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Original Article

Assessment of right ventricular strain and strain rate in patients with severe mitral stenosis before and after balloon mitral valvuloplasty

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ABSTRACT

Objective: Right ventricular (RV) dysfunction in isolated severe mitral stenosis (MS) patients have prognostic significance. Study aim was to assess RV function in these subjects by strain and strain rate analysis, pre and post-balloon mitral valvuloplasty (BMV).

Methods: Twenty five patients with isolated severe MS in sinus rhythm were assessed for RV function by two dimensional (2D) longitudinal strain & strain rate imaging before and after BMV and compared with that from twelve healthy age matched controls.

Results: Patients with severe MS had significantly lower global RV systolic strain; segmental strain at basal, mid, apical septum and basal RV free wall; but similar strain at mid and apical RV free wall as compared to controls. The systolic strain rate was significantly lower only at mid septum. In addition, they had higher estimated pulmonary artery systolic pressure and RV myocardial performance index; lower tricuspid annular plane systolic excursion (TAPSE), peak systolic velocity at lateral tricuspid annulus, isovolumic acceleration and fractional area change (FAC). Global RV systolic strain as well as, segmental strain at basal, mid and apical septum showed a statistically significant rise after BMV. TAPSE and FAC also increased significantly post BMV.

Conclusions: RV systolic function is impaired in patients with severe MS and can be assessed by global and segmental RV strain before the appearance of clinical signs of systemic venous congestion. Impaired global and segmental RV strain values in these patients are primarily due to increased after load and improve after BMV with reduction in RV afterload.

1. Introduction

Right ventricular (RV) function plays an important role in development of clinical symptoms and prognosis in patients with mitral stenosis (MS).[1,2] This is primarily affected by hemodynamic effects on RV due to pulmonary hypertension (PH). RV dysfunction is not detected clinically until the development of clinical signs of systemic venous congestion.

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RV functional assessment is difficult and not done routinely because of its complex anatomy and high load dependence. Many indices have been developed for quantifying RV function, among which strain and strain rate is relatively new. Myocardial strain is a measure of tissue deformation, which is expressed as a percentage change, whereas, strain rate is the rate of such deformation. Although till recently, tissue Doppler imaging (TDI) method was used for evaluation of RV function by strain and strain rate,[3] this method is plagued by various limitations, such as angle dependence. Of late, two-dimensional (2D) speckle tracking method has been used to quantify strain and strain rate for assessment of global and regional myocardial function. This method measures myocardial movement and deformation without depending on the Doppler signals. Various studies have demonstrated the importance of 2D strain and strain rate analysis in assessing RV function in different disorders. However, there are only a few studies, which assessed 2D RV strain and strain rate in patients with isolated MS.[4]

Long-term improvement in RV function in patients with MS has been shown in different hemodynamic studies after percutaneous balloon mitral valvuloplasty (BMV).[5,6] However, immediate effect of BMV on RV function was examined in only few studies.[7] One of such study showed discordant result in terms of improvement in RV function post BMV, as measured by conventional echocardiographic parameters.[8] The effect of BMV on RV by 2D longitudinal strain and strain rate in patients with severe MS has not been studied yet.

As the RV function has a prognostic importance in patients with MS, the present study intended to assess RV function as quantified by 2D longitudinal global and segmental RV strain, strain rate and other conventional parameters in patients with isolated severe MS, before and after BMV.

2. Methods

2.1. *Population*

Our study included adult patients older than 18 years who had isolated severe MS, in sinus rhythm, and were admitted for the BMV. Patients with atrial fibrillation, NYHA class I or IV symptoms, overt right heart failure, pregnancy, chronic obstructive pulmonary disease, other valvular lesions or undergoing emergency BMV were excluded from the study. Patients who developed more than mild mitral regurgitation after BMV were also excluded from the study. Twenty five patients, who met inclusion criteria, were assessed for RV strain and strain rate, and other conventional echocardiographic parameters of RV function. The effect of BMV on these parameters was also assessed. These parameters were also compared with that from twelve healthy age matched controls.

2.2. *Echocardiographic measurements*

Echocardiographic evaluation was done with 3.5 Hz probe using – iE 33 echocardiography machine, Philips Medical Systems, USA. All the measurements were performed according to guidelines for assessment of right heart set by American society of echocardiography (ASE).[9] All examinations were recorded for off-line analysis. RV functional parameters, RV strain and strain rate were derived from modified apical 4 chamber view (A4C) – RV focused view. Echocardiographic measurements were done and recorded for five cardiac cycles and an average of three values was taken. All these measurements were repeated 24–48 hours after BMV. Frame rates used for 2D longitudinal strain analysis were 40–80 frames/s. The data were transferred to a software system (QLAB, Philips Systems) for off-line analysis. After defining the three points (RV apex, medial and lateral tricuspid annulus) the software automatically traced the endocardial border and epicardial border in modified A4C view. After adjusting tracking points manually, if required, and adjusting myocardial penetration, 2D longitudinal strain and strain rate curves for each segment were obtained. Peak negative longitudinal systolic strain and systolic strain rates were derived from these curves (Figs. 1 and 2). The myocardium of the interventricular septum (IVS) and the RV free wall both were subdivided into three segments each (apical, mid, and basal) that resulted in six segments. The longitudinal peak negative systolic strain and peak systolic strain rates were obtained for each segment. In addition global RV systolic strain was also obtained. The peak systolic strain was defined as a peak negative strain after pulmonary valve (PV) opening. The systolic strain rate was defined as the peak negative strain rate between PV opening and PV closure.

RV fractional area change (FAC), Tei index or RV myocardial performance index (MPI) and tricuspid annular plane systolic excursion (TAPSE) were also calculated as per ASE guidelines.[9] Peak systolic velocity at the lateral tricuspid annulus (S') was obtained from pulsed TDI and highest systolic velocity was recorded without averaging the Doppler envelope (Fig. 3). Isovolumic contraction time (IVCT) was measured from the duration of isovolumic velocity (IVV) measured by pulse wave TDI at the lateral tricuspid annulus. Isovolumic relaxation time (IVRT) was measured from the end of S' to the onset of early diastolic lateral tricuspid annular velocity (E'). RV MPI was calculated by dividing isovolumic

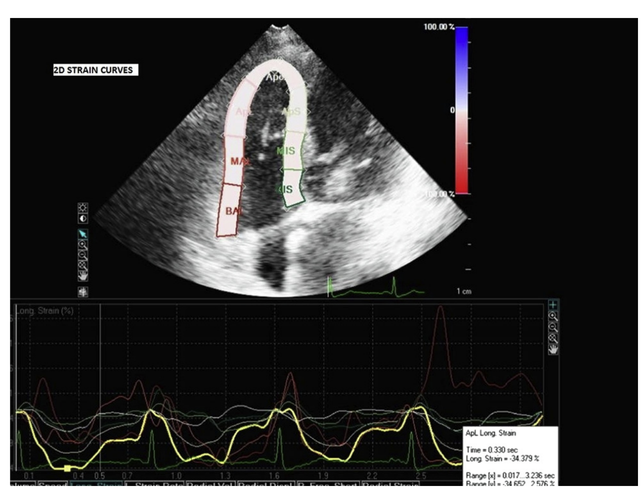

Fig. 1 – Graphic demonstration of 2D longitudinal strain curves for each segment of RV free wall and interventricular septum.