

Research Article

Effect of Valsalva Maneuver in Measuring Valve Area

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Abstract

Background: Echocardiographic measurement of the mitral valve in patients with mitral stenosis is important for treatment and follow-up. The aim of this study was to assess the effect on the valsalva maneuver mitral valve area measurement.

Methods: 83 patients with mitral stenosis were included in the study. Valve area of the patients was measured by echocardiography before and after valsalva maneuver.

Results: Mitral valve area of the patients were measured as the planimetric being 1.62 ± 0.41 , cm². It was found out that valsalva maneuver had no effect on valve area measured by planimetry. It was observed that valve area measured by PHT decreased with valsalva maneuver while valve area measured by PISA method significantly increased with valsalva maneuver. It was understood from other echocardiographic findings that systolic pulmonary artery pressure, gradients on the cover and velocities decreased with the valsalva.

Conclusion: The modes of measurement of mitral valve area are discretely influenced by valsalva maneuver. It is significant to keep in mind potential effects as patients may suffer involuntarily during echocardiography.

Keywords: Mitral valve area; Planimetry; PHT; PISA; Valsalva

1. Introduction

Rheumatic mitral stenosis (MS) is still an important public health problem in developing countries although there has been decrease in the incidence of acute rheumatic fever in industrialized countries in the last 50 years thanks to

improved socioeconomic conditions [1]. The normal history of rheumatic MS is characterized by an asymptomatic inactive period taking after the introductory scene of rheumatic fever. The cruel interim between acute rheumatic fever and the appearance of indications related to MS is more than 15 years. When valve surgery is demonstrated, but denied by the patient, survival with therapeutic treatment was 44% after 5 years, 32% after 10 years, and 19% after 15 years [2]. The area of the mitral orifice is 4 to 6 cm² and when the valve area diminishes below 2 cm², a diastolic pressure gradient between the left atrium and left ventricle appears with a transmitral peak velocity greater than 1 m/s suggesting mitral stenosis [3]. Although the transmitral pressure is a useful indicator of MS severity, it is critically affected by loading conditions. Therefore, measuring mitral valve area (MVA) in deciding the seriousness has appeared to be a more solid strategy with overall acceptance [3, 4]. However, each echocardiographic strategy of MVA estimation in MS has potential inherent confinements [4]. In spite of the fact that hemodynamic parameters measured at rest are affected by age, heart rate, loading conditions, and the properties of the left ventricle and left atrium, some maneuvers can help within the assessment of the cardiac hemodynamics [5]. The valsalva maneuver, which is a complex hemodynamic process that includes four discrete phases, could be a supportive noninvasive instrument for evaluation of diastolic filling of the heart by Doppler echocardiography [6-8]. The recent study of Ozeke et al. was the first one which built up that bringing down preload during the strain stage of valsalva maneuver diminished the LA pressure and transmitral gradient in patients with MS [9]. As transmitral pressure is influenced by loading conditions and measuring mitral valve area (MVA) in deciding the seriousness appeared to be a more reliable strategy, in this study, we aimed to investigate the effect of valsalva maneuver onto different methods which are used to calculate mitral valve area.

2. Methods

Eighty three consecutive patients with rheumatic MS who were conceded to outpatient department of our unit were enlisted into the study up on obtaining informed consent. Clinical and echocardiographic data were obtained tentatively by an expert echocardiographer. Those with extreme left sided other valve disease, which rules the clinical picture (i.e., patients with moderate to severe aortic stenosis, severe aortic regurgitation); those with previous history of coronary artery disease; indistinguishable patients; patients with recent history of rheumatic fever within the last 6 months, and those with any kind of past cardiac surgery were excluded from the study. The hospital ethics committee approved the protocol that was a thesis in proficiency and all participants gave informed written consent. All patients experienced echocardiographic examinations with a cardiac ultrasound scanner (Vivid 4, GE) and a 2.5 MHz transducer in the left lateral decubitus position, with utilization of standard views and measurements by an expert echocardiographer according to the recommendations of the American Society of Echocardiography [10]. A 12-lead electrocardiogram was recorded for each patient at the same time. Resting heart rate during echocardiography was between 55-85/min in all patients. In order to eliminate interobserver variability, the same operator who was not part of the study recorded all echocardiograms with codes without identities and timing records. Each echocardiogram before and during valsalva was recorded with a new code as every measure was repeated during strain phase of valsalva maneuver, Recorded and coded data were put into random order by computer assistance and were evaluated offline by another expert echocardiographer, who did not know which patient was investigated in which stage (pre-valsalva or during valsalva).

Patients with MS were decided on the premise of the following criteria: Fibrotic thickening of the mitral valve, doming of the anterior mitral valve along with diminished E to F slope during diastole, and upward movement of the posterior valve during early diastole [11]. MVA was decided by 2-dimensional planimetry, Doppler pressure half-time (PHT) and proximal isovelocity surface area method (PISA). Planimetry estimation was obtained through direct tracing of the mitral orifice including opened commissures on a parasternal short-axis view [11]. Mitral valve orifice by PHT strategy was estimated by using the formula [11]: $MVA = 220/T^{1/2}$. $T^{1/2}$ was obtained by tracing the deceleration slope of the E- wave on doppler spectral display of transmitral flow (longest flow in those with atrial fibrillation) and valve area is automatically calculated by the echo-machine. The hemispherical shape of the convergence of diastolic mitral flow on the atrial side of mitral valve is the basis of the proximal isovelocity method. MVA was determined by dividing mitral volume flow by the maximum velocity of diastolic mitral flow by using the formula: $MVA = \pi(r^2)(V \text{ aliasing})/\text{peak } V \text{ mitral} \cdot \theta/180$, where r is radius of the convergence hemisphere (in cm), V aliasing is the aliasing velocity (in cm/sec), peak V mitral is the peak diastolic continuous wave Doppler velocity of mitral inflow (in cm/sec), and θ is the opening angle of mitral leaflets relative to flow direction [12].

The modified Bernolli equation at rest [13] was used to calculate the transmitral gradient including the mitral peak pressure gradient and mitral mean pressure gradient and it was repeated subsequently during the strain phase of Valsalva maneuver. The mitral valve Wilkins echocardiographic score was calculated between 4 and 16 for each patient [14]. Systolic pulmonary artery pressure (PAP) was derived from the tricuspid regurgitation jet velocity through modified Bernolli equation ($4v^2$) and estimating a right atrial pressure from inferior vena cava collapsibility [15]. Masuyama method was used for the calculation of mean pulmonary artery pressure (MPAP) [16]. Before and during echocardiography, all patients were carefully instructed about Valsalva maneuver. The Valsalva maneuver, which is expiratory strain, performed against a closed glottis, is a part of dynamic auscultation in cardiovascular practice. Whole population was inquired to start and keep up the strain 15 to 20 seconds after normal inspiration by forcefully blowing into a small caliber tube, connected to an aneroid manometer to maintain a constant expiratory effort equivalent to an intraoral pressure of 40 mmHg during a certain period of time. All tests were repeated during strain phase of Valsalva maneuver.

3. Results

Mean age of the subjects was 47.2 ± 12.9 years (65 females, 18 males). The fundamental rhythm in 35 patients (42.2%) was atrial fibrillation. Forty three patients (51.8%) had mild mitral stenosis, characterized as mitral valve area by planimetry $>1.5 \text{ cm}^2$ at baseline. Median NYHA was class II. Mean body surface area was $1.76 \pm 0.18 \text{ m}^2$. Mitral valve area (MVA) before and after valsalva maneuver was measured and then recorrected according to body surface area. Mean MVA at baseline was $1.62 \pm 0.41 \text{ cm}^2$ by planimetry, ranging between $1.36\text{-}2.31 \text{ cm}^2$. Corrected MVA per body surface area (cm^2/m^2) by each method was presented in Table 1.

Measurement	Before Valsalva	Overall p for Anova	during Valsalva strain phase	Overall p for Anova	P for paired samples
Planimetry	0.93 ± 0.23	<0.001	0.92 ± 0.26	0.445	0.637
PHT	0.90 ± 0.22		0.88 ± 0.22		0.048
PISA	0.72 ± 0.37		0.86 ± 0.47		<0.001
MPAP	24 ± 13	-	24 ± 14	-	0.888
SPAP	31 ± 18	-	26 ± 16	-	<0.001
Mean gradient	6 ± 3.6	-	4.4 ± 3.2	-	<0.001
Peak gradient	13.4 ± 6.1	-	9.8 ± 5.4	-	<0.001
Mitral peak diastolic velocity	1.78 ± 0.38	-	1.50 ± 0.38	-	<0.001
Radius of converging hemisphere	0.94 ± 0.23	-	0.93 ± 0.25	-	0.549

Post hoc tests before Valsalva: Planimetry versus PHT: $p=0.753$, planimetry versus PISA: $p<0.001$, PHT versus PISA: $p<0.001$; Post hoc tests after Valsalva influence: Planimetry versus PHT: $p=0.681$, planimetry versus PISA: $p=0.421$, PHT versus PISA: $p=0.902$.

Table 1: Influence of Valsalva in whole group.

3.1 Parameters before Valsalva maneuver

Planimetric valve area was correlated with PHT ($r=0.890$, $p<0.001$), and correlated with PISA ($r=0.589$, $p<0.001$) concerning MVA measurements per body surface area in whole study group. Additionally there was correlation between PHT and PISA ($r=0.654$, $p<0.001$). However, it was of note that PISA underestimated MVA per BSA (cm^2/m^2) compared to both planimetry and PHT (Table 1).

Among those with mild mitral stenosis ($n=43$), defined by planimetric MVA $>1.5 \text{ cm}^2$, there was correlation between planimetry and PHT ($r=0.792$, $p<0.001$) and PISA ($r=0.350$, $p<0.001$), and there was correlation between PHT and PISA ($r=0.531$, $p<0.001$). Among those with moderate to severe mitral stenosis ($\text{MVA} \leq 1.5 \text{ cm}^2$), there was correlation between planimetry and PHT ($r=0.645$, $p=0.001$), PISA ($r=0.342$, $p=0.033$), and there was correlation between PHT and PISA ($r=0.394$, $p=0.013$).

All patients were classified into two as those with low Wilkins score (score <8 , $n=46$) and those with high Wilkins score (score ≥ 8 , $n=37$). Among patients with low score, MVA by planimetry was correlated with MVA by PHT ($r=0.887$, $p<0.001$), and with MVA by PISA ($r=0.518$, $p<0.001$), and MVA by PHT was correlated with MVA by PISA ($r=0.602$, $p<0.001$). Besides, among those with high score, MVA by planimetry was correlated with MVA by PHT ($r=0.870$, $p<0.001$), and with MVA by PISA ($r=0.711$, $p=0.002$), and MVA by PHT was correlated with MVA by PISA ($r=0.591$, $p<0.001$).

3.2 Parameters after Valsalva influence (i.e.,: during strain phase of valsalva)

Concerning MVA measurements per body surface area in whole study group, planimetric valve area was neither correlated with PHT ($r=0.148$, $p=0.202$), and nor with PISA ($r=0.096$, $p=0.410$). However, MVA/m² by PHT was correlated with PISA ($r=0.679$, $p<0.001$). Among those with mild mitral stenosis, MVA per body surface area by planimetry was not correlated with PHT ($r=0.184$, $p=0.248$), and PISA ($r=0.006$, $p=0.971$). Whereas, PHT was correlated with PISA ($r=0.409$, $p=0.006$). Among those with moderate to severe mitral stenosis, planimetry was not correlated with PHT ($r=0.285$, $p=0.097$), PISA ($r=0.291$, $p=0.09$), though, there was slight tendency for a relationship, and PHT was correlated with PISA ($r=0.442$, $p=0.005$).

Valsalva maneuver did not concede any change in MVA by planimetry, whereas, MVA by PHT slightly diminished, and MVA by PISA increased significantly up on Valsalva in the overall group. Gradients, SPAP, velocities decreased up on Valsalva maneuver, whereas, MPAP remained stable regarding other measurements (Table 2).

Condition	Measurement	Before valsalva	during valsalva strain phase	P for paired samples
Patients with moderate-severe mitral stenosis (n=40)	Planimetry	0.77 ± 0.10	0.93 ± 0.25	0.001
	PHT	0.74 ± 0.11	0.73 ± 0.14	0.466
	PISA	0.52 ± 0.29	0.62 ± 0.39	0.049
	MPAP	28 ± 13	28 ± 14	0.906
	SPAP	38 ± 17	31 ± 15	<0.001
	Mean gradient	7.6 ± 3.8	5.7 ± 3.8	<0.001
	Peak gradient	15.5 ± 6.6	12 ± 6.4	<0.001
	Mitral peak diastolic velocity	1.94 ± 0.37	1.66 ± 0.39	<0.001
	Radius of converging hemisphere	0.83 ± 0.21	0.82 ± 0.22	0.790
Patients with mild mitral stenosis (n=43)	Planimetry	1.11 ± 0.17	0.92 ± 0.28	<0.001
	PHT	1.05 ± 0.18	1.02 ± 0.18	0.059
	PISA	0.89 ± 0.34	1.06 ± 0.43	<0.001
	MPAP	21 ± 12	20 ± 13	0.755
	SPAP	25 ± 18	21 ± 15	<0.001
	Mean gradient	4.5 ± 2.5	3.1 ± 1.7	<0.001
	Peak gradient	11.4 ± 4.8	7.8 ± 3.2	<0.001
	Mitral peak diastolic velocity	1.64 ± 0.32	1.35 ± 0.29	<0.001
	Radius of converging hemisphere	1.05 ± 0.2	1.03 ± 0.24	0.512

Table 2: Temporal change of parameters by subgroups according to severity.

However, although, planimetric MVA seemed to remain stable up on valsalva maneuver, it was noticed that among those with moderate-severe mitral stenosis, planimetric MVA yielded increase, and, among those with mild mitral stenosis, planimetric MVA yielded decrease in measurements with a neutral outcome in the whole group. On the other hand, considering those with moderate-severe mitral stenosis, MVA by PISA seemed less influenced by valsalva, though, it continuously yielded lower estimation. It was of note that MVA by PHT seemed not to be influenced by valsalva significantly, particularly among those with moderate-severe mitral stenosis. Herein, it might be important to remind that MPAP was unaffected in both subgroups.

Planimetric method seemed resistant to valsalva among patients with trivial-mild or moderate-severe mitral regurgitation, whereas, MVA by PHT among those with moderate-severe mitral regurgitation decreased significantly up on valsalva maneuver. Herein, it was of note that MPAP was resistant to valsalva maneuver (Table 3).

Condition	Measurement	Before valsalva	During valsalva strain phase	P for paired samples
Patients with accompanying trivial-mild mitral regurgitation (n=51)	Planimetry	0.93 ± 0.23	0.94 ± 0.27	0.841
	PHT	0.88 ± 0.21	0.87 ± 0.21	0.553
	PISA	0.74 ± 0.33	0.86 ± 0.42	0.002
	MPAP	25 ± 14	25 ± 16	0.737
	SPAP	28 ± 17	23 ± 16	<0.001
	Mean gradient	5.5 ± 2.5	4 ± 2.3	<0.001
	Peak gradient	12.3 ± 4.4	9.3 ± 4	<0.001
	Mitral peak diastolic velocity	1.73 ± 0.35	1.44 ± 0.31	<0.001
	Radius of converging hemisphere	0.95 ± 0.22	0.93 ± 0.24	0.167
Patients with accompanying moderate-severe mitral regurgitation (n=32)	Planimetry	0.96 ± 0.22	0.90 ± 0.25	0.365
	PHT	0.94 ± 0.23	0.9 ± 0.22	0.011
	PISA	0.68 ± 0.41	0.84 ± 0.54	0.011
	MPAP	23 ± 12	22 ± 11	0.548
	SPAP	36 ± 19	30 ± 15	<0.001
	Mean gradient	6.7 ± 4.8	4.9 ± 4.1	0.001
	Peak gradient	15.1 ± 7.9	10.6 ± 7	<0.001
	Mitral peak diastolic velocity	1.86 ± 0.41	1.59 ± 0.45	<0.001
	Radius of converging hemisphere	0.93 ± 0.25	0.94 ± 0.27	0.717

Table 3: Temporal change of parameters by subgroups according to regurgitation.

Valvular calcification did not seem to influence the effect of valsalva onto different methods (Table 4).

Condition	Measurement	Before valsalva	during valsalva strain phase	P for paired samples
Patients with non-mild valvular calcification (n=27)	Planimetry	0.93 ± 0.25	0.87 ± 0.16	0.370
	PHT	0.86 ± 0.25	0.84 ± 0.24	0.285
	PISA	0.63 ± 0.34	0.75 ± 0.45	0.122
	MPAP	23 ± 11	24 ± 12	0.737
	SPAP	35 ± 20	28 ± 16	<0.001
	Mean gradient	6.7 ± 4.6	4.7 ± 4	<0.001
	Peak gradient	14.3 ± 7.3	10.5 ± 6.5	<0.001
	Mitral peak diastolic velocity	1.80 ± 0.37	1.54 ± 0.4	<0.001
	Radius of converging hemisphere	0.89 ± 0.20	0.89 ± 0.22	0.167
Patients with moderate-severe valvular calcification (N=56)	Planimetry	0.95 ± 0.21	0.95 ± 0.30	1.000
	PHT	0.92 ± 0.20	0.9 ± 0.2	0.101
	PISA	0.76 ± 0.37	0.9 ± 0.47	<0.001
	MPAP	24 ± 14	24 ± 15	0.702
	SPAP	29 ± 17	25 ± 16	<0.001
	Mean gradient	5.6 ± 2.9	4.2 ± 2.7	<0.001
	Peak gradient	12.9 ± 7-5.5	9.5 ± 4.8	<0.001
	Mitral peak diastolic velocity	1.77 ± 0.38	1.48 ± 0.37	<0.001
	Radius of converging hemisphere	0.96 ± 0.24	0.95 ± 0.26	0.377

Table 4: Temporal change of parameters by subgroups according to calcification.

4. Discussion

This study investigated the effect of Valsalva maneuver on different methods of measuring the valve area and hemodynamics in MS patients and results indicate that measurement of the mitral valve area by different methods was influenced by Valsalva maneuver when different subgroups were examined, and each method was affected differently in different subgroups. Although when the whole groups were examined, the planimetric method was not affected by Valsalva maneuver, and the valve areas measured by PHT and PISA methods before valsalva were not significantly correlated with the valve areas measured after the maneuver; in the subgroups of patients with mild and moderate to severe MS, PHT method seemed to be more reliable with no influence of Valsalva maneuver. We think

physicians should take care of bidirectional Valsalva influence onto planimetric method. However, planimetric method was found out to be the most reliable one in patients who had significant mitral regurgitation accompanying mitral stenosis. Although, in patients with none to mild valvular calcification, Valsalva maneuver had no effect on the other methods, in patients with moderate to severe valvular calcification PISA method could overestimate valve area following Valsalva maneuver. Additionally, there was an important change in all measures except for MPAB in response to Valsalva.

All echocardiographic methods of MVA measurement in MS have potential intrinsic limitations, although measuring mitral valve area (MVA) in determining the severity seems a more reliable method [3, 4]. Two dimensional echocardiographic planimetry is not always feasible [17, 18], and is dependent on locating the true mitral orifice in the short axis view and on the use of the proper gain settings [19]. The accuracy of PHT may be influenced by tachycardia, atrial fibrillation, associated regurgitations, changes in the left ventricular end-diastolic pressure and acute chamber compliance after post-valvotomy [20-22]. Because of the fact that the proximal convergence region can be easily visualized [23], The PISA method is attractive for MVA determination in MS, however the accuracy of the 2D-PISA method [24] may sometimes be reduced by the low frame rate and temporal resolution of the 2D- colour imaging. It is not always possible to use each method in every patient for the mitral valve area evaluation in patients with mitral stenosis because of these limitations. Besides, we showed that Valsalva maneuver could affect the measurements obtained by different methods, and physicians should take into account that during echocardiographic examination some patients may strain involuntarily mimicking the effects of Valsalva maneuver. Hence, it may be important to remember that each method has its own limitation in different subgroups.

Valsalva maneuver is a complex hemodynamic process that involving 4 phases. Alteration of loading conditions during the Valsalva maneuver is a helpful ancillary method in the noninvasive assesment of diastolic filling of the heart by Doppler echocardiography [5-7] is also well-known. The clinicians use the period at the end of phase II (the strain phase) in order to enhance the accuracy of physical diagnosis. The hemodynamic manifestation of the Valsalva maneuver are in part the result of changes in the venous return accompanying changes in the intrathoracic pressure [5-8]. Valsalva maneuver may result in decrease in LA pressure and subsequent transmitral gradient in MS [9]. Hence, in this study we showed that Valsalva maneuver influenced the results of different methods to measure mitral valve area.

5. Conclusion

In conclusion, we suggest that clinicians should measure the mitral valve area by using different methods, and also should be alerted to relax patients during each measurement to minimize the effects of Valsalva maneuver especially for making a clinical decision. Because, Valsalva maneuver can affect both hemodynamics and measurements of mitral valve area by different methods, and during echocardiographic examination some patients may strain involuntarily mimicking the effects of Valsalva maneuver.

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