

Assessment of Statistical Relationship of Ejection Time and Acceleration Time with the Severity of Valvular Aortic stenosis

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Abstract

Valvular aortic stenosis is a relatively common disease among valvular heart diseases and can be rheumatic, degenerative or congenital. Evaluation of the severity of the disease is sometimes challenging and problematic. Besides, the use of more parameters of non-invasive methods for the assessment of valvular disease and its severity seems attractive and helpful. Transthoracic echocardiography (TTE) is an appropriate modality for the evaluation of the aortic valve.

In this study, TTE was performed for 80 patients with valvular aortic stenosis. The goals were to assess the statistical relationships between ejection time (ET) and acceleration time (AT) and their ratio (AT/ET) with the four traditional parameters of the echocardiographic severity of aortic valvular stenosis (aortic jet velocity, aortic valve area, mean pressure gradient and LVOT VTI/aortic VTI ratio). There was a meaningful relationship between adjusted ET with the four above-mentioned parameters. d. ET (ET-adjusted ET according to heart rate and stroke volume) was inversely related with the aortic valve area (calculated with continuity equation).

AT/ET was significantly correlated with the four mentioned parameters. The regression equations were calculated. The cut-off value of AT/ET for the echocardiographic diagnosis of severe valvular stenosis was 0.36 (with 95% level of confidence) (*Iranian Heart Journal 2011; 12 (2):10-15*).

Keywords: Valvular aortic stenosis ■ Ejection time ■ Acceleration time ■ Echocardiography

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Valvular aortic stenosis with rheumatic, degenerative or congenital etiologies has been extensively studied with echocardiography.¹ Echocardiographic parameters of stenosis severity mainly include peak jet velocity, valve area (calculated by continuity equation), mean pressure gradient, and LVOT VTI/aortic valve VTI ratio.² Discrepancy between clinical and echocardiographic data leads to cardiac catheterization according to the current guidelines.³ To decrease the usage of invasive methods, it seems necessary to find new non-invasive echocardiographic parameters to assess valvular aortic stenosis.

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Study population

The patients in our study were referred to the echocardiographic laboratory for transthoracic echocardiography (TTE) for the evaluation of the existence of valvular aortic stenosis and its severity.

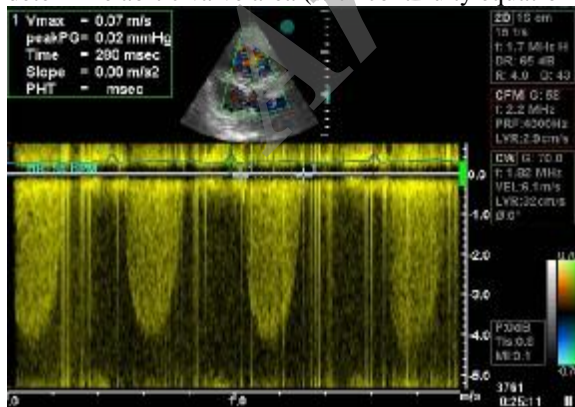
Inclusion criterion was valvular aortic stenosis (even mild degree) detected by echocardiography. Exclusion criteria were significant hemodynamic instability, significant left ventricular dysfunction (LVEF<35%), significant abnormality of other valves or aortic valve regurgitation, and significant coronary artery disease. The sampling in our study was conventional. The sample size was determined for the correlation of AT/ET with mean pressure gradient to Bumgarther⁴, with the static $r = 0.91$, $\alpha = 0.05$, and $\beta = 0.1$ and 80 patients were included in the study.

Technical Information

The patients were interviewed and examined for demographic and clinical data, including cardiological history, pulse rate, hemodynamic stability (blood pressure and orthostatic changes). They subsequently underwent TTE with VIVID machines versions 3 or 7, by the echocardiologist. Echocardiographic variables to be determined included LVEF, LVOT diameter by 2-D echocardiography, LVOT VTI by Doppler pulsed wave, aortic jet velocity by Doppler continuous wave, aortic valve VTI, mean and peak pressure gradient, aortic ejection time (the time interval between beginning of aortic valve opening click on continuous Doppler signal of aortic valve to mid part of closing click), and aortic acceleration time (the time interval between beginning of aortic valve opening click on continuous Doppler signal of aortic valve to peak velocity of aortic valve) as shown in Fig 1.

Study Design and Statistics:

This study was an analytical, cross-sectional type, extending from September 2007 to February 2009 to gather information from the patients studied. The recorded data were analyzed with SPSS version 17. Computations to determine aortic valve area (with continuity equation formula) and LVOT VTI/aortic VTI were performed.



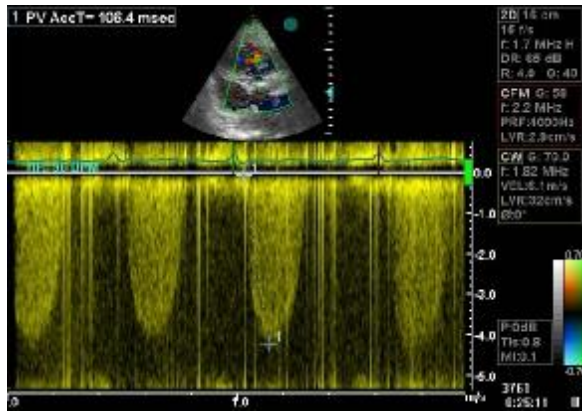


Fig.1. AT and ET measurements using continuous Doppler signal of AV

The traditional four parameters of stenosis severity were grouped for later analysis according to the current guidelines of stenosis severity (severe vs. mild or moderate).

Regarding the confounding effects of heart rate and stroke volume on ejection time, ET was adjusted for heart rate with the formula proposed by Stafford RW⁶, and also separately for stroke volume with the formula proposed by Harey A.⁷ d.ET (delta ejection time) was computed for simultaneous adjustment of ejection time for heart rate and stroke volume (the algebraic difference between measured ET with adjusted ET for heart rate or stroke volume, whichever larger algebraically, negative values were regarded zero finally). Statistical relationship between ET, AT/ET and d.ET with the ungrouped four parameters of stenosis severity was assessed with the Pearson Correlation test. The meaningful results were followed by regression test and were presented with scatter plot using Harvard Graphics software. The same relationship for the grouped (severe vs. mild or moderate) four variables of stenosis severity and AT/ET was assessed with the independent sample test and calculated statistics for each variable were used to determine the cut-off value of AT/ET for severe valvular aortic stenosis with 95% level of confidence according to the formula $t = d/SED$.

Ethical considerations

The clinical and echocardiographic evaluations of the patients were performed according to routine medical discipline requested by their managing physicians, with no extra exposure or charge. In addition, all the patients gave written consent for inclusion in the study.

Results

The result included 80 patients (53 male [66.3%] and 27 female [33.8%]). The range of age was 14 -84 years (mean= 53 yrs; SD=18.8 yrs). The results of the echocardiographic variables are depicted in Table I.

Table I. the results of echocardiographic variables

The correlation between d.ET and the four parameters of stenosis severity is presented in Table 2. The relationship is significant only for the aortic valve area. Only the aortic valve area had a meaningful (negative) correlation with d.ET.

Table II. Correlation tests between d.ET and four echocardiographic variables of severity of aortic stenosis

Variable	Correlation coefficient	P value
Aortic jet velocity	0.037	0.744
Aortic valve area	-0.345	0.002
Mean pressure gradient	-0.004	0.982
LVOT VTI/Aortic VTI	-0.180	0.110

The correlation between AT/ET and the four parameters of stenosis severity is presented in Table 3. All the tests revealed significant results with considerable correlation coefficients.

Table III. Correlation tests between AT/ET and four echocardiographic variables of severity of aortic stenosis

Variable	correlation coefficient	p value
Aortic jet velocity	0.626	<0.001
Aortic valve area	0.515	
Mean pressure gradient	0.637	
LVOT VTI/Aortic VTI	0.626	

The regression equation and respective scatter plot for each of the significant correlation test of the Tables have been determined and presented in Figs. 1-5.

Variable	range	mean	Standard deviation
Ejection Fraction(%)	36-60	51.6	8.5
LVOT- diameter(cm)	1.06-2.75	2.16	0.25
LVOT-VTI(cm)	9.83-44.43	20.44	5.17
Stroke volume(ml)	23.9-153.8	75.6	26.0
Aortic jet velocity(m/s)	2.25-7.32	4.43	1.02
Mean pressure gradient(mmHg)	9.84-141.50	49.22	23.78
LVOT VTI/Aortic VTI	0.093-0.532	0.237	0.096
Aortic valve area(cm ²)	0.23-1.99	0.87	0.40
Aortic ejection time(ms)	222-388	310.9	34.7
Aortic acceleration time(ms)	48-183	110.0	28.2
d.ET(ms)	0-110.6	26.1	27.5
AT/ET	0.17-0.54	0.35	0.08

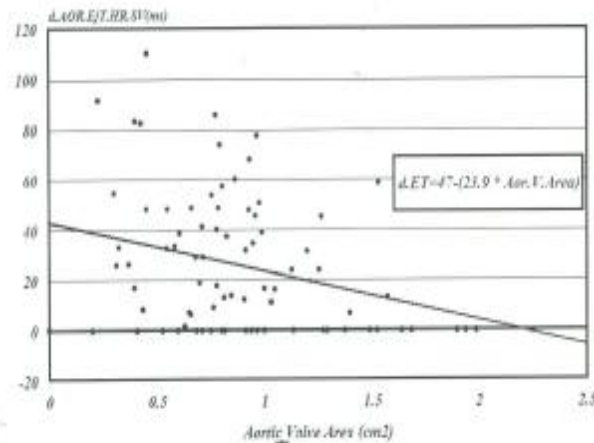


Figure 1 : Regression equation and scatterplot relating d.ET with Aortic Valve Area

Fig. 1.

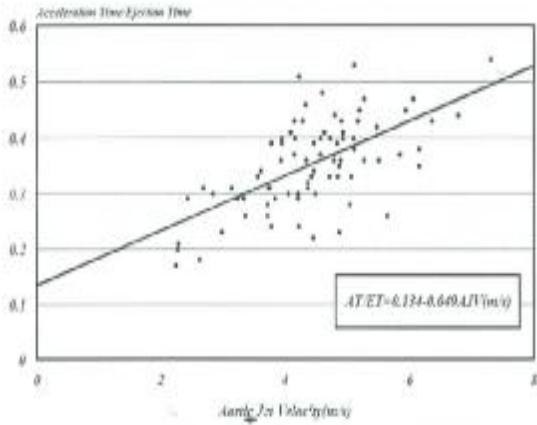


Figure 2 : Regression equation and scatterplot relating AT/ET with Aortic Jet Velocity

Fig. 2

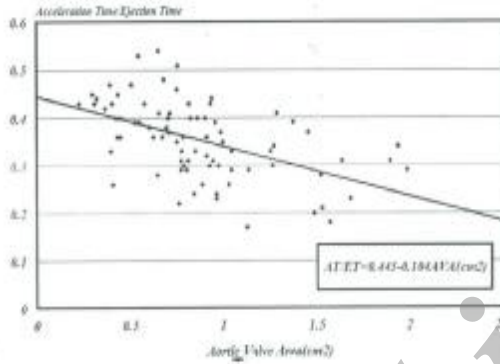


Figure 3 : Regression equation and scatterplot relating AT/ET with Aortic Valve Area

Fig. 3.

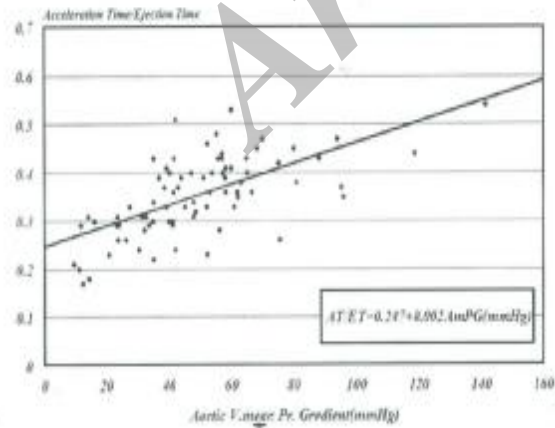


Figure 4 : Regression equation and scatterplot relating AT/ET with Aortic Valve mean Pressure Gradient

Fig. 4.

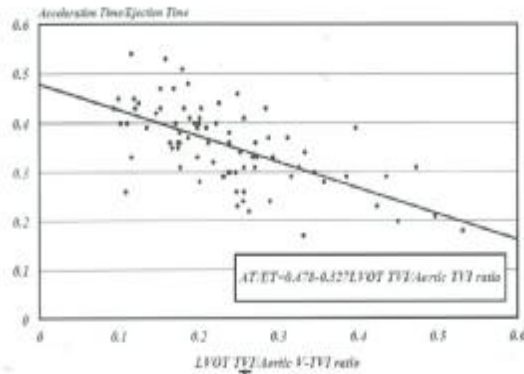


Figure 5 : Regression equation and scatterplot relating AT/ET with LVOT TVI/Aortic TVI ratio

Fig. 5.

Statistical comparison of AT/ET according to the groups of patients with respect to the each of the four echocardiographic variables of severity of aortic stenosis (severe vs. mild or moderate) has been presented in Table IV. It was possible using the independent sample t- test. Normally, the distribution of the valves in each group was shown with the Kolmogrov test.

Table IV. Comparison of AT/ET according to each of the four echocardiographic variables of severity of aortic stenosis

Variable	Mean(n) Mild to moderate severe	Mean difference	Std. error of difference	P value
Aortic jet velocity	0.289(24) 0.381(56)	0.092	0.017	<0.001
Aortic Valve area	0.292(20) 0.374(60)	0.083	0.019	<0.001
Mean pressure gradient	0.291(27) 0.389(53)	0.095	0.159	<0.001
LVOT TVI/Aortic TVI	0.298(29) 0.385(51)	0.087	0.016	<0.001

Using the data presented in Table IV, the cut-off point of AT/ET for the severe degrees of aortic stenosis with 95% level of confidence was calculated for each variable according to the formula $t = \text{difference}/\text{standard error of difference}$. The average was 0.364.

Discussion

Demographic distribution of the patients was in accordance with the reference; the patients were mainly male and aged more than 50 years.² According to the four echocardiographic variables of stenosis severity, 63.8 – 75% of our patients had severe valvular aortic stenosis, and only 10% of the patients had mild stenosis.

Lack of statistically significant correlation between the raw ejection time and the four variables of stenosis severity is not compatible with some of the previous studies,^{4, 8} although there are also similar findings in some other previous studies.⁹ This lack of correlation might be explained by the confounding effects of heart rate and stroke volume on ejection time. As we can see, ET which was adjusted for heart rate and stroke volume (d. ET) had a meaningful significant correlation with aortic valve area, and a trend for correlation with LVOT VTI/Aortic VTI. Considering the “ratio” of AT to ET, it would be expected to neutralize the confounding factors, such that AT/ET was significantly correlated with the four variables of stenosis severity.

Practical implication of AT/ET mainly is the determination of the cut-off value for severe valvular aortic stenosis.

This has one more advantages because the contour of the Doppler signal and its shape is not so angle dependent.

This was calculated to be 0.364 for 95% level of confidence. Such a precise and detailed calculation was not found in the literature; only a crude value of 0.3 was presented in the study of Bumgarther H, et al.,⁴ which is nearly consistent with our cut-off point. Although there are no guidelines using the parameters of AT or AT/ET ratio for native valve stenosis,¹⁰ the last ASE guidelines for the evaluation of prosthetic valves included usage of AT in routine studies of the prosthetic valve in the position of the aortic valve. According to these guidelines with AT > 100 ms, prosthetic stenosis should be considered.¹¹ In addition, calculation of AT/ET ratio has been recommended for prosthetic aortic valve stenosis and ratios > 0.4 are also consistent with prosthetic valve obstruction.¹¹

These recommendations and cut-off values are completely consistent with our findings for native aortic valve stenosis.

Conclusion

The ratio of AT/ET is a reliable parameter to determine the valvular aortic stenosis, alongside other routine parameters, including aortic jet velocity, aortic valve area (calculated with continuity equation), mean pressure gradient, and LVOT VTI/aortic VTI ratio. The analytically calculated cut-off value of AT/ET for severe valvular aortic stenosis is 0.364, with 95% level of confidence.

Conflict of Interest

No conflicts of interest have been claimed by the authors.

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