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A SRI STUDY OF MYOCARDIAL DEFORMATION INDICES IN PATIENTS WITH PARTICULAR AR (AORTIC REGURGITATION)

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Abstract

Moderate to severe "AR" aortic regurgitation, specifically in patients who have early discovery of MC "myocardial contractility" disturbance leads to initial operative intervention, which is enough to preclude from postoperative HF "heart failure" prognosis.

The basic objective of this study is subclinical left ventricular (LV) dysfunction, by novel echocardiographic methods, myocardial deformation directories in patients with asymptomatic and particular AR.

Standard echocardiogram and complementary TDI (Tissue Doppler Imaging) and Doppler based strain and strain rate (S/SR) imaging were achieved in 44 asymptomatic patients with pure and particular AR and EF ejection fraction higher than 50% (mean age: 49.9±17.2 years, 50% male) and 20 healthy respondents (mean age: 47.3±13.8 years, 65% male). In addition to TDI velocities to investigate the LV longitudinal deformation, peak systolic S and SR were measured at septal, lateral and posterior walls. The LV modified myocardial performance index (MPI) or Tie index also were calculated via TDI study.

AR group had particularly increased LV end systolic and end diastolic volumes, inter-ventricular septum and posterior wall thickness compared to controls. In AR, Sm and Em of septal wall, Sm of lateral wall; S and SR of both septal and lateral walls were particularly decreased while MPI were particularly increased compared to healthy respondents.

The outputs showed the PW-TDI and S/SR modalities in discovery of the early subclinical irregularities in asymptomatic patients with particular chronic AR.

Keywords: *AR; Tissue Doppler Imaging; LV Velocity; Strain; Strain Rate; Subclinical LV*

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INTRODUCTION:

According to the previous studies, in aortic regurgitation (AR), changes in regurgitated volume or increases in left ventricular (LV) systolic or diastolic pressure can cover underlying abnormal changes in myocardial force development due to the myocardial damage. It is challenging to determine the subclinical myocardial irregularities and also the optimum time for operative intervention in asymptomatic patients with chronic particular AR (Chin, Chen and Lo, 2017).

It is important not to subject patients to the early and unnecessary operative risks and morbidity related to prosthetic valves and postpones the operation until irreversible LV systolic dysfunction occurs. In the initial process of AR, many patients are asymptomatic since compensatory mechanism such as LV eccentric hypertrophy keeps the LV ejection fraction (EF) in the normal ranges with progressive LV dilation, contractility impairment would occur, however, all of the symptoms are not related to developing LV dysfunction (Florescu et al., 2016).

Therefore, early discovery of subclinical LV systolic dysfunction is crucial and could influence patients' prognosis by aiding the clinician to candidate patients for better management. As well, conventional echocardiography indices may not show any subclinical systolic dysfunction at the early stage of myocardial irreversible damage. There is still no consensus on measurement variables which could absolutely discriminate the subclinical LV systolic dysfunction in patients with chronic AR; however, EF and LV end-systolic diameter (ESD) are the two most widely utilized methods to evaluate LV function and the surgery is recommended to be performed on the asymptomatic severe AR patients before the ejection fraction (EF) falls below 50% and LVESD exceeds 55mm. As these parameters are in- direct measurements of myocardial function, they could only evaluate late hemodynamic consequence of AR and are not too able to detect subclinical LV systolic dysfunction (Chin, Chen and Lo, 2017).

Thus there is a need to higher sensitive tool which could detect myocardial damage at its initial phase. Recently, pulsed-wave tissue Doppler imaging (PW-TDI) and also 2D or Doppler based strain (S)strain rate (SR) derived parameters have been shown to be useful noninvasive tools for detecting subtle LV contractile changes in the preceding reduced LVEF and markedly dilated LV in patients with AR (Florescu et al., 2016).

OBJECTIVES:

Our aim was to study subclinical left ventricular (LV) dysfunction, by novel echocardiographic methods, myocardial deformation indices in patients with asymptomatic, particular aortic regurgitation (AR).

METHODS:

Study Respondants:

Among the patients between October 2015-March 2016, due to suspicious cardiac sounds or as a part of medical checkup, we included 44 asymptomatic patients (mean age ± SD: 49.9 17.2 years), 50% male) with a diagnosis of isolated chronic AR with any etiology (Rheumatismal, Bicuspid or degenerative) who were asymptomatic and had moderate or higher than moderate degree AR, determined by echocardiographic criteria according to published American Society of Echocardiography(ASE) guidelines, who did not meet the study exclusion criteria as follows: 1) coexisting other valvular diseases higher than mild degree, 2) non sinus cardiac rhythm, 3) LV ejection fraction < 50% , 4) left ventricular end systolic diameter(LVESD) > 55mm or left ventricular end diastolic diameter (LVEDD) > 75mm, 5) any known or suspected coronary artery disease based on electrocardiogram or angiogram or having major risk factors, 6) previous cardiac surgery, 7) low quality echocardiographic image for TDI or S/SR analyses. During the same period, 20 healthy controls (mean age ± SD: 47.3 ± 13.8 years, 65% male) have been enrolled from the hospital staff via advertisements using announcements in the local media (Chin, Chen and Lo, 2017).

Conventional Echocardiography:

A combination of standard transthoracic, PW-TDI and study of longitudinal SR and S were performed by the use of commercially available ultrasound system. All patients were examined at rest in left lateral decubitus position. Measurements were made according to the ASE guidelines. By the use of M-mode study, left ventricular end-diastolic (LVEDD) and left ventricular end-systolic (LVESD) diameters, left atrium (LA) diameter, inter ventricular septum (IVS) and posterior wall (PW) thickness were measured from parasternal long-axis view. From the apical four chambers view, left ventricular end-diastolic (LVEDV) and end-systolic volumes

(LVESV) and LV EF were calculated using modified Simpson's method (Florescu et al., 2016).

Tissue Doppler Imaging:

PW-TDI study was set for a frame rate between 120 and 180 Hz, and a cine loop of three consecutive heart beats. The 2.5mm TDI sample volume was placed at the junction of the LV wall with the mitral annulus of the septal and lateral myocardial segments from the four chamber view. Efforts were done to obtain the best angle (near to zero) and the best optimal gain for better signal to noise ratio. Off-line analysis was performed by a single expert cardiologist.

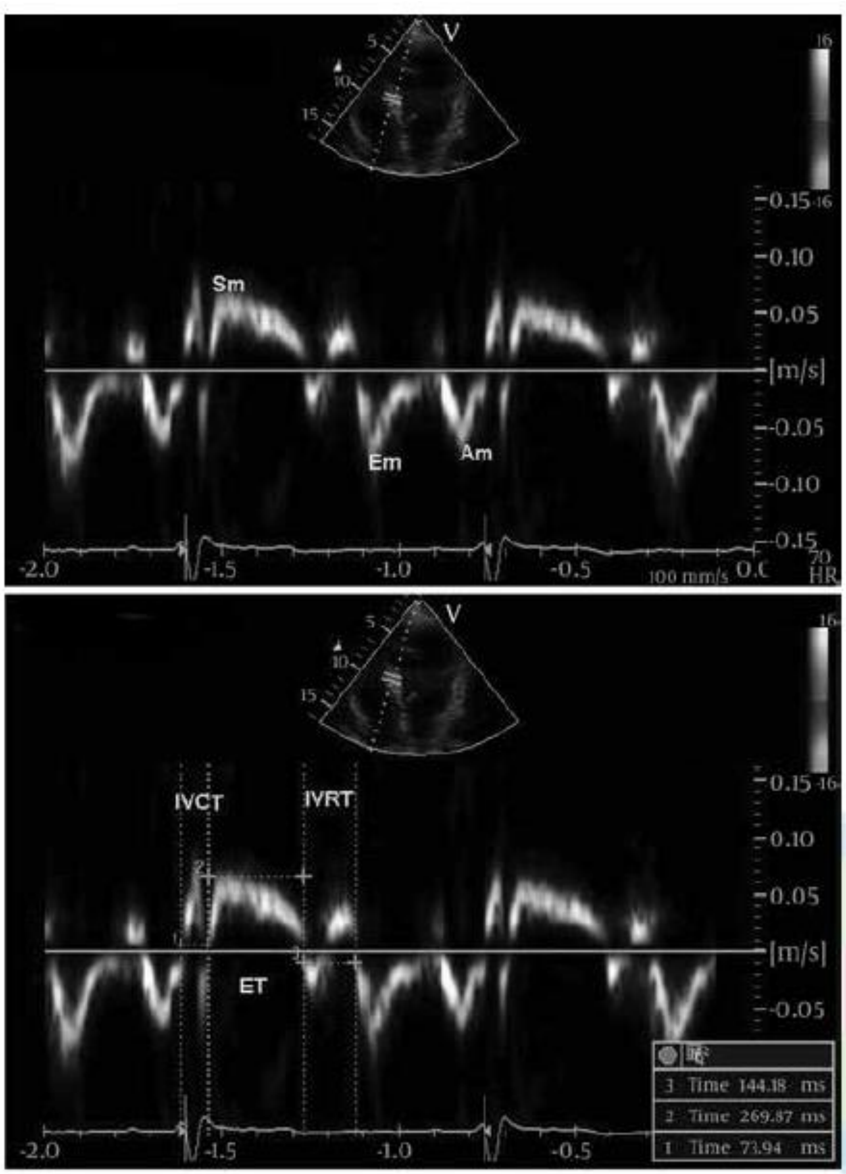

Figure 1. Pulsed-Wave Tissue Doppler Measurements at the Septal Mitral Annulus of a Patient With AR

(Source: Chin, Chen and Lo, 2017)

Strain and Strain Rate Imaging

Longitudinal strain (%) is an excellent parameter for quantification of regional myocardial deformation and contractility, and strain rate (1/S) defines the rate of this deformation. For evaluation of TD based longitudinal myocardial contraction, base of septal and lateral walls (from apical four-chamber view) and posterior wall (from three -chamber view) were nalyzed. Peak systolic SR and late-systolic S values were averaged over three consecutive cycles for each segment(Florescu et al., 2016).

Reproducibility of Data

Inter- and intra-observer variability for TDI parameters in our echocardiography lab has been previously published.

Statistical Analysis

The values are presented as mean ± SD (standard deviation) for the quantitative variables and are summarized by frequency (percentage) for the categorical variables. The comparisons between case and control groups were made using the chi-square test for the categorical data and independent two-sample t-test for continuous variables. Correlations between interval variables were measured using Pearson's correlation coefficient. P-value ≤ 0.05 was considered being statistically particular (Nishimura et al., 2017).

RESULTS:

The demographic and conventional echocardiographic data of all patients and controls are summarized in Table1.

Table 1. Demographic Data and Standard Echocardiographic Measurements of the Patients with Aortic Regurgitation (AR) and Healthy Control Groups

Demographic Data	AR Patients (n = 44)	Control Group (n = 20)	P value
Age, y[b]	49.9 ± 17.2	47.3 ± 13.8	0.555
Gender, male, No. (%)	22 (50)	13 (65.0)	0.264
Echocardiographic findings			
Left ventricle ejection fraction (%)	54.3 ± 3.7	56.9 ± 5.0	0.023
Thickness of intra-ventricular septum,mm	10.0 ± 1.8	7.9 ± 1.2	< 0.001
Thickness of Posterior wall, mm	10.0 ± 1.9	8.3 ± 1.1	< 0.001
Diameter of left atrium (mm)	36.0 ± 6.8	33.6 ± 4.8	0.166
Diameter of Aortic root, mm	31.2 ± 4.9	27.7 ± 2.9	0.001
Left ventricle end systolic diameter, mm	36.3 ± 6.3	29.0 ± 4.7	< 0.001
Left ventricle end diastolic diameter, mm	55.8 ± 6.5	48.7 ± 5.3	< 0.001
Left ventricle end systolic volume, mm^3	78.1 ± 17.6	49.8 ± 17.6	< 0.001
Left ventricle end diastolic volume mm^3	161.2 ± 56.1	113.4 ± 24.4	< 0.001

[a] All the data are shown with Mean ± SD

(Source: Nishimura et al., 2017)

There was no particular difference between groups regarding age (P value = 0.555) and sex (P value = 0.264) LVEF was particularly lower and LV diameters (end systolic and end diastolic) and LV volumes (end systolic and end diastolic) were particularly higher in patients with AR compared to control group (all P values < 0.001). IVS and PW were particularly thicker (both P values < 0.001) and aorta was particularly higher dilated (P value = 0.01) in patients than control respondants (Pislaru et al., 2017). The mean of LA diameter was not particularly different between groups (P = 0.166). Data of PW-TDI and S/SR imaging of patients' assessment are summarized in Table2.

Table 2. Comparison of Pulsed wave Tissue Doppler Imaging and Strain and Strain Rate Imaging Derived Strain and Strain Rate Parameters Between Patients with Aortic Regurgitation (AR) and Healthy Control Group

Parameters	AR Patients (n = 44)[b]	Control Group (n = 20)	P value
Tissue doppler imaging parameters			
Septal wall Sm[a], cm/s	7.5 ± 1.8	9.3 ± 1.7	< 0.001
Lateral wall Sm, cm/s	8.1 ± 1.7	11.4 ± 2.8	< 0.001
Septal wall Em[a], cm/s	8.3 ± 2.8	11.6 ± 2.1	< 0.001
Septal wall Am[a], cm/s	9.2 ± 2.2	9.9 ± 1.8	0.197
Isovolumic relaxation time, s	101.3 ± 29.3	69.4 ± 15.7	< 0.001
Isovolumic contraction time, s	74.8 ± 20.0	68.0 ± 15.9	0.185
Ejection time, s	281.98 ± 31.60	274.3 ± 22.8	0.333
LV myocardial performance index	0.6 ± 0.2	0.5 ± 0.1	< 0.001
Strain rate imaging parameters			
Septal wall strain (%)	-17.6 ± 5.9	-21.0 ± 2.7	0.002
Lateral wall strain (%)	-16.5 ± 7.2	-21.7 ± 4.8	0.005
Posterior wall strain (%)	-14.2 ± 7.6	-17.0 ± 5.8	0.181
Septal wall strain rate (s^{-1})	-1.2 ± 0.4	-1.6 ± 0.6	0.003
Lateral wall strain rate (s^{-1})	-1.1 ± 0.6	-1.6 ± 0.5	0.003
Posterior wall strain rate (s^{-1})	-1.1 ± 0.6	-1.1 ± 0.6	0.998

[a] Abbreviation: Am, Peak late diastolic velocity; Em, Peak early diastolic velocity; Sm, Peak systolic velocity
[b] All the data are shown with Mean ± SD

(Source: Nishimura et al., 2017)

DISCUSSION:

The present study confirmed that PW-TDI and strain and strain rate imaging methods are useful methods for early discovery of the subclinical LV systolic dysfunction and could be applied as complementary echocardiography techniques for the evaluation of LV function in asymptomatic patients with chronic particular AR who had normal or preserved EF level and LV dimensions. Based on our findings, longitudinal myocardial contraction indices are particularly lower than corresponding indices in healthy respondants indicating longitudinal contraction impairment in AR patients even with preserved global LVEF. LV velocity indices such as Sm and Em of septal wall, Sm of lateral wall and longitudinal peak systolic S and SR values of septal and lateral wall were particularly reduced in patients with moderate or higher than moderate AR in comparison to healthy controls. Likewise, LV MPI, as a good index of evaluating combined LV systolic and diastolic functions, was particularly increased in these patients, indicating impairment in LV global function (Nishimura et al., 2017).

It is particularly decreased peak systolic S and SR in each of six LV basal segments in patients with AR and preserved LV EF compared to the age and sex matched controls. Likewise, the mean of LV MPI values of patients were particularly increased compared to healthy respondants in both of these studies. Despite the preserved LVEF level and normal LV dimensions, asymptomatic patients with chronic particular AR had lower EF level and higher LV dimensions than that of healthy controls in our study. Chronic particular AR, with a resulting volume overload leads to increasing the LV dimensions. To cope with this situation, LV hypertrophy occurs to preserve the wall stress and therefore LV contractility within the normal limits (Nishimura et al., 2017).

In this stage, many patients remain asymptomatic despite developing subtle LV myocardial dysfunction. Sub-endocardial ischemia as an initial stage of heart failure would firstly impair the longitodinal myocardial contraction. Without any interventions, ischemia would also influence the other myofibrils and reduce the EF level since the cardiac output is mainly dependent on shortening of the circumferential fibers. Whereas patients with moderate AR showed changes in S and SR that reflects the speed of deformation closely linked to the intrinsic force production. These results would propose that while total deformation is preserved, the speed of deformation is already starting to decrease even in moderate degree of regurgitation. So deformation is not directly related to the severe degree of AR. Altogether, it seems that those previously established indices based on the conventional echocardiography imaging such as EF and end systolic and diastolic LV dimensions might not be sufficient to demonstrate subclinical ventricular dysfunction in these patients (Pislaru et al., 2017).

Deformation indices could provide higher accurate estimation on LV function and could reflect an earlier sign of myocardial damage before that the LVEF falls and the clinical signs and symptoms of overt cardiac failure appears and thus, these complementary method to conventional echocardiography are recommended to be applied for an early determination of LV dysfunction in asymptomatic patients with particular AR and identifying patients who need surgery before developing irreversible severe heart failure (Nishimura et al., 2017).

CONCLUSION:

Small number of our study respondents', especially in control group, and unavailability of 2D-strain/strain rate speckle imaging software were major limitations of this study. In addition, follow up of the patients group is needed to detect the small changes in the variables to the time of AVR based on the available updated guidelines to define a cutoff point for myocardial SR/S before AVR timing. Myocardial deformation study may be used as adjunctive, consistent, noninvasive parameters for evaluating subclinical ventricular dysfunction in patients with chronic particular AR. This may help to recognize patients for closer follow-up and to establish the need for surgery before developing irreversible, severe heart failure. Of course further outcome studies based on indices of global and regional deformation, are required to confirm whether reducing in deformation indices in patients with isolated AR is better index for better management strategy.

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