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SPOTLIGHTS ON TO MYSTRİES OF THE ECHOCARDIOGRAPHIC DIAGNOSIS OF VALVULAR AORTIC STENOSIS

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ABSTRACT

Aortic valve stenosis (AS) is a common cardiac valve disease, and its prevalence is likely to rise linked to growing aging population. Thus, in a recent future, AS is likely to become a major health burden facing the worldwide communities. AS has several etiologies, that can be classiffied as congenital or acquired. The congenital group consists of unicuspid, bicuspid and rarely, quadricuspid valves. The calcific group consists of degenerative changes, and rheumatic disease. Although the history and physical examination can give important clues to the diagnosis in the evaluation of AS, it is often difficult to determine the severity of AS. The qualitative diagnosis of AS relies on two-dimensional echocardiography mainly. The aims of echocardiography in AS can be summarized as diagnose and determine its etiology and reveal other valve pathologies that accompanies with AS.

KEYWORDS: Aortic valve, echocardiography, assessment of aortic stenosis.

INTRODUCTION

A normal aortic valve contains three thin cuspis and they are observed as open in the systole. The normal area of aortic valves is approximately 3-4 cm^2 and a normal opening causes a 2-cm spacing between the valves. This opening is preserved during a part of the systole if the patient does not have a low cardiac stroke volume or left ventricular outflow tract obstruction.[1] It does not create serious hemodynamic changes unless the valve area does not decrease below 0.75-1 cm^2. If the aortic valve area is between 1.5-2cm^2, is defined as mild aortic stenosis, between 1-1.5 cm^2 is moderate aortic stenosis, below 1 cm^2 is defined as advanced aortic stenosis.[2] In addition, in the case of the measurement of the valve area is less than 0.8 cm^2 (0.5 cm^2/m^2) and cardiac output is normal, the average systolic gradient is above the 50 mmHg is called a serious (critical) aortic stenosis.[3] The obstruction at the left ventricular outlet is most commonly settled in the aortic valve and is discussed in this region. In addition, obstruction may occur in supravalvular or subvalvular or it may be based on the hypertrophic obstructive cardiomyopathy. There are three main reasons of aortic stenosis valvular: congenital, rheumatic and degenerative.[4] It will be better understandable of how important is to identify the existing of AS when considering that aortic sclerosis which means calcification and thickening of aortic leaflets without obstruction, occurs in 25% of the population over 65 years of age.[5] Calcification of the congenital bicuspid or normal tricuspid aortic valve is the first etiologic reason in adults especially in Western countries. However, in developing countries, AS almost always occur along with the involvement of mitral valve and this situation demonstrate that acute rheumatic fever is still an important etiological cause.[6]

Although the history and physical examination can give important clues to the diagnosis in the evaluation of aortic stenosis, encountering difficulties in determining the severity of aortic stenosis increases the importance of echocardiography which is a non-invasive method. The purpose of echocardiography in aortic stenosis is to confirm the diagnosis and to determine the anatomy of the valve by investigating the clues about the etiology, to show the degree of the stenosis and to monitor its development, to reveal the other valve pathologies if present and to evaluate the response of the left ventricle to this stenosis.[7] In addition, an echocardiographic examination is required for the initial evaluation of the known or suspected aortic stenosis, for an annual evaluation of asymptomatic severe aortic stenosis, for re-evaluation when there is a change in clinical findings. The annual evaluation is not necessary unless there is a change in clinical findings in patients with asymptomatic mild aortic stenosis.[8] The indications of echocardiography in aortic stenosis are summarized in the table (1).[8]

Table 1: Indications for Echocardiography in Aortic Valvular Stenosis.

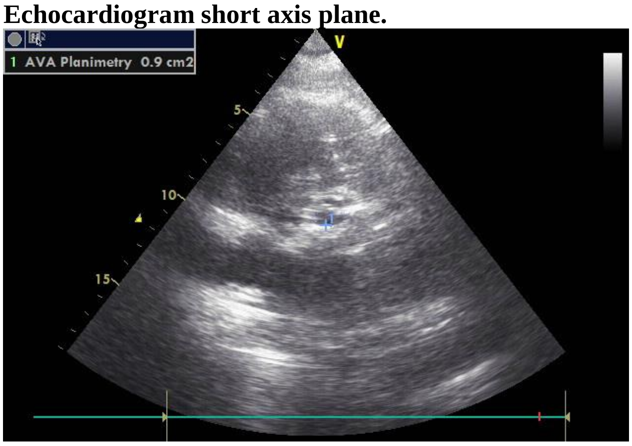
Indication	Class
Diagnosis; Assesment of hemodynamic severity	I
Assesment of right and left ventricular size, function and hemodynamics	I
Reevaluation of patients with known valvular stenosis with changing symptoms	I
Assesment of changes in hemodynamic severity and ventricular compansation in patients with known valvular stenosis during pregnancy	I
Reevaluation of asymptomatic patients with severe stenosis	I
Assesment of hemodynamic significance of mild to modarate aortic stenosis by stress doppler echocardiography	IIa
Reevaluation of patients with mild to modarate aortic stenosis with left ventricular dysfunction even without clinical symptoms	IIa
Reevaluation of patients with mild to modarate aortic stenosis with stable signs and symptoms	IIb
Dobutamine echocardiography for the evaluation of patients with low-gradient aortic stenosis and ventricular dysfunction	IIb
Routine reevaluation of asymptomatic adult patients with mild aortic stenosis having stable physical signs and normal left ventricular size and function	III

In the echocardiographic evaluation of aortic stenosis, 2D Echocardiography, M-mode, and Doppler echocardiographic methods were preferred.[7]

2D Echocardiography: For the display of sclerotic and stenotic aortic valves, trans-thorasic echo (TTE) parasternal long and short axes, apical four and five chambers, the transesophageal echocardiography (TEE) basal short (usually 35-55 degrees), and the long axis (120-140 degree) images are the best image segments.[2] The normal width of the opening of the aortic valve is between 1.6 cm and 2.6 cm. The two-dimensional transthoracic echocardiography helps to identify the severity of the stenosis by the determinate the valvular calcifications, drawing of the frame of the leaflets, and sometimes by the imaging of the orifice. Transesophageal echocardiography offers more precise short axis image of the aortic valve and orifice can be observed more clearly by this. The two-dimensional echocardiography is invaluable in determining the accompanying mitral valve disease, aortic root diameter in patients with bicuspid leaflets and the evaluation of left ventricular systolic performance, dilatation, and hypertrophy. The newly developed three-dimensional echocardiographic methods are promising by providing numbers in the determination of the aortic valve structure and mobility and the severity of the aortic stenosis.[4]

The qualitative diagnosis of aortic stenosis is largely based on 2D Echocardiography. In systole and diastole, the opening and closing of the valves provide to identify the stenosis safely. In the basal short-axis image, three aortic valves can be displayed in aortic annulus at the diastole. Three shutdown lines normally occurred in the shape of the ' Y ' (The sign of Mercedes Benz).[9] The short-axis image is the most useful image in determining the number of valves and adhesion in one or more comissure. In the case of acquired valve stenosis, the valves are thick and their ability to move is limited. The ability to move in severe cases may be completely lost. As the anatomy is disrupted severely, the valves may not be determined seperately in these cases.[7] Aortic stenosis cannot be assessed quantitatively with the 2D echocardiography. However, it is possible to assess it qualitatively. For example, the thick and calcific aortic valves which maintain the ability to move defines aortic sclerosis (typical Doppler speed < 2.5 m/sec). Intense calcific valves that have very little or no movement, indicate serious valve stenosis. If one valve is moved normally, severe stenosis can be excluded.[8] It is possible to measure the aortic valve area with "planimetry" in the parasternal short flow (Figure 1).

Figure 1: AVA measurement with 2D-Echocardiogram short axis plane.



This figure demonstrates the method of direct planimetry of the aortic valve orifis. İn this example, severe stenosis was confirmed. AVA: Aortic valve area.

However, the most important difficulty of this method is that the small and free edges of the calcific aortic valves are irregular; also, capturing the maximum opening section can be difficult due to the fact that the calcific valve does not show a planar structure. The planimetry of TEE well correlated with the aortic valve area (AVA) which is calculated by the Gorlin formula with performing heart catheterization.[7]

A method of quantitative fixation is based on the examination of TEE. This technique is a great way to evaluate the morphology of the aortic valve. In the short-axis view, the measurement of the area of the valve with the level of valve orifice is possible in more than 90% of the cases. Three-dimensional structure of the valve orifice irregularity, shading of the calcific valve and the aortic root (shadowing) are the most important disadvantage of this method. This method is not used in routine due to technical difficulties.[10]

Three-dimensional echocardiography provides some advantages. It provides a better image of the narrow valve orifice, especially. Many studies have been confirmed the applicability of this method. Despite the small absolute faults, the advantage of evaluation with planimetry at very narrow valve area should be taken into consideration. However, the observed shading due to the calcific valves continues as the disadvantage of this method.[11]

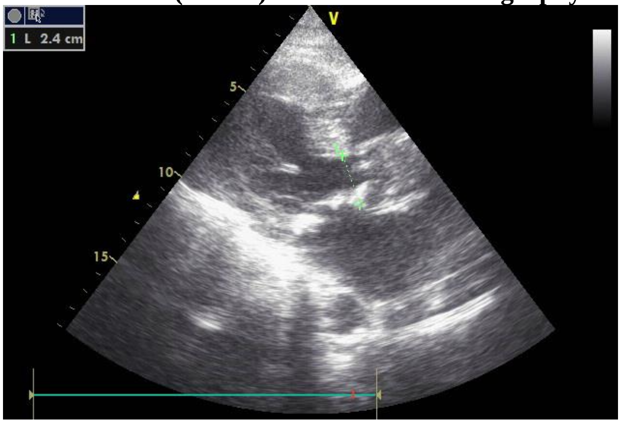
DOPPLER ECHOCARDIOGRAPHY: The severity aortic stenosis in terms of hemodynamics is determined by 2D and Doppler echocardiography. This is evaluated by the aortic peak current velocity, the mean pressure gradient and the ratio of velocity integral time (TVI) between the aortic valve area (AVA) and the left ventricular outflow tract and formulated as (LVOT/ AVA TVI). All of these defined variables are originated by the value of the aortic peak current velocity. Therefore, it is necessary to make a careful examination for the maximal aortic velocity.[12] In Doppler echocardiographic evaluation, maximal and mean aortic pressure gradient is used most frequently for determination and follow-up of AS severity.[13] Doppler evaluation of aortic stenosis starts with the maximal speed of jet stream passing through the valve. Using this value in the simplified Bernoulli equation, instant peak gradient is calculated. This method is practical, it is a noninvasive method that determines the aortic valve gradient and has been shown to be associated with instantaneous values measured by invasive methods.[14]

The accuracy of the aortic stenosis with doppler examination depends on the evaluation of maximal speed of the jet stream. Peak stream rate usually occurs in the middle of the systole. Jet stream rate in the late period, is also the characteristic of dynamic subaortic stenosis observed in hypertrophic cardiomyopathy. Many views such as the apical five chambers, suprasternal and right parasternal views, are used to achieve the parallel doppler signals to the jet stream of the stenosis. If doppler signals could not parallel to the stream, the current velocity evaluated as lower than the real.[12]

The instantaneous peak and the average pressure gradient from doppler records are calculated by the simplified Bernoulli equation. The maximal gradient is calculated according to this formula. P (mmHg) = $4v^2$ (v = Maximum jet stream). This equation is a form of simplified of the full Bernoulli equation. The proximal stream speed is ignored here because the distal stream speed is faster than the proximal stream speed. However, in cases where the proximal stream speed is higher than 1, 5m/sec, and the distal stream speed is moderate (lower than 3.5m/sec), the proximal stream speed cannot be ignored and the exact equation should be used. P = 4 ($vmaximal^2$-$vproximal^2$). This condition is evident with severe aortic regurgitation (due to high forward pulse volume) or in the case of gradual stenosis observed in combined subvalvular and valvular aortic stenosis.[15]

The accuracy of the instantaneous and mean pressure gradient which obtained by doppler has been checked by cardiac catheterization.[16,17] However, there is a slight difference in the aortic valve pressure gradient which obtained by the doppler and catheter due to the pressure recovery phenomenon. Some of the kinetic energy lost during streaming is recovered during passage from a small orifice. With the cause of pressure recovery, an increase in absolute pressure is observed when jet stream passes through the stenotic aortic valve and reached to the ascending aorta. This also explains why the pressure gradient measured by the catheter is lower than the pressure gradient measured by doppler (Doppler echocardiography measures the highest value). The pressure recovery is less when aorta is dilated.[18] When deciding on the seriousness of the stenosis, the cardiac output and the stroke volume should be considered. The continuity equation, derived from the same basic hydraulic formula (Stream = Space x Stream velocity) as the Gorlin formula, calculates the stroke volume from the cardiac orifice, and provide a reliable estimate of the valve area. On the other hand, good correlations have been obtained between valve areas which obtained measured with echocardiography and catheter.[19-22] The aortic valve area (AVA) is calculated using the continuity equation as follows: first the stroke volume is found from diameter of the left ventricular outflow tract (DLVOT) and the its TVI value (Figure 2): SV (Stroke Volume) = $(DLVOT/2)^2 \pi$ xTVI, SV = $(DLVOT)^2$x0.785xTVI

Figure 2: Visualization of the Left Ventricular Outflow Tract (LVOT) with 2D Echocardiography.



Secondly, the maximum aortic velocity is provided by following CW (Continue wave) echocardiography along with many echo views. By scanning the maximum jet velocity, the mean aortic pressure gradient and the TVI value are calculated and three different gradient types are defined: The maximal instantaneous gradient, the mean gradient and the peak-peak (peak to peak) gradient (Figure) (3,4). Finally, the aortic valve area is calculated using the continuity equation (1): $AVA = (DLVOT)^2 x0.785xTVI_{(LVOT)} / TVI_{(Aortic\ Valve)}$, $AVA = SV/TVI_{(Aortic\ Valve)}$

Figure 3: Calculation of maximum jet velocity.

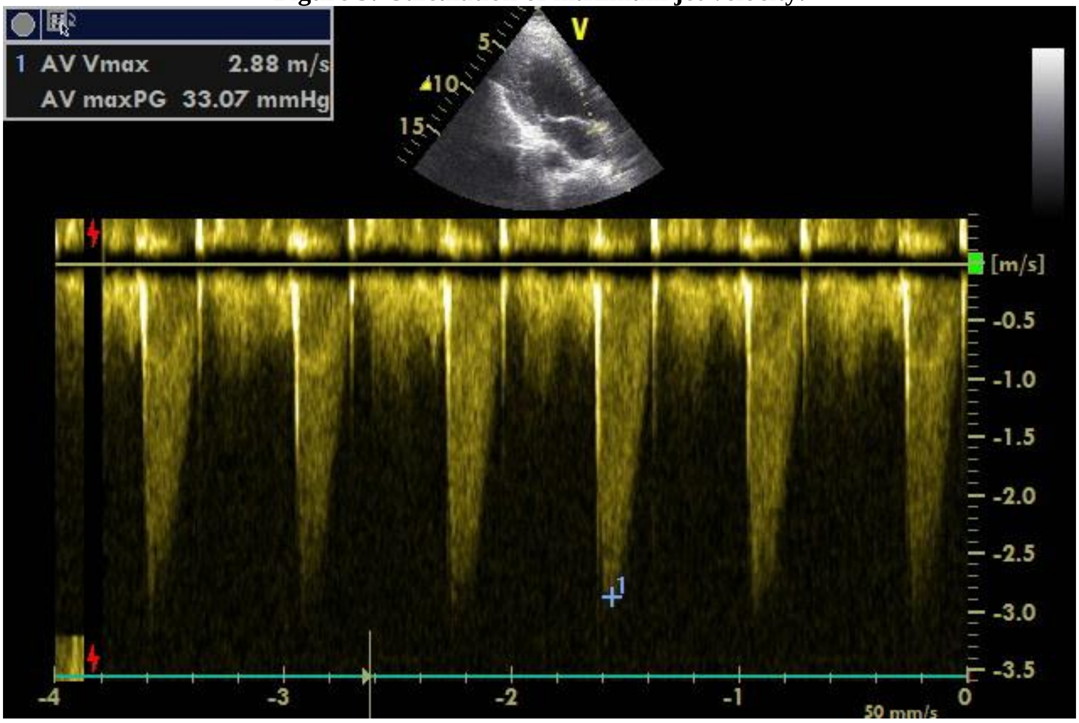
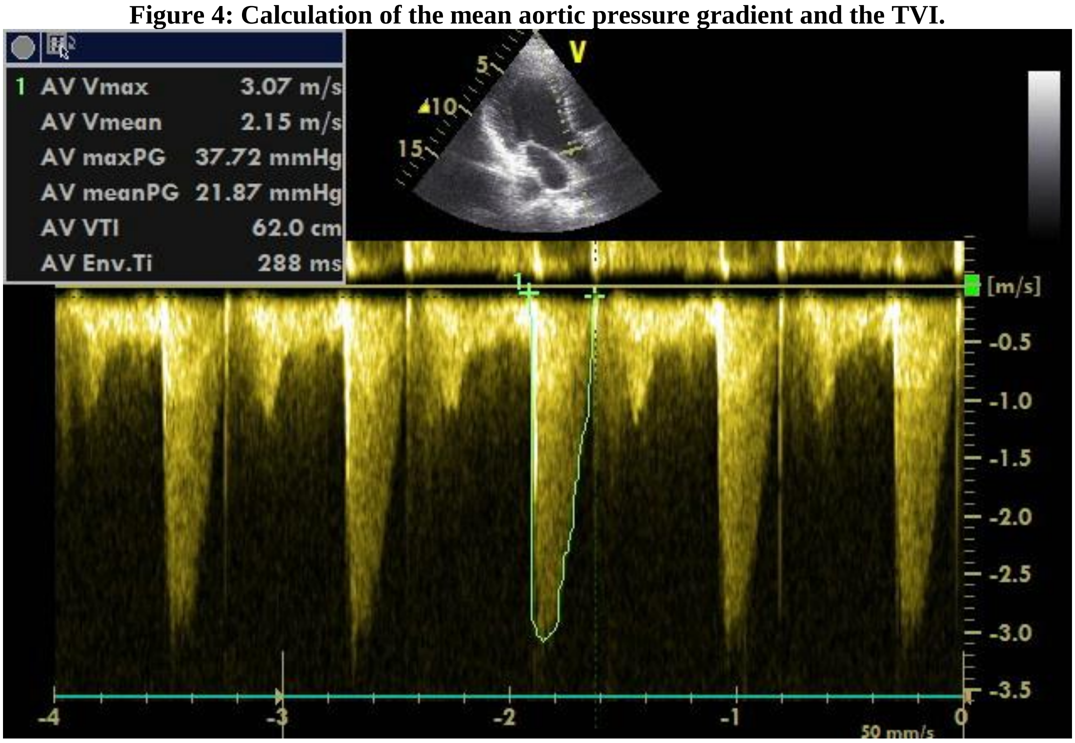


Figure 4: Calculation of the mean aortic pressure gradient and the TVI.



There are some publications to show the mean pressure gradient is more consistent with the cardiac catheterization compared to maximum pressure gradient.[19] If the mean gradient > 50mmHg the valve area is < 0.75 cm^2, if the mean gradient is < 20 mmHg the valve area can be considered as >1 cm^2; If the mean gradient is between 20-50 mmHg, the valve area must be calculated with other methods.[7] The mean pressure gradient is usually obtained by marking the doppler signals as planimetric. The device determines instantaneous stream speed and calculates the mean value. It should be emphasized that the mean gradient cannot be calculated by the square of the mean speed. The mean gradient is calculated as follows: ΔP (mean) = ΔP (maximal)/1.45 + 2mmHg.[8]

In general, when performing measurements of the aortic pressure gradient it should be noted in particular: the CW doppler must be parallel to the stream, the measurement should be repeated in many views to achieve the highest pressure gradient value, and if the patient have not sinus rhythm, the average of at least 4-6 consecutive measurements should be taken; in addition, if the speed measured on the left ventricular outflow tract > 1m/s, "non-simple" Bernoulli equation should be used. Another important point is that when the left ventricular flow output is low, it is necessary to "be careful" when using pressure gradients to assess AS severity; in such cases, it should be noted that dobutamine stress echocardiography can help.[7] The determination of the seriousness of the aortic stenosis and aortic sclerosis by echocardiography has been shown in the following Table (2).[2]

Table 2: The determination of the seriousness of the Aortic Sclerosis and Aortic Stenosis by echocardiography.

Seriousness	**Valve Morphology**	**Peak/Mean Gradient(mmHg)**	**Valve Area(cm^2)**	**Valve Area İndex (Valve area/Body surface area)(cm^2/m^2)**
Sclerosis	Thick and hyperechoic	<16/<10	> 2.0	>1,1
Mild Stenosis	Thick/Calcific, (+) reduction in valve movement	16-25/<20	1,5-2.0	0,9-0,11
Moderate Stenosis	Thick/Calcific, (++ or +++) reduction in valve movement	25-64/20-45	1,0-1,5	0,6-0,9
Severe Stenosis	Evident thickening/Calcification, İmmobile valve	>64/>45	<1	<0,6
Valve area index is very important, for instance; an aortic valve area of 1.4 cm^2 corresponds to obviously mild AS in a small-bodied individual with BSA 1.5 m^2 (Valve area index: 0.93 cm^2/m^2). However, in a large-bodied person with BSA 2.5 m^2 the valve area index is 0.56 cm^2/m^2 and the AS should be assessed as severe.				

The full echocardiographic evaluation of aortic stenosis in most cases involves calculating the aortic valve area with continuity equation. According to the principle of conservation of the mass, the stroke volume in the proximal aortic valve (on the left ventricular outflow tract) should be equal to the stroke volume which passing through the narrow area. Because of the stroke volume is equal to the cross-sectional surface area (CSA) and Velocity Time Integral (TVI), the continuity equation can be revised as follows. Aortic valve area (AVA) = CSA_{LVOT} (cross-sectional surface area of the left ventricular output tract) xTVI_{LVOT} (TVI of the left ventricular output tract)/TVI (the TVI of the aortic stenosis jet stream).[2]

In order to measure the cross-sectional surface area of the output tract, it is usually measured in a circular way from the parasternal long axis view. In the field measurement, due to using area = πr^2, minor errors in the measurement affect the last equation. In cases where the annulus is small, the error rate in relation to the wrong estimation is higher. The main reasons for the occurrence of errors are the calcification of the annulus (because it prevents the actual diameter), the non-circular annulus (overrides the equation) and could not measure the net dimensional of the actual diameter. In most cases it is measured smaller than the actual diameter, so the output tract diameter measurement is the most important cause of faults and should be measured very carefully. The continuity equation could be revised by using LVOT and jet stream (v) speed of aortic valve instead of TVI.[6] By this means, the continuity equation can be written as $AVA = CSA_{(LVOT)} x V_{(Jet\ stream\ of\ LVOT)} / V_{(Jet\ stream\ of\ aortic\ stenosis)}$. Valve area obtained by this equation gives as accurate result as full equation.[8]

The continuity equation provides two significant advantages compared to the Bernoulli equation in evaluating aortic stenosis. Firstly, due to accompanying aortic regurgitation, the transvalvular pressure gradient may increase depending on the increase in the stroke volume passing through to the aortic valve at systole. The continuity equation is not affected by the aortic regurgitation. Moreover, left ventricular systolic dysfunction, despite severe aortic stenosis (due to decreased stroke volume), may cause the low gradient measurement. The continuity equation is not affected significantly by this situation as well, and in the case of stroke volume is normal or decreased, it provides to calculate the valve area correctly.[1]

In cases where the aortic valve area cannot be calculated by the continuity equation, it is suggested that various parameters should be used in the evaluation of AS. It is extremely important to use these parameters in conjunction with other methods that described and to make a good synthesis when evaluating the AS. These parameters include aortic valve resistance (AVR), fractional shortening speed ratio (FSSR), ejection fraction speed ratio (EFSR), left ventricular stroke workload loss (SWL) and Doppler Velocity Index (DVI).[7]

M-mode echocardiography: With the emergence of doppler methods M-mode echocardiography is not used nowadays in the evaluation of AS. The opening of the aortic valve leaves in the parasternal long axes can be measured by this method (Figure 5,6). If the maximum opening is less than 11 mm, the AVA is assumed to be < 0.75 cm^2, and the maximum opening is more than 13 mm, the AVA is assumed to be >1 cm^2.[13]

Figure 5: Measurement of normal aortic valves with M-mod echocardiography.

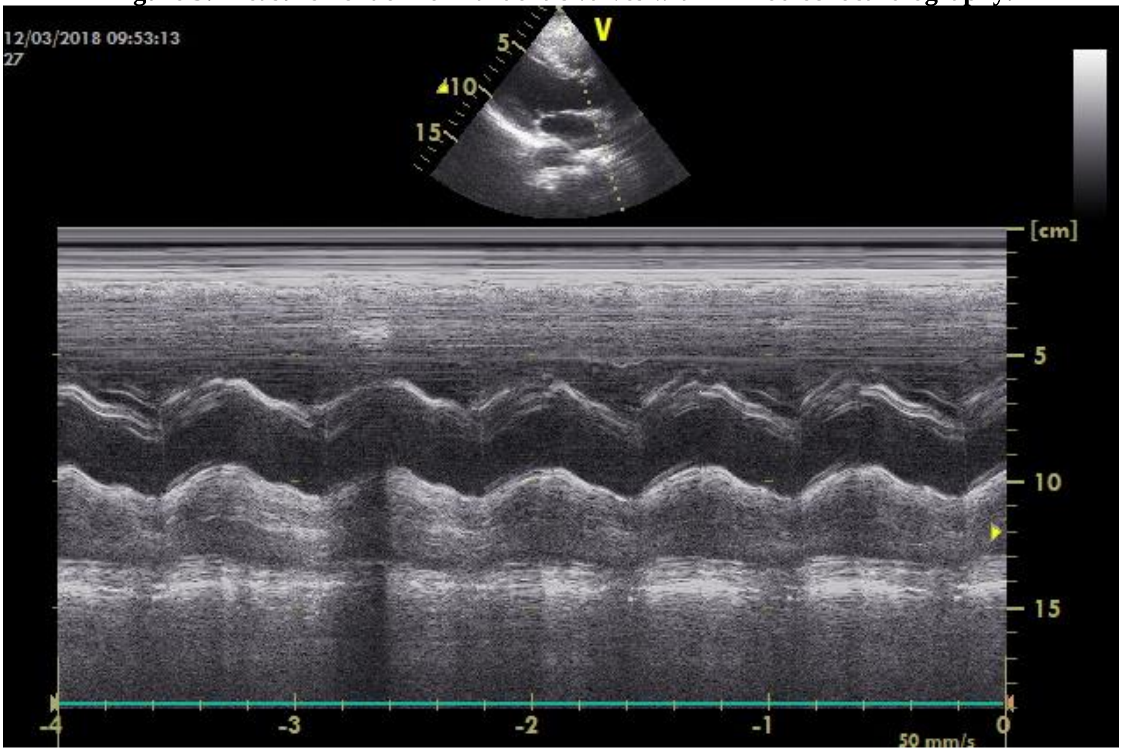
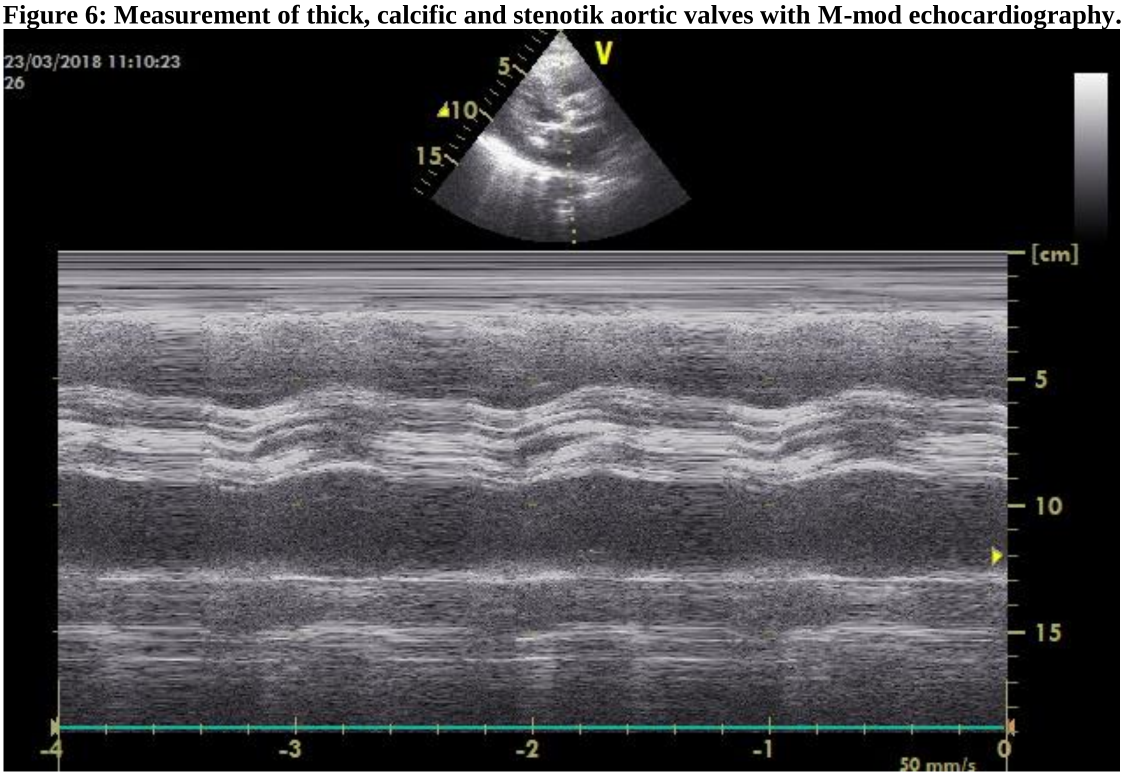


Figure 6: Measurement of thick, calcific and stenotik aortic valves with M-mod echocardiography.



Aortic Valve Resistance (AVR): This parameter determines the severity of stenosis as partial independent from the stream. Aortic Valve Resistance (AVR) is calculated as follows: AVR = The mean pressure gradient (P mean)/ The mean stream rate (Q mean) x1333. The relationship between the mean resistance and the valve area is shown as follows: Mean Resistance = 28x√‾Mean gradient /AV area.[23]

Left Ventricular Stroke Workload Loss (SWL): The left ventricular stroke workload loss (SWL) is the new approach in determining the degree of aortic stenosis. SWL is ratio the gradient of aortic valve pressure to the gradient of the systolic blood pressure and calculated as follows: SWL (%) = (100xΔP_{mean})/ (ΔP_{mean}+ systolic blood pressure).[8]

The mean aortic valve gradient is indicated as ΔP (mean) and workload loss is indicated as (%). This value is based on the principle that the left ventricle to exerts power to keep the aortic valve open in the systole and transmits the blood to the aorta. This depends on the hardness of the aortic valves and is less affected by the stream compared to other parameters. The loss of workload has been found to be the best determinant for symptom development and clinical endpoints. Values above %25 determine good and bad clinical course efficiently. However, the using of this method in practice is limited.[8]

Fractional Shortening Speed Ratio (FSSR): This parameter is the ratio of the left ventricular fractional contraction percentage to the aortic valve pressure gradient. It is calculated with the formula of (% FS)/(4 x V^2). (FS: Fractional shortening, V: Aortic valve systolic flow velocity).[22] The left ventricle FS (% FS) is found with M-mode and parasternal long axis with the formula of (EDD-ESD)/EDD. (EDD: End Diastolic left ventricular diameter, ESD: end-systolic left ventricular diameter).[7]

Ejection Fraction-Velocity Ratio (EFVR): The ejection fraction velocity ratio is the percentage of the left ventricular ejection fraction to the aortic valve pressure gradient and is found by the formula of (%EF)/ (4 x V^2) (EF: Left ventricular ejection fraction, measured in parasternal long axis view with two-dimensional echocardiography, V: Aortic valve systolic flow velocity).[23]

Doppler Velocity Index (DVI): The Doppler velocity index is the ratio of the systolic flow velocity of the left ventricular outflow tract to the aortic valve flow velocity. DVI is calculated as follows: V1/V2 (V1: left ventricular outflow tract flow velocity, V2: aortic valve systolic flow velocity).[24]

Furthermore, in recent years, it has been tried to evaluate the AS with the help of some parameters which have yet to be experimental, such as the "Energy Loss Index".[7] The blood passing through the left ventricular outflow tract has lost energy in the form of heat during passes through the aortic valve to the ascending aorta. It was thought that the amount of energy lost could be beneficial in determining the extra burden of the left ventricle, in the existing of AS, and evaluating the hemodynamic effects of stenosis.[7]

Echocardiographic Description of Severe Aortic Stenosis: In patients with normal left ventricular systolic function, aortic stenosis is considered severe in the following cases.[1]
1) Peak aortic valve velocity > 4.5 m/sec.
2) Mean pressure gradient> 50mmHg
3) Aortic valve area < 0.75cm^2
4) $LVOT_{(TVI)}/AV_{(TVI)}<0.25$

However, in the heart valve diseases guide prepared by AHA/ACC (American Heart Association/American College of Cardiology), it is recommended that if the value of the aortic valve area is 1cm^2 and under this, instead of the traditionally accepted 0.75 cm^2, should be considered as a criterion of a serious aortic stenosis.[21]

Dobutamine Stress Echocardiography in Severe Aortic Stenosis with Low Aortic Pressure Gradient: It is claimed that, in most aortic stenosis, as the flow rate increases the valve area is increased. In contrast, if the flow velocity is too low, the opening of valves will be decreased, which may cause in the fact that the valve area is actually lower. Therefore, when the left ventricular systolic dysfunction is evident, the quantitative evaluation of the valve area becomes difficult. In these cases, it may be difficult to distinguish the actual serious aortic stenosis from mild-medium aortic stenosis (Reduced opening of the valve due to reduced flow velocity, e.g. dilated cardiomyopathy patient).[8] In such cases, in order to distinguish morphologically severe aortic stenosis and low cardiac flow rate caused by decreased effective stenotic orifices area (false severe aortic stenosis), increasing the stroke volume with gradual dobutamine infusion (5-20microgram/kg/min) may help.[25-27] In patients with real severe aortic stenosis, while the dobutamine infusion increase, TVI and peak flow values of LVOT and aortic valve increase proportionally ($LVOT_{(TVI)}$ /$AV_{(TVI)}$ rate remains constant), in the case of wrong serious aortic stenosis, when the cardiac output rises the increasing in TVI and velocity of LVOT is much more than the increasing of TVI and velocity of the aortic valve. This results in increased $LVOT_{(TVI)}$ /$AV_{(TVI)}$ in patients with functional severe aortic stenosis.[1] If the aortic valve area is 1 cm^2 or less and the dobutamine mitral gradient is 30mmhg or above, it is considered to be a severe aortic stenosis requiring aortic valve replacement.[26] If the infusion of the dobutamine increases the stroke volume by 20% or more, and the aortic valve area remains 1cm^2 or less, it is recommended to consider aortic valve replacement.[1] Another possible response to the dobutamine infusion is that there is no significant valve area and gradient change due to the absence of a left ventricular response. This response is indicative of poor prognosis and considers the likelihood of accompanying coronary artery disease.[8] Even if the inotropic reservoir is not adequate with dobutamine, aortic valve replacement is better than the leave patient's untreated, but mortality is quite high.[27-29]

Considerations for Echocardiographic Evaluation of Aortic Stenosis

1) If the patient's rhythm is not sinus, the average velocity which obtained from 5 or more cardiac cycles (Usually three or more beats are averaged in sinus rhythm) to obtain the TVI or velocity ratio should be used because the aortic and LVOT velocity changes depending on the RR range which occurs just before them in each cardiac cycle, or RR ranges must be paired to obtain the TVI and velocity ratios for LVOT and aortic valve. A simpler way is to use the highest velocity of the aortic valve, LVOT, and their ratios.[30]

2) Aortic stenosis jet stream; It should be distinguished from the findings of mitral insufficiency, LVOT obstruction, tricuspid insufficiency, and other systolic doppler findings such as pulmonary stenosis.[30]

3) It can be difficult to obtain a satisfactory LVOT velocity in case of LVOT obstruction connected to the basal hypertrophy simultaneously. In this situation, the stream velocity in the the proximal aortic valve, reaches 2 m/sec and causes a higher detection of aortic pressure gradient obtained with the modified Bernoulli than the real pressure gradient.[1]

4) In the case of severe calcification of the aortic valve or the annulus, it may not be able to measure the diameter of the VLOT. In this case, another non-leakage orifice (right ventricular outflow tract or mitral valve) should be used to calculate the stroke volume. In this case; due to the differences in the stream ejection periods, the TVI ratio should be used rather than peak velocity ratio.[1]

5) Some studies show that aortic valve area calculations are affected by changes in the stroke volume.[31] Therefore, a slightly larger area determined by dobutamine stress echocardiography may be associated with a continuity equation rather than a real change in the valve area.[32] The planimetry made with TEE can help with this issue.[33]

6) Aortic valve resistance is another hemodynamic index showing the severity of aortic stenosis. The measured aortic flow velocity shows a good correlation with the aortic valve area (AVA). The mean aortic valve resistance is calculated using the 28-constant coefficient that Bermejo et al. obtained with nonlinear regression analysis[32]: Mean Resistance = 28 √‾Mean Gradient/AVA

Despite all this, no echocardiographic parameters are perfect in the AS assessment. In our opinion, the best approach in the AS evaluation, to use all the parameters that can be obtained and be careful to synthesize them along with the "clinical" suitability.

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