Study of left ventricular torsion in patients with rheumatic mitral stenosis before and after successful balloon mitral valvuloplasty

Thesis

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LIST OF ABBREVIATIONS

AVR................ Aortic valve regurge

AVS................. Aortic valve stenosis

A.LV.R .... Apical left ventricle rotation

A.LV.R.V .... Apical left ventricle rotation velocity

AOP .... Aortic pressure

B. LV.R........... Basal left ventricular rotation

B. LV.R.V....... Basal left ventricular rotation velocity

BMV .... Balloon mitral valvuloplasty

BMI................. Body mass index

BSA................. Body surface area

ECG................ Electrocardiography

Echo................ Echocardiography

EF .... Ejection fraction

FS.................... Fractional shortening

IVPG............... Intraventricular pressure gradient

LAP................ Left atrial pressure

LV .... Left ventricle

LVEDP .... Left ventricular end diastolic pressure

LV.EF............. Left ventricular ejection fraction

LV.T .... Left ventricular torsion

LV.T.V .... Left ventricular torsion velocity

M.I .... Myocardial infarction

M.P.G .... Mean pressure gradient

M.R.I .... Magnetic resonance imaging

M.R................. Mitral regurge

M.S .... Mitral stenosis

PAPs .... Pulmonary artery systolic pressure

PBV................. Percutaneous balloon valvuloplasty

RV................... Right ventricle

RVPs............... Right ventricle systolic pressure

STE................. Speckle tracking Echocardiography

STI .... Speckle tracking imaging

TR .... Tricuspid regurge

TS.................... Tricuspid stenosis

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INTRODUCTION

The complex active and passive physiological events occurring during the cardiac cycle are related to the complex structure of the heart which is a helix that contains an apex **(Stoylen et al., 2000)**.

The myocardium is arranged in three layers; an inner sub-endocardial layer with a right-handed helical orientation, a middle layer with a circumferential orientation and an outer sub-pericardial layer with a left- handed helical. Both the inner and outer layers cause a wringing motion of the heart known as torsion **(Natomi et al., 2005)**.

Left ventricular (LV) torsion occurs in early systole with the base of the left ventricle rotating clockwise and the apex rotating in a counter-clockwise direction if viewed from the apical prospective. The sub-pericardial layer is at a larger radius from the cardiac axis than the sub-endocardial layer and thus has a more torque to drive the torsional deformation toward its direction **(Saito et al., 2009).**

L V rotation and torsion were first assessed using magnetic resonance imaging (MRI) myocardial tagging technique, but recently, after the introduction of speckle tracking techniques, its calculation using echocardiograph became possible **(Khoury et al., 2008).**

Speckle tracking is a new simple, easy, and inexpensive method with potential of becoming reference clinical bedside tool for the evaluation of LV function (shortening, thickening, and torsion) **(Wang et al., 2008).**

Percutaneous balloon mitral valvuloplasty is a standard care technique for suitable cases with rheumatic mitral stenosis. The change which occur in left ventricle post balloon mitral valvuloplasty include increasing in left ventricular end diastolic volume and improving in systolic performance which are attributed to an increase in the ventricular distensibility **(Ben Farhat et al., 1998)**.

The change which occurs in the left ventricular torsion post balloon mitral valvuloplasty is not being studied yet.

Aim of the Study

This study aims at assessing the left ventricular torsion by speckle tracking imaging in patient with rheumatic mitral stenosis before and after balloon mitral valvuloplasty.

Chapter 1

TORSION

Quantification of left ventricular function remains an important part of daily cardiology practice. Measures of radial and longitudinal function along with assessment of changes in cardiac volume have been most commonly used; however, it is clear that assessment of other aspects of cardiac motion may yield new or additional information about cardiac physiology and pathophysiology. As our understanding of the architecture of the heart grows, it has become apparent that torsion or twisting motion, which results from rotation of the apex and base of the heart in different directions, is integral to normal cardiac function. Assessment of torsion may provide important insights into differing types of myocardial dysfunction and the effects of different treatments **(Thomas et al., 2006).**

Leonardo Da Vinci and William Harvey were the first to appreciate that the mammalian heart rotated during the cardiac cycle. More recently, McDonald used radio-opaque markers attached to the epicardium of patients undergoing closed mitral valvotomy and observation of coronary artery motion during angiography to conclude that the pre ejection phase of the cardiac cycle was characterized not only by descent of the base towards the apex but also by counterclockwise rotation of the epicardial surface when observed from the apex **(McDonald et al., 1970).**

The twisting motion of the heart was further explored as a possible mechanism of the outward motion of the systolic apical impulse and, subsequently, to explain the M-mode echocardiographic observations of interventricular septal motion **(McDonald et al., 1972).**

Later studies of the rotational motion of the heart used implanted radio-opaque and sonomicrometry markers which could be tracked through the cardiac cycle. With the advent of tissue Doppler imaging (TDI) and magnetic resonance imaging (MRI), non-invasive tissue tracking became possible and provided a new understanding of the rotational motion of the heart **(Figenbaum et al., 1972).**

In this review, we will explore our current understanding of the anatomical basis for rotational motion of the heart and its role in normal and abnormal cardiac function, with particular focus on the use of speckle tracking imaging, a new echocardiographic tool to assess torsion.

ANATOMICAL BASIS FOR ROTATIONAL MOTION

Cardiac motion in multiple planes including rotation can be explained by the complex helical orientation of cardiac myofibres **(Ingels et al., 1989)**.

This structure has been further delineated by the dissections of Torrent-Guasp et al, who introduced the concept of a single myofibre originating at the base of the pulmonary valve which is twisted into a double helix and attached to the base of the aortic valve. Although some dispute this theory, this helical arrangement would explain the simultaneous twisting motion, long-axis and radial shortening of the left ventricle during systole. During diastole, long-axis and radial lengthening are preceded by untwisting to facilitate filling of the ventricles **(Torrent-Guasp et al., 2001).**

In more detail, the subendocardial fibers are arranged in a right-handed helix and the subepicardial fibers in a left-handed helix **(Wu et al., 2006).**

Earlier activation of the subendocardial helix may explain the brief initial clockwise rotation observed at the apex **(Knudtson et al., 1997).**

With activation of the subepicardial helix slightly later in systole, a rotational vector with greater torque is created in the subepicardium owing to its larger radius, which leads to a net counterclockwise rotation during systole **(Azhari et al., 1992).**

During systole, this torsional deformation compensates for the opposing vectors in the subendocardium and subepicardium which reduce ventricular transmural strain and oxygen consumption **(Beyar et al., 1985)**.

Physiology of rotational motion:

Systole

In normal human subjects isovolumic contraction involves counterclockwise rotation (when viewed from the apex) at all short-axis levels **(Sengupta et al., 2005).**

Subsequently, the base begins to rotate clockwise while the apex continues counterclockwise creating a ‘‘wringing’’ or torsional motion. At the level of the papillary muscles, minimal rotational motion has been observed **(Beyar et al., 1989).**

Early studies suggested that basal rotation can be ignored however; more recent studies have confirmed that the clockwise rotation of the base contributes significantly to net torsional motion **(Knudtson et al., 1997).**

Ignoring basal motion results in a more straightforward analysis, but is an over simplification of complex cardiac dynamics **(Notomi et al., 2005).**

To quantify torsion, various methods have been proposed. The most common contemporary definition is based on the simplification that net torsion is the result of apical and basal rotation in opposite directions with counterclockwise rotation of the apex arbitrarily defined as positive **(Nakai et al., 2006).**

Left ventricular torsion = apical rotation – basal rotation