatic Fever
RHD	Rheumatic Heart Disease
ROI	Region of interest
RV	Right Ventricular
SD	Standard deviation

SR	Strain Rate
SR A	Atrial Strain Rate in Late Diastole
SR E	Atrial Strain Rate in Early Diastole
SR S	Atrial Strain Rate Systole
STE	Speckle Tracking Echocardiography
STI	Speckle Tracking Imaging
SVC	Superior Vena Cava
SWT	Septal Wall Thickness
TDE	Tissue-Doppler Echocardiography.
TDI	Tissue Doppler Imaging
TEE	Trans Esophageal Echocardiography
TPLS	Time to Peak Longitudinal Strain
TR	Tricuspid Regurgitation
TTE	Transthoracic echocardiography
TTP	Time To Peak
TVI	Tissue velocity imaging
VST	Ventricular septal thickness
VVI	Velocity Vector Imaging
WHO	The World Health Organization

List of Tables

List of Figures

Introduction

Rheumatic fever (RF) and Rheumatic heart disease (RHD) remain significant causes of cardiovascular diseases in the world today. Despite a documented decrease in the incidence of acute RF and a similar documented decrease in the prevalence of RHD in industrialized countries during the past five decades, these non-suppurative cardiovascular sequel of group A streptococcal pharyngitis remain medical and public health problems in both industrialized and industrializing countries even at the beginning of the 21st century. The most devastating effects are on children and young adults in their most productive years.[(1)]

The estimated prevalence of RHD in sub Saharan Africa is 5.7 per 1000 and in North Africa 1.8 per 1000 derived from all relevant population- based data from the 1980s and 1990s.[(2)]

Although the developed world is for the large part free of RHD, there has been an unexplained resurgence and persistence in some areas.[(3)]

Most cases of mitral stenosis are caused by rheumatic fever. While rheumatic fever is now very rare in developed nations, it remains epidemic in much of the world. In the US rheumatic fever occurs in about 2 per 100,000 people, whereas in the developing world the attack rate may be 50 times that. [(4, 5)]

The most common cause of chronic primary MR in developed countries is mitral valve prolapse, which has a wide spectrum of etiology and presentation. Other less common causes of chronic primary MR include IE, connective tissue disorders, rheumatic heart disease, cleft mitral valve, and radiation heart disease. If the subsequent volume overload of chronic primary MR is prolonged and severe, it causes myocardial damage, HF, and eventual death.[6]

The spectrum of rheumatic mitral valve disease that is hemodynamically severe in developing countries differs from that currently reported in the United States. Severe, pure rheumatic mitral regurgitation is as prevalent as pure stenosis but has an entirely different time course, surgical anatomy, and relation to disease activity, suggesting a separate pathophysiologic mechanism.[7]

Mitral valve disease is one of several pathophysiological conditions associated with changes in atrial function. The effect of pure mitral regurgitation versus pure mitral stenosis with their different pathophysiologic mechanisms, on the left atrial functions needs further evaluation and comparison.

The left atrium (LA) serves three major roles that exert a profound effect on left ventricular (LV) filling and overall cardiovascular performance. The LA is a contractile chamber that actively empties immediately before the onset of LV systole and establishes final LV end diastolic volume.[8,9] It is a reservoir that stores pulmonary venous return during LV contraction and isovolumic relaxation after the closure and before the opening of the mitral valve.[10] Lastly, the LA is a conduit that empties its contents into the LV down a pressure gradient after the mitral valve opens[11] and continues to passively transfer pulmonary venous blood flow during LV diastasis. These contraction, reservoir, and conduit functions of the LA mechanically facilitate the transition between the almost continuous flow through the pulmonary venous circulation and the intermittent filling of the LV.[12]

The loss of atrial contribution to the LV filling and stroke volume in atrial fibrillation often leads to symptomatic deterioration. LA is an important determinant of cardiovascular morbidity and mortality. This was shown both in general population and in patients with various pathological conditions.[13-17]

Traditionally, assessment of left atrial function has been performed by measuring volumes with 2D echocardiography. Additionally, it can be assessed with transmitral Doppler and pulmonary vein Doppler.

Recently, an alternative method has been incorporated, namely, measurement of myocardial deformation with color tissue Doppler-derived strain.[18,19] However, this method has several limitations, such as suboptimal reproducibility, angle-dependence, signal artifacts and the fact that it only measures regional strain and does not obtain information about the curved portion of the atrial roof.

To overcome these limitations in the quantification of atrial function, the use of speckle tracking echocardiography (STE) strain has been proposed. This technique is not derived from Doppler but rather from 2D echocardiography; it is angle-independent and allows one to measure global as well as regional atrial strain.[20-22]

STE is a new technique of 2D- echocardiography image analysis that allows the study of regional atrial myocardial deformation expressed by a dimensionless parameter, the strain, which is defined as the percentage change from the original dimension. Deformation of atrial tissue occurs over time during the cardiac cycle, and the rate of this deformation, the strain rate, measures the velocity with which this myocardial deformation occurs. STE allows accurate assessment of segmental strain deformation by grey-scale-based image analysis, frame