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Research Article

Reduced Early Diastolic Mitral Annulus Acceleration by Tissue Doppler Imaging in Grade 1 Left Ventricular Diastolic Dysfunction

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Abstract

Reduction of the early diastolic mitral annulus velocity by tissue Doppler imaging (TDI) has been found in patients with left ventricular diastolic dysfunction. Observations in our echo lab suggested that in patients with impaired relaxation, not only is this velocity reduced, but the time to peak velocity (TPV), a reflection of the acceleration of the annulus in early diastole, is prolonged. Twenty-nine patients with Grade 1 diastolic dysfunction were compared with 23 normal patients. All patients in both groups had normal systolic function and ejection fraction. Patients with impaired relaxation showed on average a prolonged TPV and a flatter slope, compared with the shorter TPV and steeper slope seen in the normal patients. None of the normal patients had a TPV greater than 70 msec, while 62% of the impaired relaxation patients had a TPV greater than 70 msec. Thus, this study suggests that patients with mild diastolic dysfunction have a reduction of mitral annulus acceleration in early diastole as shown by a prolonged TPV.

Keywords: *Reduced mitral annulus acceleration diastolic dysfunction.*

Introduction

Tissue Doppler Imaging (TDI) has been used in the evaluation of left ventricular diastolic dysfunction (1). Compared to normal individuals, patients with diastolic dysfunction show a reduction in the early diastolic mitral annular velocity (Ea). Data from our echo lab suggest that not only is the peak value of the early mitral annular velocity decreased, but the time it takes to reach peak velocity (TPV) is prolonged in diastolic dysfunction. This would mean that the mitral annulus acceleration would also be reduced as acceleration equals the change in velocity divided by the time. This concept has not been well studied. This study was done to examine mitral annulus acceleration in patients with Grade 1 diastolic dysfunction.

Methods and Results

A total of 52 adult patients was divided into two groups: Group 1 (23 patients) had normal diastolic dysfunction, defined as an E/A ratio of greater than 1.0 and an early diastolic mitral annular velocity of greater than 10 for the septal annulus and greater than 12 for the lateral annulus. Group 2 (29) patients) had Grade 1 diastolic dysfunction (impaired relaxation), defined as an E/A ratio of less than 1.0 and an early diastolic mitral annular velocity of less than 10 at both the septal and lateral annulus. All 52 patients had normal ejection fraction, normal LV size, and no LV wall motion abnormalities on resting echocardiogram. Full transthoracic 2D echocardiography was performed on all 52 patients by a trained sonographer according to the standard recommendations of the American Society of Echocardiography. Standard parasternal (long and short axis) and apical views (2 and 4 chamber) plus continuous pulsed-wave, and tissue Doppler exams were performed using the GE Vivid 6 machine (GE Healthcare, Milwaukee, WI).

Measurements were taken using dedicated offline software (EchoPAC 7.0, General Electric). From the apical 4 chamber view, mitral inflow measurements of peak early velocity (E), peak late velocity (A), and the E/A ratio, were obtained at the level of the mitral valve leaflet tips. Pulsed TDI sample volume was placed at the level of the lateral and septal annulus of the mitral valve. The peak early diastolic (Ea) and peak late diastolic (Aa) velocities were measured. The annular velocities were recorded at a sweep speed of 100mm/sec. Images were obtained at end-expiration in the apical 4-chamber view. Additionally, the time to peak velocity (TPV) was recorded as the time needed to go from the zero baseline to the peak velocity point for both the early and late annular velocities. The slope of the line from the point on the zero baseline to the peak velocity point was also calculated. Values for the TPV and slope were obtained from both the septal and lateral mitral annulus. Continuous variables are presented as mean plus/minus standard deviation, and compared using Student t test. A P value<0.05 was considered statistically significant. All statistical analysis was performed using SPSS 11.0 for Windows (SSPS Inc., Chicago, Il.). Group 1 (16 females and 7 males) patients were significantly younger than Group 2 (17 females and 12 males) patients. The average age for Group 1 was 42.5 years, while the average age for Group 2 was 70.5 years (P>0.001). Two of the Group 1 patients had mild mitral regurgitation, but the remaining 21 had normal echo examinations and no clinical heart disease. Group 2 patients had the following clinical conditions and echo findings: 4 had mild mitral regurgitation, 1 had moderate mitral regurgitation, 2 had mild aortic stenosis, 2 had moderate aortic stenosis, 1 had mild aortic regurgitation, 3 had diabetes, and 1 had IHSS. Echo Doppler results are presented in Table 1. Group 1 patients had an E/A ratio of greater than 1.0, with a mitral inflow E velocity greater that the A velocity, and an early diastolic mitral annular Ea velocity greater than the late mitral annular Aa velocity at both the septal and lateral annulus. Group 2 patients with impaired relaxation had an E/A ratio of less than 1.0, with an Ea velocity less than the A velocity, and an early diastolic mitral annular Ea velocity less than the late diastolic mitral annular Ea velocity at both the septal and lateral annulus. Group 2 also had a larger average left atrial size (3.83 cm by M-mode) compared to Group 1 (3.40 cm), (P<0.003). TDI recordings showed that the time to peak velocity (TPV) of the early diastolic Ea annular velocity was prolonged in Group 2 compared to Group 1 (P<0.001). No patient in Group 1 had TPV (Ea) greater than 70 msec, while 62% (18 of 29 patients) in Group 2 had a TPV (Ea) greater than 70 msec. Group 2 patients had a flatter slope (the line drawn from the zero baseline to the point of peak velocity) compared to Group 1 patients who had a steeper slope (P<0.001), as shown in Figure 1 and Figure 2. These findings were present at both the septal and lateral annulus. However, for the late mitral diastolic annular Aa velocity, there were no differences in the TPV or slope between Group 1 and Group 2. Thus, these results support the observation that for many patients with impaired relaxation, the acceleration of the mitral annulus in early diastole is significantly reduced, compared to the more rapid acceleration of the annulus seen in normal patients.

TABLE 1. Summary of Doppler findings presented as mean +/- standard deviation

Variable	Group 1	Group 2	P
Age (years)	42.5+/-15.2	70.5+/-10.1	<0.001
Left Atrial Size (cm)	3.40+/-0.37	3.83+/-0.59	< 0.003
Ejection Fraction (%)	63.3+/-3.48	62.3+/-4.98	0.935
E/A ratio	1.44+/-0.30	0.78+/-0.14	<0.001
Peak E velocity (cm/s)	87+/-0.13	75+/-0.21	0.20
Peak A velocity (cm/s)	59+/-0.14	97+/-0.25	<0.001
Septal Ea velocity (cm/s)	9.87+/-1.96	6.00+/-1.56	<0.001
Septal TPV Ea (msec)	48+/-12	74+/-14	<0.001
Septal Slope Ea (cm/s2)	219+/-81.9	84.4+/-32.5	<0.001
Septal Aa velocity (cm/s)	8.60+/-1.64	9.00+/-1.79	0.410
Septal TPV Aa (msec)	39+/-7	40+/-7	0.612
Septal Slope Aa (cm/s2)	226+/-58	225+/-50	0.944
Lateral Ea velocity (cm/s)	12.9+/-2.76	7.31+/-2.07	<0.001
Lateral TPV Ea (msec)	43+/-10	78+/-17	<0.001
Lateral slope Ea (cm/s2)	316+/-104	99.5+/-38	<0.001
Lateral Aa velocity (cm/s)	9.26+/-2.22	11.3+/-1.62	<0.001
Lateral TPV Aa (msec)	35+/-6	38+/-8	0.143
Lateral Slope Aa (cm/s2)	269+/-75	295+/-85	0.256

FIGURE 1. TDI from a normal patient showing a short TPV (+) (30 msec) and a steep slope (400 cm/s2) consistent with normal early mitral annulus acceleration.

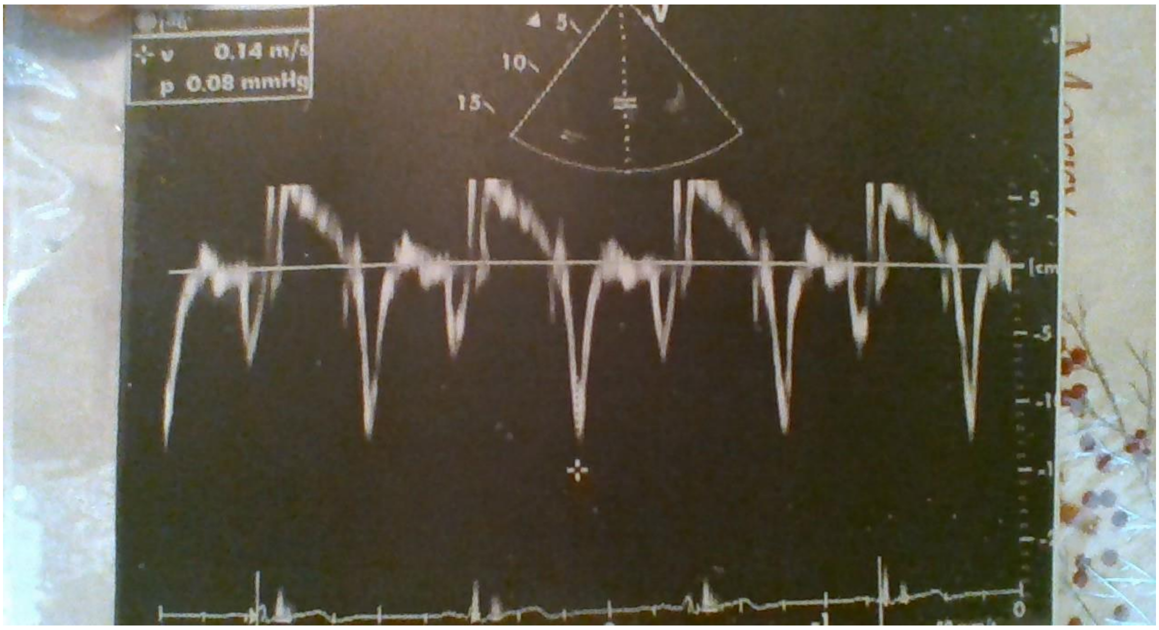
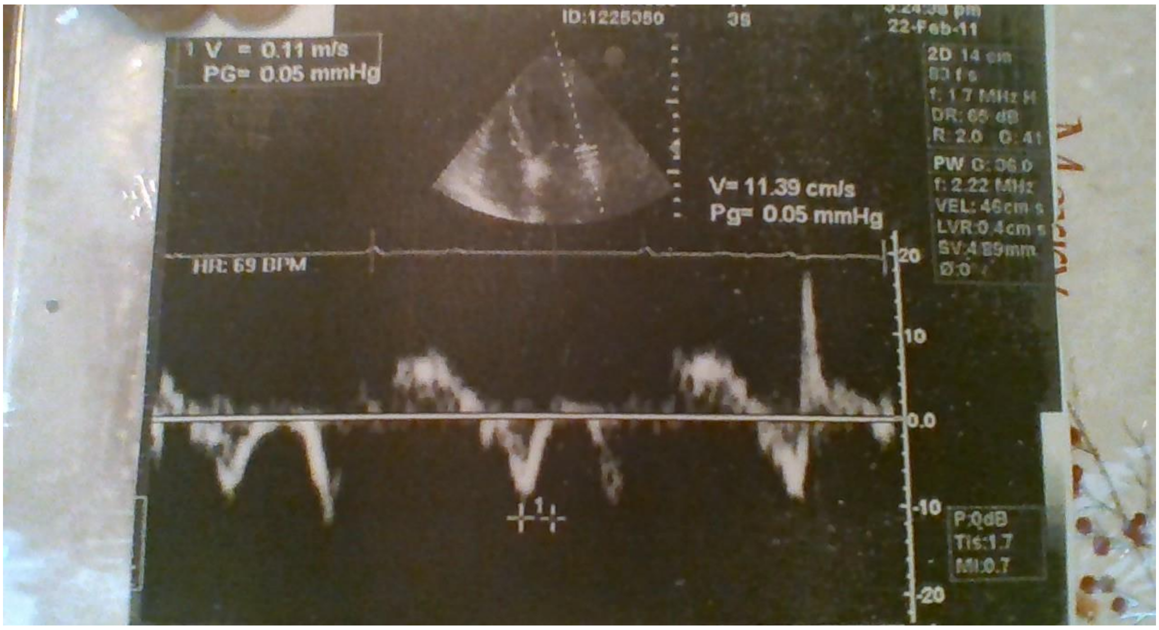


FIGURE 2. TDI from a patient with impaired relaxation showing a prolonged TPV (++) (90 msec) and a flatter slope (88 cm/s2) consistent with reduced early mitral annulus acceleration.



Discussion

Left ventricular diastolic dysfunction is a condition that reflects an impairment of the filling properties of the left ventricle. In its mildest form (Grade 1), there is a reduction in the early diastolic filling E wave associated with an increase in the late diastolic atrial systolic A wave, resulting in a reverse of the E/A ratio (impaired relaxation).

TDI in these patients shows a reduced mitral annulus Ea velocity recorded at the septal and lateral annulus, along with an increase in the annulus Aa velocity (2). This study found that patients with impaired relaxation as a group often have a prolonged time to peak velocity (TPV) of the mitral annulus, along with a flatter slope, compared to the shorter TPV and steeper slope seen in normal patients. None of the normal patients had a TPV greater than 70 msec, while 62% of the impaired relaxation group had a TPV greater than 70 msec. These findings were present at both the septal and lateral annulus. Thus, patients with impaired relaxation often show a reduced acceleration of the mitral annulus in early diastole, compared to the more rapid acceleration of the annulus seen in normal patients. Early in diastole, the mitral annulus rapidly moves away from the apex toward the left atrium. This is associated with the process of left ventricular suction that accelerates blood out of the left atrium toward the LV apex. This acceleration and suction effect are particularly vigorous in young people and athletes (3), and is consistent with the short TPV and steep slope (annulus acceleration) seen in the Group 1 normal patients. The prolonged TPV and flatter slope (reduced annulus acceleration) seen in the impaired relaxation patients is consistent with the reduced early diastolic suction seen in patients with LV diastolic dysfunction (4). Interestingly, the TPV and the slope of the late diastolic mitral annulus Aa velocity recordings were not different between the Group 1 and Group 2 patients. Perhaps the early diastolic mitral annulus velocity, predominantly a marker of LV relaxation, may be expected to change relatively early in the development of LV diastolic dysfunction, while the late diastolic mitral annulus velocity, predominantly a marker of atrial contraction, may not be affected early but only later in the development of LV diastolic dysfunction. In conclusion, this small observational study showed that patients with mild LV diastolic dysfunction often have reduced early mitral annulus acceleration compared to normal patients. Decreased mitral annulus acceleration appears to be another parameter of LV diastolic dysfunction. Further larger studies which include patients with greater degrees of diastolic dysfunction would be of interest.

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