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Measurement of interatrial septal thickness by echocardiography in patients with moderate to severe rheumatic mitral stenosis undergoing percutaneous balloon mitral valvuloplasty

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ABSTRACT

Background: Longstanding severe rheumatic mitral stenosis (MS) is associated with changes in the atrial chamber dimensions. It is not known whether there is an increased thickness of the inter-atrial septum (IAS) in patients with severe rheumatic mitral stenosis. The objective of this study was to evaluate pre-procedural IAS thickness by echocardiography in patients with moderate to severe rheumatic mitral stenosis undergoing percutaneous balloon mitral valvuloplasty (PBMV).

Methods: The thickness of the IAS was measured by transesophageal echocardiography (TEE) in 86 patients between 14 and 65 years of age. Patients with moderate to severe rheumatic mitral stenosis undergoing percutaneous mitral balloon valvuloplasty (PMBV) at the National Institute of Cardiovascular Diseases (NICVD), Karachi were recruited for this study. IAS thickness was measured by TEE using standard views and 3 different phases of cardiac cycles were evaluated.

Results: Out of 86 patients, almost three fourths (73.3%) were between 14 and 29 years of age and two thirds (62.8%) were females. Mean IAS thickness was 2.56 (SD 0.92) mm at anterior region (AR), 1.89 (SD 0.75) mm at fossa ovalis (FO), and 2.95 (SD 0.97) mm at posterior region (PR). None of the demographic and clinical groups showed any statistically significant difference in IAS thickness.

Conclusions: Inter-atrial septum (IAS) thickness measurement does not change in the presence of moderate to severe rheumatic mitral stenosis as compared to the reported normal values of IAS thickness in cadaveric hearts.

1. Introduction

Rheumatic mitral stenosis is a frequent sequela to longstanding chronic rheumatic heart disease and still contributes to significant morbidity and mortality in the endemic south-east Asian region [1]. A small but substantial occurrence of rheumatic mitral stenosis exists and as per population-based data on rheumatic heart disease prevalence, will likely continue to exist in Asia [2–4]. Percutaneous mitral balloon valvuloplasty (PMBV) is one of the nonsurgical commissurotomies and is the preferred procedure to treat symptomatic patients with mitral stenosis and a favorable valve anatomy. [5] PBMV has excellent immediate and long-term success rates in terms of valve area improvement which compares well with surgical commissurotomy [6–8].

With the increasing number of percutaneous catheter-based procedures involving trans-septal access to the left side of the heart, precise anatomical consideration of the inter-atrial septum assumes an important role in the safe and effective performance of these interventional procedures [9–10]. Echocardiography is the preferred imaging modality to evaluate the inter-atrial septum. Accurate estimation of inter-atrial septum dimensions using the transthoracic approach may be difficult in some cases. Transesophageal echocardiography (TEE) overcomes these limitations by providing high-resolution images of the inter-atrial septum (IAS) in most subjects [11].

Longstanding severe rheumatic mitral stenosis is associated with changes in the atrial chamber dimensions. It is not specifically known whether there are changes in the IAS dimensions proportionate to the increasing severity of rheumatic mitral stenosis, however, there is some evidence that there may be relative sparing of the interatrial

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septum [12–14]. Since no previous studies have reported echocardiographic changes in the IAS thickness or thinning in valvular heart disease patients; the aim of this study was to evaluate IAS thickness by transesophageal (TEE) in a consecutive series of patients undergoing percutaneous balloon mitral valvuloplasty for moderate to severe rheumatic mitral stenosis.

2. Methods

We enrolled 86 patients with mitral stenosis presenting to the echocardiography department at The National Institute of Cardiovascular Diseases (NICVD), Karachi. Inclusion criteria for the patients were: symptomatic mitral stenosis with mitral valve area (MVA) ≤ 1.5 cm^2, isolated moderate to severe mitral stenosis with ≤grade II mitral regurgitation and patients with moderate to severe restenosis of mitral valve who had undergone prior PBMV or mitral commissurotomy. Excluded from the study were patients with poor echocardiographic windows, presence of left atrial thrombus, recent thromboembolic event (within the last 3 months), other associated significant valve lesions that need surgical correction, and the presence of significant coronary artery disease. In our institute, PBMV is done by Inoue and multi-track balloon catheter and transseptal puncture are done under fluoroscopic guidance, TEE is not used. The purpose of the study and the procedural risk-benefit ratio were explained in detail to the patient and the informed consent was taken. The hospital ethical review committee approved the study protocol. A detailed history with particular emphasis on heart failure symptoms, past medical history, and comorbid conditions were taken.

Transesophageal echocardiography (TEE) was performed by an echocardiographer with work experience of more than five years. TEE was performed in awake patients after administration of mild sedation, using a multiplane probe (GE Vivid S5 cardiovascular ultrasound, GE Healthcare, Inc., USA). All patients underwent transesophageal echocardiography within 24 h before the percutaneous mitral balloon valvuloplasty procedure. The bicaval view and 4 chamber view were used (transverse midesophageal short-axis view at the level of the aortic valve with the transducer plane at 90° and 0° respectively) to obtain maximal measurements of the interatrial septum in end-systole and end-diastole (Fig. 1). Bicaval view image of IAS thickness measurement in a patient with atrial fibrillation, measurements were done before the onset of QRS complex (Fig. 2). The depth was adjusted so that all measurements were performed at the same scale in all studies.

The data was entered and analyzed using SPSS v 21.0 and data was cross-validated by random checking. Frequencies and percentages were calculated for categorical variables, while the means ± standard deviation (SD) was calculated for continuous variables. Shapiro–Wilk test was applied to test the normality of distribution and appropriate Independent Sample *t*-test or Mann-Whitney *U* test was applied to compare the average thickness by baseline characteristics. Two-sided *p*-value of ≤0.05 was the set criteria of statistical significance.

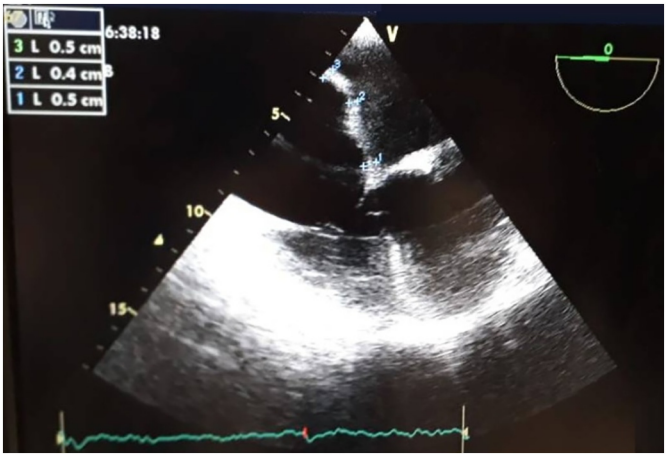

Fig. 2. Trans-esophageal echocardiography mid-esophageal level 4 chamber view (0°) of the interatrial septum in a patient with severe mitral stenosis in atrial fibrillation. (Points where thickness was measured: 2 = Region of gradual thinning at fossa ovalis, 1 = Superior region of constant thickness (SVC rim in bicaval view) and 3 = Inferior region of constant thickness (IVC rim in bicaval view), see text for details.)

3. Results

A total of 86 patients were included in the analysis. Almost three fourths (73.3%) were in the young age group of 14–29 and two thirds (62.8%) were females. Left ventricular dysfunction was observed in 25.6% [22] patients, this can be attributed to rheumatic myocarditis in our population. Only 5.8% [5] were diabetics, 3.5% [3] had past history of percutaneous mitral balloon valvuloplasty, 4.7% [4] had past history of mitral commissurotomy, while, 1.2% [1] had pulmonary arterial hypertension.

Table 1 presented the thickness measured on transesophageal echocardiography (TEE) at different sites during different phases. Mean thickness measured on transesophageal echocardiography (TEE) was 2.56 (SD 0.92) mm at anterior region (AR), 1.89 (SD 0.75) mm at fossa ovalis (FO), and 2.95 (SD 0.97) mm at posterior region (PR).

Comparisons of mean thickness by demographic and clinical characteristics of the patients are presented in Table 2. None of the demographic and clinical groups showed any statistically significant difference in thickness measured by transesophageal echocardiography (TEE). IAS thickness of four patients with prior history of mitral commissurotomy was found to be statistically insignificant.

4. Discussion

Longstanding severe rheumatic mitral stenosis is associated with changes in the atrial chamber dimensions; however, it is unclear if IAS

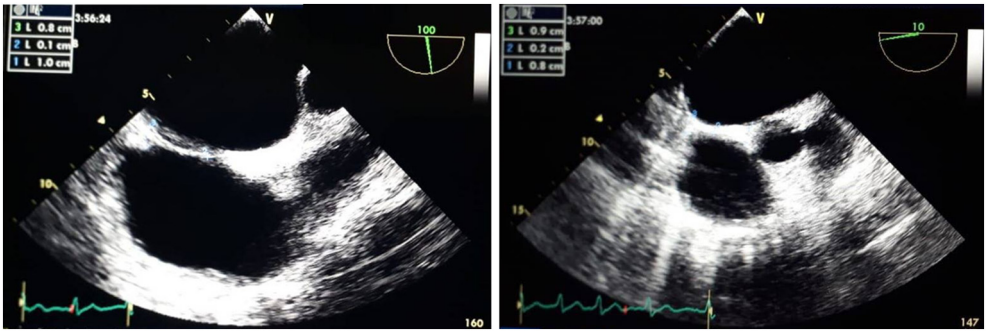

Fig. 1. Trans-esophageal echocardiography mid-esophageal level. (i) Bicaval view (100°) and (ii) modified 4 chamber view (7°) of the interatrial septum in a patient with severe mitral stenosis in sinus rhythm. (Points where thickness was measured: 2 = Region of gradual thinning at fossa ovalis, 1 = Superior region of constant thickness (SVC rim in bicaval view) and 3 = Inferior region of constant thickness (IVC rim in bicaval view), see text for details.)

Table 1
Thickness measured at different sites by transesophageal echocardiography (TEE).

Site	Anterior region (AR)	Fossa ovalis (FO)	Posterior region (PR)
Before AS	2.60 ± 0.89 mm	1.91 ± 0.75 mm	2.98 ± 0.99 mm
During AS	2.59 ± 0.90 mm	1.85 ± 0.77 mm	2.91 ± 0.97 mm
End VS	2.62 ± 0.92 mm	1.91 ± 0.77 mm	2.97 ± 1.00 mm
Overall mean	2.56 ± 0.92 mm	1.89 ± 0.75 mm	2.95 ± 0.97 mm

thickening increases proportionately with increasing severity of rheumatic mitral stenosis. Hence, this study was conducted with the aim to evaluate whether changes in the thickness or thinning of the IAS as measured by transesophageal echocardiography may be related to the severity of rheumatic mitral stenosis with respect to different phases of the cardiac cycle. Mean values of IAS thickness were similar in patients with moderate to severe rheumatic mitral stenosis as compared to the reported normal values of IAS thickness in autopsy heart [15].

We used the values of IAS thickness as published previously by Sweeney and Rosenquist [15] as normal reference values to compare with the values of our study population. This was chosen as we could not perform a TEE in a control group of healthy individuals without a standard indication for the procedure. Our results are in agreement with the autopsy findings of Sweeney and Rosenquist. In our study mean thickness was 2.56 (SD 0.92) mm at anterior region (AR), 1.89 (SD 0.75) mm at fossa ovalis (FO), and 2.95 (SD 0.97) mm at posterior region (PR). In their study the anterior margin of the IAS was the widest region, measuring 24 mm on average with a range of 15 to 34 mm. Between the fossa ovalis and anterior margin, there was an isthmus of tissue which measured an average width of 5 mm (range 2 to 13 mm) and posterior to the fossa ovalis, a tissue isthmus with an average width of 6 mm (range 2 to 11 mm). Another study by the same authors in autopsy heart specimens noted no change in the relative area and thickness at different locations of IAS despite a reduction in IAS area of almost 23% and increase in tissue thickness of 60% after fixation in formol. In all normal specimens, the fossa ovalis was the thinnest portion of the septum, averaging 0.4 mm in adults [16]. We compared baseline values of IAS thickness considering three different phases of the cardiac cycle as there are variations in IAS thickness measurement with both atrial systole and diastole. The findings from our study concord with the work by Schwinger and Galzerano [17,18].

Table 2
Baseline characteristics and comparisons of mean thickness by demographic and clinical characteristics of the patients.

Characteristics	% (n)	Mean thickness
Age		
14–29	73. 3% (63)	2.45 ± 0.66 mm
30 and above	26.7% (23)	2.52 ± 0.77 mm
		p-value = 0.66
Gender		
Male	37. 2% (32)	2.49 ± 0.65 mm
Female	62.8% (54)	2.46 ± 0.71 mm
		p-value = 0.81
Duration of onset of symptoms		
Up to 1 year	67. 4% (58)	2.39 ± 0.65 mm
>1–5 years	32.6% (28)	2.65 ± 0.73 mm
		p-value = 0.10
Rhythm		
Sinus rhythm	80. 2%(69)	2.42 ± 0.69 mm
Atrial fibrillation	19.8% (17)	2.69 ± 0.65 mm
		p-value = 0.14
Mitral stenosis		
Moderate	19.8% (17)	2.45 ± 0.83 mm
Severe	80. 2%(69)	2.48 ± 0.65 mm
		p-value = 0.88
Wilkin's score		
<8	86.0% (74)	2.44 ± 0.69 mm
8 and above	14.0% (12)	2.68 ± 0.65 mm
		p-value = 0.26
Size of atrium		
20–40	17.4% (15)	2. 27 ± 0.61 mm
>40	82.6% (71)	2.51 ± 0.70 mm
		p-value = 0. 22

Despite a tremendous surge in interventional and electrophysiology procedures utilizing transseptal puncture or device implantation across the inter-atrial septum, the role of IAS thickness assessment has not received much attention and is a rather less studied entity in literature. Evaluation of IAS anatomy is possible using transthoracic and transesophageal echocardiography [17–19], cardiac computed tomography imaging [20], magnetic resonance imaging [21] and intra-cardiac echocardiography [22].

There are few echocardiographic studies focusing on interatrial septal thickness measurement [17–19]. Only a small number of studies have been performed to characterize IAS thickness in normal subjects and in the presence of cardiac diseases [17]. However, we are not aware of any studies regarding the detailed evaluation of IAS thickness measurements in patients with valvular heart disease. The anatomy of the atrial septum distinguishes the portions of the atrial septum that may be consistently visualized from those that fall below the current limits of resolution of existing echocardiographic equipment. Transesophageal echocardiography provides a unique method for studying the anatomy of the IAS because of the close proximity of the high-frequency ultrasound beam to the IAS and the suitable angle of incidence between the interrogating beam to the axis of the IAS [11]. The IAS is the thickest peripherally at the site of its attachment to the atrial free walls and gradually narrows toward the more centrally located fossa ovalis. The interatrial septum is a region of varying flexibility with a concave anterior margin that follows the posterior aortic root, an inferior edge defined by the mitral annulus and a posterior portion that follows the posterior margins of the right and left atria [15,17].

Longstanding rheumatic mitral valve disease or previous mitral valve surgery may lead to calcification of the left atrium as an uncommon complication. It has been suggested that the calcification of the left atrium is a response to the chronic strain forces present in the setting of mitral disease [13,14]. A review by Harthorne et al. has remarked that the interatrial septum is often spared and free from calcification [1]. An increased IAST was noted in elderly patients with atrial fibrillation using transthoracic echocardiography [23]. Furthermore, Galzerano and associates have demonstrated eventual thinning of the interatrial septum once sinus rhythm is restored after conversion of AF [18]. These reported changes in atrial-wall thickness might correspond to changes in the atrial extracellular matrix components that might trigger atrial remodeling as documented by Xu et al. [24].

5. Study limitations

The limitation of our study was, it was not head to head comparison that is TEE of normal patients with the study population. No study of TEE mentioning the thickness of IAS was found in the literature probably of ethical issues. Our study is the first description to evaluate the relationship of IAS thickness in patients with valvular heart disease, especially rheumatic mitral stenosis. Furthermore, we could not ascertain if the values of IAS thickness measured by TEE in our study differs from normal individuals; this is due to lack of reference values for IAS thickness in normal individuals because performing TEE in normal individuals without a standard indication and just for having a control group values would not be ethically permissible.

6. Conclusions

Detailed understanding of the anatomy of the atrial septum is increasingly important for the interventionalist for the safe and effective performance of trans-septal puncture. Echocardiography is the preferred imaging modality for evaluating the IAS. IAS thickness measurement by

echocardiography provides a reasonable roadmap to guide transseptal puncture. IAS thickness measurement does not change in the presence of moderate to severe rheumatic mitral stenosis. A pre-procedural TEE may be sufficient and may obviate the need for detailed assessment of IAS thickness and anatomy relevant to the performance of transseptal catheterization in most patients. Reference values of IAS thickness in normal individuals by TEE need to be established in future studies.

Disclaimer

None to declare.

Conflict of interest

None to declare.

Source of funding

None to declare.

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