

Measurement of Atrial Septal Defect Size: A Comparative Study between Transesophageal Echocardiography and Balloon Occlusive Diameter Method

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Abstract

Background: Transcatheter closure of atrial septal defect secundum (ASD-II) has become an alternative method for surgery. We sought to compare the two-dimensional transesophageal echocardiography (TEE) method for measuring atrial septal defect with balloon occlusive diameter (BOD) in transcatheter ASD-II closure.

Methods: A total of 39 patients (71.1% female, mean age: 35.31 ± 15.37 years) who underwent successful transcatheter closure of ASD-II between November 2005 and July 2008 were enrolled in this study. Transthoracic echocardiography (TTE) and TEE were performed to select suitable cases for device closure and measure the defect size before the procedure, and BOD measurement was performed during catheterization via TEE. The final size of the selected device was usually either equal to or 1–2 mm larger than the BOD of the defect.

Results: The mean defect size obtained by TEE and BOD was 18.50 ± 5.08 mm and 22.86 ± 4.76 mm, respectively. The mean difference between the values of ASD size obtained by TEE and BOD was 4.36 ± 2.93 mm. In comparison with BOD, TEE underestimated the defect size in 94.9%, but TEE value being equal to BOD was observed in 5.1%. There was a good linear correlation between the two measurements: $BOD = 0.773 \times ASD \text{ size by TEE} + 8.562$; $r^2 = 67.9.1\%$. A negative correlation was found between TEE sizing and the difference between BOD and TEE values ($r = -0.394$, $p \text{ value} = 0.013$).

Conclusion: In this study, BOD was larger than ASD size obtained by two-dimensional TEE. However, TEE maximal defect sizing correlates with BOD and may provide credible information in device size selection for transcatheter ASD closure.

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Introduction

The secundum type atrial septal defect (ASD-II) is a common form of congenital heart disease with an incidence of 3.78 per 10,000 live births.¹ The transcatheter closure

of ASD-II has become an effective alternative method for surgery after the first attempt in 1976 by King and Mills.^{2,3}

An accurate measurement of ASD size and the determination of its spatial relationship with the neighboring structures are crucial for successful transcatheter closure.

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The stretch balloon diameter (SBD) measurement of ASD during catheterization is widely considered the gold standard for selecting the size of the device.⁴ Two-dimensional transesophageal echocardiography (2D-TEE) can provide valuable information about the size, position, and number of defects and the surrounding structures. It can also guide intracardiac device deployment procedures effectively.⁵⁻⁷ Balloon diameter measured at the point where the maximal diameter of the balloon prevents any residual shunt is recently evaluated as balloon occlusive diameter (BOD) sizing. Measurements by 2D-TEE have been shown to have better correlation with BOD than SBD. Balloon occlusive sizing is a commonly used method of ASD measurement in our institution.

Therefore, the aim of this study was to compare ASD sizing by two methods: 2D-TEE and BOD, in our catheterization laboratory.

Methods

Between November 2005 and July 2008, 46 patients with the secundum type atrial septal defect (ASD-II) that were appropriate in size, morphology, and rims to the neighboring structures according to transthoracic echocardiography (TTE) and TEE were referred to the catheterization laboratory in Tehran Heart Center for ASD closure.

The defect size was obtained via two methods: 1) pre-procedure TEE and 2) BOD under TEE guidance during catheterization.

Due to the growing nature of ASD-II, we hypothesized that the relation between the measurements by the two methods might vary with aging. We, therefore, divided the patients into two groups according to the age of ASD closure (age < 18 and age \geq 18 years) to examine this hypothesis.

Under local anesthesia, two-dimensional TEE was performed with a multi-plane 7.0 MHz TEE probe (Vivid 3, GE). The diameter of the defect was measured in various planes to obtain the maximal defect size. The sizes obtained in the most useful views consisted of mid-esophageal four-chamber view at 0°, short-axis view at 45-60°, and bicaval long-axis view at 90-110°. The maximal diameter of the defect was acquired during the cardiac cycle.

The rims of the defect were measured from the margin of the defect to the inferior vena cava, superior vena cava, right upper pulmonary vein, tricuspid and mitral valves, aorta, and coronary sinus wherever possible. Exclusion criteria for the device closure in this study were multiple ASDs and maximum ASD diameter > 30 mm, both assessed by TEE; and ASD rims \leq 5 mm, except for the anterior superior rim.

TEE was also performed for the second time during balloon sizing and device implantation.

During catheterization, an appropriate occluder device size was estimated by Amplatzer stretched balloon sizing

(AGA Medical). A cylindrical sizing balloon was inflated in the left atrium and then pulled back against the ASD. It was thereafter deflated to reach a size sufficient to enable it to be pulled into the right atrium through the defect. BOD was defined as the balloon size that completely occluded the ASD and prevented any shunt across the defect without deforming the balloon. The balloon diameter was measured directly on the screen connected to the fluoroscopy.

TEE was used to ensure that the balloon was perpendicular to the septum during the balloon sizing of the ASD. After releasing the device from the cable by unscrewing it, a final TEE examination was performed to demonstrate the position of the device and any residual shunting.

The numerical variables were presented as mean \pm SD (range), while the categorical variables were summarized by percentages. The continuous variables were compared using Student's t-test across the two age groups (age < 18 vs. age \geq 18 years) and compared via the paired t-test between the two defect sizing methods. The association between the maximal defect size of ASD obtained by two-dimensional TEE and BOD was assessed through the Pearson correlation and linear regression analysis. The graphical method of the Bland and Altman plot was also performed so as to assess the agreement between the two methods of clinical measurement. For the statistical analysis, the statistical software SPSS version 13.0 for Windows (SPSS Inc., Chicago, IL) was used. All the P-values were 2-tailed, with statistical significance being defined by $P \leq 0.05$.

Results

Forty-six patients fulfilled the initial inclusion criteria. Five patients were excluded because of the failure of the procedures, and complete data of two patients were not available. The remaining 39 patients (71.1% female) were included for further analysis. The mean age was 35.31 ± 15.37 years (range: 9-71 years). The mean maximal diameter measured by 2D-TEE was 18.50 ± 5.08 mm (range 10-31 mm), while the mean BOD was 22.86 ± 4.76 mm (range 12-31 mm). This difference was statistically significant (p value < 0.001). The mean difference between the values of the ASD size obtained by TEE and BOD was 4.36 ± 2.93 mm.

There was a good correlation between the TEE maximal defect sizing and BOD measurements ($r = 0.824$, p value < 0.001). By the linear regression analysis, $BOD = 0.773 \times \text{ASD size by TEE} + 8.562$; $r^2 = 67.9\%$. A negative correlation was found between TEE sizing and the difference between BOD and TEE values: the larger the TEE sizing, the smaller the difference between the TEE and BOD sizing ($r = -0.394$, p value = 0.013). In 94.9% of the cases, BOD values were larger and only in 5.1% were they similar to 2D-TEE. Furthermore, the Bland and Altman plot showed agreement

Table 1. Measurement of ASD by TEE and BOD according to age

	age <18 y (n=6)	age ≥18 y (n=33)	P**
TEE maximal diameter* (mm)	14.67±3.89 (10–19)	19.20±5.00 (10–31)	0.043
Balloon occlusive diameter* (mm)	18.83±4.31 (12–23)	23.60±4.52 (15–31)	0.022

*Data are presented as mean ± SD (range)

P**, referred for the comparison by Student's t-test between the two groups

ASD, Atrial septal defect; TEE, Transesophageal echocardiography; BOD, Balloon occlusive diameter

between the two measurements because the number of points laid out of the 95% range of agreement (± 1.96 SD) was less than 5% of all the observations (Figure 1).

As depicted in Table 1, in patients ≥ 18 years old, TEE and BOD measurements were significantly larger than those obtained in younger patients (p value = 0.022 and 0.042, respectively). The linear regression analysis of the two groups highlighted a higher correlation in the younger age group between the parameters obtained by TEE maximal defect sizing and BOD: $BOD = 1.031 \times ASD \text{ by TEE} + 3.712$ for age < 18 y ($r^2 = 86.3\%$, p value = 0.007); and $BOD = 0.712 \times ASD \text{ size by TEE} + 9.914$ for age ≥ 18 years ($r^2 = 62.3\%$, p value < 0.001)

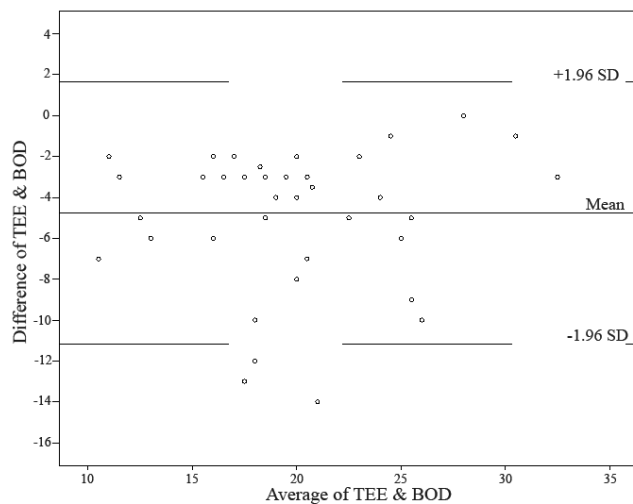


Figure 1. Bland & Altman plot for assessing agreement between the two methods of ASD measurement

TEE, Transesophageal echocardiography; BOD, Balloon occlusive diameter; SD, Standard deviation

Discussion

In our study, there was a good positive linear correlation between TEE and BOD measurements of ASD, while a negative correlation was found between TEE sizing and the difference between BOD and TEE values. The defect size obtained via BOD was greater than that via TEE.

The results of the present study were similar to the findings

of the Zhu et al. study,⁴ which showed that balloon sizing was larger than two-dimensional TEE measurements with a mean difference of 2.41 mm. Zhu et al. also found a good linear correlation between 2-dimensional TEE measurements and BOD.

In our study, the defect size measured via BOD was larger than that via two-dimensional TEE in 94.9% of the patients and there was a good agreement between the two (Figure 1). Also, in a study by El-Said and colleagues,⁸ in 81% of patients whose TEE results were available, the measurement obtained via stretch balloon diameter was larger than the pre-catheterization measurement by 2-dimensional TEE.

In our study, a negative correlation was found between TEE sizing and the difference between BOD and TEE values. McMahon et al.⁹ showed that up to two thirds of isolated secundum ASDs grew over an intermediate-term follow-up. In the present study, ASD size measured by either TEE or BOD was also significantly larger in patients over 18 years old. In patients >18 years of age compared to younger patients, the difference between BOD and TEE was smaller. This finding shows that in larger defects, TEE measurement is closer to BOD.

Conclusion

In this study BOD was larger than the ASD size obtained by 2-dimensional TEE. TEE maximal defect sizing correlates with BOD and is a good adjunct in selecting an appropriate device size in patients scheduled for transcatheter ASD closure.

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