2. Saito K, Okura H, Watanabe N, et al. Comprehensive evaluation of left ventricular strain using speckle tracking echocardiography in normal adults: comparison of three-dimensional and two-dimensional approaches. J Am Soc Echocardiogr 2009;22:1025–30.

3. Santoro C, Arpino G, Esposito R, et al. 2D and 3D strain for detection of subclinical anthracycline cardiotoxicity in breast cancer patients: a balance with feasibility. Eur Hear J Cardiovasc Imaging 2017;18:930–6.

4. Motoki H, Koyama J, Nakazawa H, et al. Torsion analysis in the early detection of anthracycline-mediated cardiomyopathy. Eur Heart J Cardiovasc Imaging 2012;13:95–103.

Focus on the Perimeter and Skip the Balloon

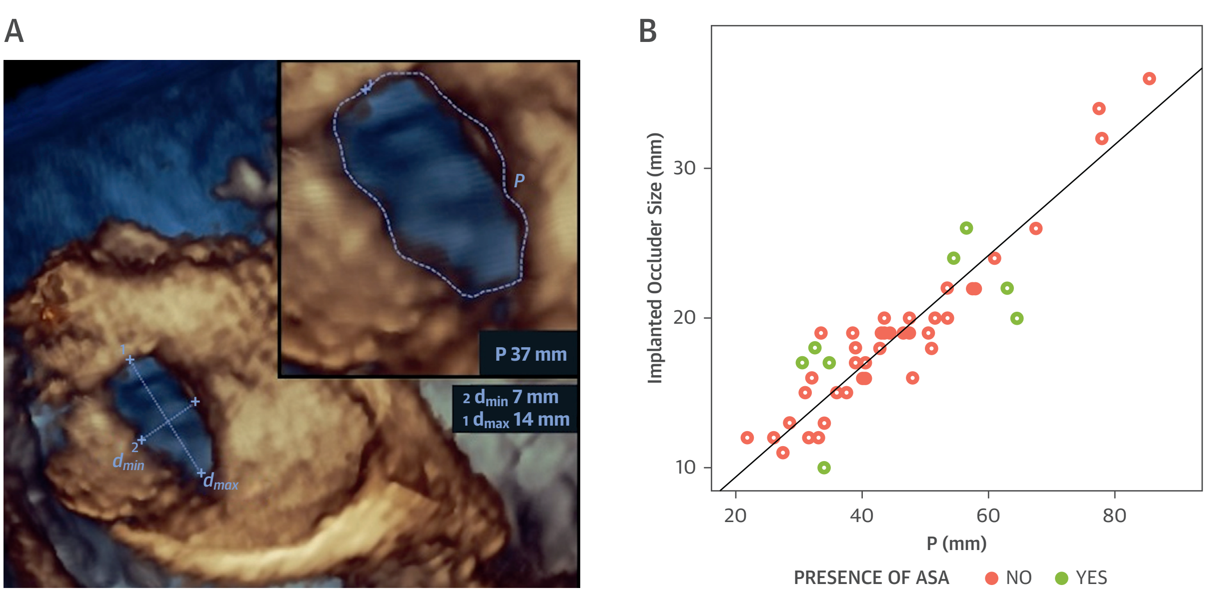
Can Atrial Septal Defect Be Percutaneously Closed Without Balloon Sizing in the Era of 3-Dimensional Echocardiography?

When technically feasible, device closure is the treatment of choice for ostium secundum atrial septal defect (ASD) (1). Three-dimensional (3D) transesophageal echocardiography (TEE) has recently emerged as a powerful tool that can accurately guide device selection in ASD closure (2,3). We aimed to investigate the utility of direct 3D TEE device sizing on the basis of the ASD perimeter.

As part of a single-center prospective observational study, 49 consecutive adults (73% women; mean age 50 ± 16 years) after successful transcatheter closure of a single ASD were enrolled between 2014 and 2016. Interventions were performed while patients were under general anesthesia, through a femoral venous access, using an Amplatzer Septal Occluder (St. Jude Medical, Inc., Little Canada, Minnesota). The actual size of the occluder implanted was chosen on the basis of the conventional strategy (i.e., 2-dimensional TEE with complementary balloon sizing). Blinded 3D TEE images were acquired before each procedure (Vivid 9 ultrasound machine, 6VT-D transducer, 3 to 8 MHz, GE Healthcare, Milwaukee, Wisconsin) for post-procedural processing. In particular, ASD perimeter was manually traced in a multiplanar en face view reconstructions in the end-systolic frame when it appeared largest. Maximum diameter (d_{max}), minimum diameter (d_{min}), and perimeter (P) were measured by 2 independent observers (**Figure 1A**). Defect shape was categorized as round or oval on the basis of the circular index (d_{max}/d_{min}), while considering defects with the ratio <1.5 as round.

Mean d_{max} was 15.7 ± 5 mm, mean d_{min} was 11.7 ± 3.9 mm, and mean P was 45.8 ± 14.2 mm. A total of 34 defects (69%) were classified as round. Mean balloon-stretched diameter and mean occluder size did not differ significantly (18.9 ± 4.9 mm and 18.9 ± 5.4 mm,

FIGURE 1 **Occluder Size Estimation on the Basis of ASD Perimeter**



(A) A 3-dimensional (3D) transesophageal echocardiography (TEE), full volume en face view reconstruction. Atrial septal defect (ASD) measurement: maximal diameter (d_{max}), minimal diameter (d_{min}), and perimeter (P). **(B)** Linear correlation between the implanted occluder size and atrial septal defect perimeter (P) measured by 3-dimensional transesophageal echocardiography; **pink dots** represent subjects without atrial septal aneurysm (ASA) (n = 41), and **green dots** represent subjects with atrial septal aneurysm (n = 8).

respectively; $p = 0.94$; 95% confidence interval: −0.20 to 0.22). Atrial septal aneurysm (ASA) defined according to the Pearson criteria (4) was present in 8 subjects (16%).

We observed a clear linear correlation between occluder size and defect perimeter, with the correlation coefficient (r) of 0.92 ($p < 0.001$). This relationship remained significantly stronger among patients without ASA than in patients with ASA ($r = 0.95$, $p < 0.001$ vs. $r = 0.70$, $p = 0.051$; $z = 2.03$; $p = 0.04$) (**Figure 1B**), independent of the defect shape.

Two mathematical formulas were proposed to predict the occluder size (D) in patients without ASA ($n = 41$). The first is a linear regression equation on the basis of 38 (93%) best-fitted observations, and it uses the 3D TEE defect perimeter (P) value exclusively:

$$D = 0.375 \times P + 1.81\,(\mathrm{mm})$$
$$r^2 = 0.94,\ p < 0.001$$

The other model was constructed for the whole study group, including outliers. Stepwise regression analysis was performed on a sample of 30 (73%) randomly chosen subjects and was then tested among the remaining 11 (27%). The formula is more complex, and apart from the 3D TEE measurements (P, d_{max}, d_{min}), it also incorporates the patient's age and sex:

$$\dot{D} = 0.0217 \times P - 0.0015 \times A' - 0.0018 \times X + 0.0385 \times Y + 1.6117$$
$$r^2 = 0.94,\ p < 0.001$$

A' is the calculated area of the defect according to the following ellipse area equation:

$$A' = \pi \times \frac{1}{2}\, d_{\max} \times \frac{1}{2}\, d_{\min}\,(mm^2)$$

X is age (years), and Y is sex (1 = male, 2 = female).

Because a non-normal data distribution was found in the subset of 30 observations, to obtain the estimated occluder size ($\dot{D} \rightarrow D$) in millimeters, Box-Cox re-transformation needs to be applied, as follows:

$$D = \sqrt[-0.149]{\dot{D} \times (-0.149) + 1}$$

A strong relationship between ASD perimeter and circumference of the implanted occluder was previously postulated by Zanchetta et al. (5) in their intracardiac echocardiography-based study. We assumed that such an association could be present for the 3D TEE-derived perimeter. Our results confirm a high correlation between these variables in subjects without ASA that may indirectly support the idea of obviating balloon sizing in such patients. Conversely, it shows that replacing balloon sizing with 3D TEE defect measurement in patients with ASA is not justified. It is probable that floppy septum tissue precludes credible reconstruction of the moving structures, and thus precise quantitative assessment of the defect cannot be accomplished.

This study points out the feasibility of ASD perimeter measured by 3D TEE as a viable alternative to balloon sizing. Certainly, further investigation is necessary to standardize the measuring technique and to validate the preliminary results.

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REFERENCES

1. Baumgartner H, Bonhoeffer P, De Groot NM, et al. ESC guidelines for the management of grown-up congenital heart disease (new version 2010). Eur Heart J 2010;31:2915–57.

2. Hascoet S, Hadeed K, Marchal P, et al. The relation between atrial septal defect shape, diameter, and area using three-dimensional transoesophageal echocardiography and balloon sizing during percutaneous closure in children. Eur Heart J Cardiovasc Imaging 2015;16:747–55.

3. Seo JS, Song JM, Kim YH, et al. Effect of atrial septal defect shape evaluated using three-dimensional transesophageal echocardiography on size measurements for percutaneous closure. J Am Soc Echocardiogr 2012;25:1031–40.

4. Pearson AC, Negelhout D, Castello R, et al. Atrial septal aneurysm and stroke: a transoesophageal echocardiography study. J Am Coll Cardiol 1991;18:1223–9.

5. Zanchetta M, Onorato E, Rigatelli G, et al. Intracardiac echocardiography-guided transcatheter closure of secundum atrial septal defect. J Am Coll Cardiol 2003;42:1677–82.