Three-dimensional echocardiography vs. computed tomography for transcatheter aortic valve replacement sizing

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Aims

The accuracy of transcatheter aortic valve replacement (TAVR) sizing using three-dimensional transoesophageal echocardiography (3D-TEE) compared with the gold-standard multi-slice computed tomography (MSCT) remains unclear. We compare aortic annulus measurements assessed using these two imaging modalities.

Methods and results

We performed a single-centre prospective cohort study, including 53 consecutive patients undergoing TAVR, who had both MSCT and 3D-TEE for aortic annulus sizing. Aortic annular dimensions, expected transcatheter heart valve (THV) oversizing, and hypothetical valve size selection based on CT and TEE were compared. 3D-TEE and CT cross-sectional mean diameter ($r = 0.69$), perimeter ($r = 0.70$), and area ($r = 0.67$) were moderately to highly correlated (all $P$-values $<0.0001$). 3D-TEE-derived measurements were significantly smaller compared with MSCT: perimeter (68.6 ± 5.9 vs. 75.1 ± 5.7 mm, respectively; $P < 0.0001$); area (345.6 ± 64.5 vs. 426.9 ± 68.9 mm², respectively; $P < 0.0001$). The percentage difference between 3D-TEE and MSCT measurements was around 9%. Agreement between MSCT- and 3D-TEE-based THV sizing (perimeter) occurred in 44% of patients. Using the 3D-TEE perimeter annular measurements, up to 50% of patients would have received an inappropriate valve size according to manufacturer-recommended, area-derived sizing algorithms.

Conclusion

Aortic annulus measurements for pre-procedural TAVR assessment by 3D-TEE are significantly smaller than MSCT. In this study, such discrepancy would have resulted in up to 50% of all patients receiving the wrong THV size. 3D-TEE should be used for TAVR sizing, only when MSCT is not available or contraindicated. The clinical impact of this information requires further study.

Keywords

transcatheter aortic valve replacement • three-dimensional (3D) transoesophageal echocardiography • multi-slice computed tomography

Introduction

Prosthesis size selection during conventional surgical aortic valve replacement (SAVR) is based on direct intraoperative measurement of the decalcified aortic annulus using a Hegar dilator. In contrast, transcatheter aortic valve replacement (TAVR) sizing relies on non-invasive imaging techniques. Appropriate TAVR sizing necessitates oversizing of the transcatheter heart valve (THV) relative to the native calcified aortic annulus and is of great importance to ensure effective THV anchoring, sealing, and function. Inappropriate THV sizing (too small or too large) can manifest as paravalvular aortic regurgitation (pAR), device embolization, aortic annular rupture, coronary occlusion, and/or prosthesis dysfunction. Such events are associated with adverse short- and long-term clinical outcomes.

Therefore, an in-depth understanding of aortic root anatomy has become pivotal, and imaging techniques have gained growing attention over the past few years. Despite lacking prospective randomized trials, the intuitiveness and convincing retrospective data have led the
medical community to embrace multi-slice computed tomography (MSCT) as the ‘gold standard’ for TAVR.\textsuperscript{7–11} Three-dimensional transoesophageal echocardiography (3D-TEE) has been proposed as a technique that provides equivalent annulus sizing to MSCT, without the latter’s distinct disadvantages: radiation and iodinated contrast media exposure; cost; motion artefact; and accessibility. In the current state of the art, however, there are concerns about the inferior spatial resolution of 3D-TEE relative to MSCT, compounded by the presence of calcium, which produce acoustic artefacts (side lobes) and may falsify the annular border.\textsuperscript{12,13} Not only is there a dearth of literature regarding 3D-TEE for transcatheter aortic valve sizing, the technique and results are also inconsistent.\textsuperscript{14–16} Hence, the clinical utility of 3D-TEE in TAVR sizing remains unclear.

In this prospective study, we sought to (i) compare MSCT and 3D-TEE-derived aortic annular measurements; and (ii) assess compliance with manufacturer-recommended TAVR sizing using 3D-TEE, with MSCT as the gold standard.

**Methods**

**Patient population and procedure**

From December 2013 to December 2014, 53 consecutive high-risk or inoperable patients with severe symptomatic aortic stenosis, and undergoing both MSCT and 3D-TEE prior to TAVR at our institution, were prospectively included in the study. The decision to proceed with TAVR was determined by the institutional Heart Team. All procedures were performed under general anaesthesia using the Medtronic CoreValve (Minneapolis, MN, USA) and Edwards SAPIEN (Irvine, CA, USA) devices, as previously described.\textsuperscript{3,8,17} CT-derived aortic annular diameters determined THV size selection. 3D-TEE datasets originally obtained for intra-procedural guiding of valve implantation were retrospectively analysed to determine 3D-TEE-derived annular diameters. This study was approved by the local ethics committee, and all patients provided written informed consent.

**Echocardiography acquisition and measurements**

Two-dimensional (2D)- and 3D-TEE were performed using a commercially available TEE transducer (Vivid 9; GE Healthcare, Milwaukee, WI, USA) according to guideline-recommended protocols.\textsuperscript{18–20} The aortic annulus was measured using 2D-TEE in the mid-oesophageal three-chamber view ($\approx$ 120°–135°) during mid-systole. Maximal diameter of the aortic annulus was determined through concomitant orthogonal views with biplane imaging. Major and minor diameters, the annular circumference (perimeter), and area were also measured, and 3-TEE volume datasets were stored for offline multi-plane reconstruction analysis. Aortic annular indices were obtained in two parallel orthogonal planes bisecting aortic valve in long and short axes (at three aortic cusp insertions). These datasets were manually adjusted, and a third orthogonal plane was centred to ensure proper alignment. The perimeter and area of the aortic annulus were obtained by direct planimetry in the short-axis view (Figure 1).

**Multi-slice computed tomography acquisition and measurements**

**CT acquisition protocol**

All examinations were performed on a Somatom Definition Flash CT scanner (Siemens AG, Munich, Germany), using standard technical parameters: gantry rotation time: 0.28 ms; axial coverage: 0.75 mm [128 $\times$ 0.6 mm]; 80–120 kV tube voltage [weight-adjusted]; milliampere intensity with Care Dose 4D modulation; temporal resolution: 70 ms.

![Figure 1](https://academic.oup.com/ehjcimaging/article-abstract/17/1/15/2464832)
Electrocardiographic gating was done. Contrast enhancement was achieved using 60–100 mL of iomeprol 350 mg/mL (lomeron, Bracco Imaging SpA, Milan, Italy). For optimal synchronization, a bolus tracking method was administered at heart rates above 70 bpm. Thickness of reconstructed images was 0.5 mm (0.8-mm increments).

**CT reconstruction and aortic annular measurements**

Aortic annulus measures were assessed in multiple plane reconstruction using dedicated software (OsirIX MD) during systole. The aortic annulus was defined as the virtual ring at the level of the basal attachments of all three valvular cusps. Multiplanar reconstructions were manually oriented to display the aortic annulus at basal attachment points. As with 3D-TEE evaluations, two orthogonal planes were manually set, bisecting the aortic valve in sagittal and coronal planes. The third orthogonal plane (double-oblique transverse view) was set to bisect aortic annulus at the most caudal attachment points of all three native cusps, orientating positioning the virtual ring as in TEE short-axis view. Dimensions of the aortic annulus were carefully assessed, including major and minor orthogonal diameters. Cross-sectional area and perimeter were measured by manually tracking luminal contours of double-oblique transverse planes (Figure 1).

**Aortic annular measurements, definitions, and geometric analysis**

Aortic annulus measurements via 3D-TEE and MSCT were as follows: major and minor orthogonal diameters, area (mm²), and perimeter (mm). The mean annular diameter (mm) was calculated as the average of the major and minor diameters ($D_{\text{mean}}$ and $D_{\text{max}}$). The area- and perimeter-derived diameters were calculated as follows: $D_{\text{area}} = 2 \times \sqrt{\text{Area}/\pi}$ and $D_{\text{perimeter}} = \text{perimeter}/\pi$. The circularity of the aortic annulus was indicated by the eccentricity index ($1 – D_{\text{min}}/D_{\text{max}}$), and an ellipsoid-aortic annulus was defined as an eccentricity index $>0.1$. CT and echo readers experienced in TAVR imaging performed 3D-TEE and MSCT measurements. For each modality, readers were blinded to results of measurements from the other modality. The aortic annulus was indicated by the eccentricity index ($1 – D_{\text{min}}/D_{\text{max}}$), and an ellipsoid-aortic annulus was defined as an eccentricity index $>0.1$. CT and echo readers experienced in TAVR imaging performed 3D-TEE and MSCT measurements. For each modality, readers were blinded to results of measurements from the other modality. The strength of correlation (correlation coefficient, $r$) between TEE and MSCT was interpreted as follows: low or weak, $≤0.35$; modest or moderate, $0.36–0.67$; strong or high, $0.68–1.0$; and very high, $>0.90$. As stipulated by the Valve Academic Research Consortium (VARC) consensus documents and current echocardiographic guidelines (EAE/AE and ASE/SCA), pAR after TAVR was graded as trace, mild, moderate, or severe.

**Statistical analysis**

Continuous variables were expressed as mean ± standard deviation or median and inter-quartile range, according to Gaussian or non-Gaussian distribution. Categorical variables were presented as frequencies and percentages. Multiple comparisons of aortic annular measurements will be analysed using analysis of variance (ANOVA) with Bonferroni correction or with the Kruskal–Wallis test. Pearson correlation coefficients were used to assess correlation between echocardiographic and MSCT measurements. Agreement between techniques was plotted using the Bland–Altman method. Predictors of difference between mean annular perimeter determined by 3D-TEE and MSCT were identified through univariate and multivariate linear regression models. To assess inter-observer variability in annulus measurements by 3D-TEE and MSCT, 30% (15/53) of imaging studies were examined by a second reader.
was 82.8 ± 6.8 years, and 60% (32/53) of patients were male. The mean Society of Thoracic Surgeons Predicted Risk of Mortality (STS-PROM) score was 6.3 ± 4.3%. Most patients (94%, [50/53]) received the Medtronic CoreValve: (23 mm, 2% [1/53]; 26 mm, 50% [25/53]; 29 mm, 36% [18/53]; 31 mm, 12% [6/53]). Post-implantation, three (6%) patients met the criteria for moderate pAR, and the remainder of cases had none, trace, or mild pAR.

### Comparison of 2D-TEE and 3D-TEE and MSCT for aortic annulus measurements

Using 2D-TEE, mean sagittal annulus measurement was 20.3 ± 1.9 mm. The sagittal annulus measurement significantly underestimated 3D-TEE (−0.5 to 1.5 mm) and MSCT (−2.5 to 3.5 mm) diameters measurements (Table 3, Figure 2).

#### Table 2 Procedural characteristics, n = 53

<table>
<thead>
<tr>
<th>Access</th>
<th>Valve Type, % (mean ± SD)</th>
<th>Overall cohort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transfemoral direct</td>
<td>Medtronic CoreValve</td>
<td>50 (94.3)</td>
</tr>
<tr>
<td>Transfemoral cut down</td>
<td>Lotus/Edwards SAPIEN</td>
<td>2/1 (5.7)</td>
</tr>
<tr>
<td>Valve size</td>
<td>23</td>
<td>2 (2.8)</td>
</tr>
<tr>
<td></td>
<td>26</td>
<td>25 (47.2)</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>2 (3.8)</td>
</tr>
<tr>
<td></td>
<td>29</td>
<td>18 (34.0)</td>
</tr>
<tr>
<td></td>
<td>31</td>
<td>6 (11.3)</td>
</tr>
<tr>
<td>Access</td>
<td>Transaortic/parasternal</td>
<td>4 (7.5)</td>
</tr>
<tr>
<td>Fluoroscopy time, min (mean ± SD)</td>
<td>25.0 ± 13.8</td>
<td></td>
</tr>
<tr>
<td>Pre-Balloon aortic valvuloplasty</td>
<td>35 (66.0)</td>
<td></td>
</tr>
<tr>
<td>Post-dilatation</td>
<td>9 (17.0)</td>
<td></td>
</tr>
<tr>
<td>Access</td>
<td>Moderate–severe post-implantation AR</td>
<td>3 (5.7)</td>
</tr>
</tbody>
</table>

Unless specified otherwise, values are n (%) of patients.

#### Table 3 Comparison between 2D- and 3D-TEE and MSCT aortic annulus measurements (n = 50)

<table>
<thead>
<tr>
<th></th>
<th>3D-TEE measurement</th>
<th>MSCT measurement</th>
<th>3D-TEE-2D-TEE-sagital</th>
<th>R*</th>
<th>MSCT-2D-TEE-sagital</th>
<th>R*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diam mean, mm</td>
<td>21.7 ± 1.9</td>
<td>22.8 ± 2.2</td>
<td>−1.43 ± 1.65**</td>
<td>0.62*</td>
<td>−2.51 ± 1.99**</td>
<td>0.49*</td>
</tr>
<tr>
<td>Diam perimeter, mm</td>
<td>21.8 ± 1.9</td>
<td>23.9 ± 1.8</td>
<td>−1.49 ± 1.65**</td>
<td>0.61*</td>
<td>−3.61 ± 2.11**</td>
<td>0.39*</td>
</tr>
<tr>
<td>Diam area, mm</td>
<td>20.8 ± 1.9</td>
<td>23.3 ± 1.8</td>
<td>−0.53 ± 1.87**</td>
<td>0.52*</td>
<td>−2.97 ± 2.14**</td>
<td>0.40*</td>
</tr>
</tbody>
</table>

R, Pearson correlation coefficient; MSCT, multi-slice computed tomography; TEE, transoesophageal echocardiography.

*Significant P-value for the Pearson correlation: *, <0.05

**Significant P-value for the difference (Bland–Altman plots for agreement between methods), P < 0.05

### Comparison of 3D-TEE and MSCT for aortic annulus measurements

Reliability assessment of aortic measurements done by cross-sectional CT and 3D-TEE indicated good reproducibility. Intra-class correlation for inter-observer variability ranged from 0.63 to 0.95 for 3D-TEE and from 0.89 to 0.96 for MSCT.

Moderate to high correlation was observed between 3D-TEE and CT mean measurements (diameter: r = 0.69; P < 0.0001; perimeter: r = 0.70, P < 0.0001; area: r = 0.67, P < 0.0001) (Table 3). However, 3D-TEE measurements were significantly smaller compared with those obtained by MSCT (perimeter: 68.6 ± 5.9 vs. 75.1 ± 5.7 mm, Bland–Altman analysis systematic difference of −6.5 mm (limits, −15.4 to 2.3 mm), P < 0.0001); area [345.6 ± 64.5 vs. 426.9 ± 68.9 mm²; Bland–Altman analysis systematic difference of −81.3 mm (limits, −186.9 to 24.3 mm), P < 0.0001] (Table 3, Figure 3A and B).

### Adherence to THV-sizing criteria

The distribution of THV size selection based on the MSCT- and 3D-TEE-generated perimeter values is illustrated in Figure 4. On the basis of CT-perimeter, a 23-mm THV was selected in 2% (1/50) of patients, a 26-mm THV in 40% (20/50) of patients, a 29-mm THV in 50% (25/50) of patients, and a 31-mm THV in 8% (4/50) of patients. On the basis of TEE perimeter, a 23-mm THV was selected in 20% (10/50) of patients, a 26-mm THV in 48% (24/50) of patients, a 29-mm THV in 32% (16/50) of patients, and a 31 mm in none. Mean relative oversizing was 15.9 ± 4.7% (range, 12.3–19.6%) for CT-perimeter-based THVs selected and 27.1 ± 8.5 (range, 23.5–39.7%) for TEE-perimeter-based THVs (P < 0.001) (Figure 4). Agreement between MSCT- and 3D-TEE-based THV sizing (perimeter) occurred in 44% (22/50) of patients. Using the 3D TEE-perimeter annular measurements, with MSCT as the gold standard, 50% of patients would have received an inappropriate valve size according to manufacturer-recommended perimeter-derived sizing algorithms (Table 4).

When hypothetical THV selected was based on MSCT and 3D-TEE area, agreement for THV sizing between 3D-TEE and MSCT was found in 19 of 50 patients (38%), and using 3D-TEE-area annular measurements, 60% of patients did not achieve the recommended THV-sizing criteria and would have received an inappropriate valve size according to manufacturer-recommended area-derived sizing algorithms. Frequencies of hypothetical THV selected based on CT and 3D-TEE-area are illustrated in Figure 4.

Figure 2, Table 3, Figure 3A, B, Figure 4.
Table 5 shows predictors identified through univariate and multivariate analyses of difference between mean annular perimeters generated by 3D-TEE and MSCT. On multivariate analysis, only larger aortic annulus by CT scan ($b = 0.472; 95\% \text{ CI}, 0.219–0.725; p < 0.001$) predicted increasing difference in mean annular perimeter between mean annular perimeters generated by 3D-TEE and MSCT. For each 1-mm increase in aortic annular perimeter, between-method difference increased by 0.486.

**Discussion**

Major findings of this study are as follows: (i) aortic annular diameters determined by 2D- and 3D-TEE were significantly smaller than those obtained by MSCT, the percentage difference between 3D-TEE and MSCT measurements being $\sim 9\%$; (ii) concordant THV size selection between 3D-TEE and MSCT-based perimeter, occurred in only 44\% of patients; (iii) using 3D-TEE perimeter annular measurement, with MSCT as the gold standard, up to 50\% of patients would have received an inappropriately sized transcatheter aortic valve. Other groups confirmed these results.8–11 In the last 2–3 years, the community has rapidly shifted towards the use of MSCT for transcatheter aortic valve size selection, and the medical community has embraced it as the gold standard for THV size selection.7,10 In our study, MSCT-derived aortic annular diameters and perimeter determined THV size selection.

Analogous to MSCT, 3D-TEE can provide a perimeter or area measurement of the non-circular aortic annulus. Our group thought that 3D-TEE might become the gold-standard imaging modality for THV sizing. However, our data are consistent with other groups that have demonstrated underestimation of annulus measurements by 3D-TEE compared with MSCT measurements.13,14 Accordingly, the observation of a percentage difference between 3D-TEE and MSCT measurements of $\sim 9–13\%$ is important, as the application of 3D-TEE measurements to sizing cut-offs originally defined for CT parameters could lead to gross prosthesis under-sizing and the potential for more pAR.

Differences in aortic annular measurements obtained by 3D-TEE and MSCT may be attributed to the lower spatial resolution of 3D-TEE volumetric imaging, the need for standard protocols to accurately locate annular plane and avoid ultrasound artefacts, and existing software that relies largely on manual measurements. Our data and most of the data assessing utility of 3D-TEE in this setting have accrued from annular dimensions determined in orthogonal

![Figure 2](https://academic.oup.com/ehjcimaging/article-abstract/17/1/15/2464832/19)

**Figure 2** Annulus diameters measured using 2D- and 3D-TEE and computed tomography (CT). Data are means and 95\% confidence intervals. ANOVA, analysis of variance.
Figure 3  Bland–Altman plots comparing 3D-TEE and MSCT annular measurements. Comparison of mean annular (A) perimeter and (B) area determinations by 3D-TEE and MSCT. For perimeter, systematic difference was –6.47 mm (black line); limits of agreement were 15.3 and 2.3 mm (dotted red lines) (A). For area, systematic difference was –81.3 mm (black line); limits of agreement were 186.9 and 24.3 mm (dotted red lines) (B).
Figure 4  Hypothetical prosthesis size selection based on MSCT and 3D-TEE perimeter (A) and area (B). Agreement for THV sizing between 3D-TEE and MSCT was found in 22 of 50 patients (44%) for perimeter and 19 of 50 patients (38%) for area.

Table 4  Comparison between 3D-TEE and MSCT aortic annulus measurements (n = 50)

<table>
<thead>
<tr>
<th></th>
<th>3D-TEE measurement</th>
<th>MSCT measurement</th>
<th>R</th>
<th>P-value (R)</th>
<th>Difference: 3D-TEE-MSCT</th>
<th>P-value (for difference)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diam max, mm</td>
<td>23.4 ± 2.2</td>
<td>26.1 ± 2.1</td>
<td>0.61</td>
<td>&lt;0.0001</td>
<td>−2.7 ± 2.04</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Diam min, mm</td>
<td>20.2 ± 2.2</td>
<td>19.5 ± 2.4</td>
<td>0.51</td>
<td>0.0001</td>
<td>−0.67 ± 2.1</td>
<td>0.0235</td>
</tr>
<tr>
<td>Diam mean, mm</td>
<td>21.8 ± 1.9</td>
<td>22.8 ± 2.0</td>
<td>0.69</td>
<td>&lt;0.0001</td>
<td>−1.00 ± 1.5</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Perimeter, mm²</td>
<td>68.6 ± 5.9</td>
<td>75.1 ± 5.7</td>
<td>0.70</td>
<td>&lt;0.0001</td>
<td>−6.5 ± 4.5</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Area, mm²</td>
<td>345.6 ± 64.5</td>
<td>426.9 ± 68.9</td>
<td>0.67</td>
<td>&lt;0.0001</td>
<td>−81.3 ± 53.9</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Eccentricity Ind., mm</td>
<td>0.13 ± 0.09</td>
<td>0.25 ± 0.07</td>
<td>0.14</td>
<td>0.31</td>
<td>−0.12 ± 0.10</td>
<td>less than 0.0001</td>
</tr>
</tbody>
</table>

n = 53 for both MSCT and 3D-TEE. Unless specified otherwise, values are mean ± SD.
3D, 3-dimensional; Diam Area, average diameter based on area; Diam max, maximum orthogonal diameter; Diam min, minimum orthogonal diameter; MSCT, multi-slice computed tomography; R, Pearson correlation coefficient; TEE, transoesophageal echocardiography; EI, eccentricity index of the annulus (mm): [1 − (minimum diameter/maximum diameter)].

Table 5  Univariate and multivariate predictors of increased annulus perimeter mean difference between MSCT and 3D-TEE

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Univariate HR</th>
<th>(95% CI)</th>
<th>P-value</th>
<th>Multivariate HR</th>
<th>(95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSCT perimeter, mm</td>
<td>0.486</td>
<td>0.221 to 0.751</td>
<td>&lt;0.001</td>
<td>0.472</td>
<td>0.219 to 0.725</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>BSA, m²</td>
<td>−0.059</td>
<td>−4.313 to 4.432</td>
<td>0.98</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valve size, mm</td>
<td>−0.035</td>
<td>1.127 to 0.516</td>
<td>0.459</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sinus calcification</td>
<td>−0.579</td>
<td>−3.782 to 2.623</td>
<td>0.718</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annulus calcification</td>
<td>0.348</td>
<td>−2.015 to 2.710</td>
<td>0.54</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eccentricity Ind. ≥0.25</td>
<td>−4.123</td>
<td>−7.211 to 1.054</td>
<td>0.01</td>
<td>−2.254</td>
<td>−5.192 to 0.685</td>
<td>0.13</td>
</tr>
</tbody>
</table>
planes or annular areas traced directly in the short-axis plane. There are substantial limitations to direct tracing of aortic annulus from 3D short-axis images. Even minor tracing errors may significantly affect perimeter and, even more so, area measurements. Partial acoustic shadowing of the annulus also creates regions of dropout, and ectopic calcification or acoustic artefacts (side lobes) may falsify the annular border. We found that larger aortic annular size was the only independent predictor of increasing difference in mean perimeter values generated by CT and 3D-TEE. A larger annulus may thus increase the risk of error by direct 3D-TEE tracing.

Improvements in 3D-TEE software should include more automated measurements and incorporate different views of the annulus for more accurate identification and sizing. Hahn et al. have used a novel 3D-TEE software that might be comparable with MSCT in reproducibility. This software engages adjacent structures, such as the septum and anterior mitral leaflet, to more reliably locate the annular plane and avoid ultrasound artefacts.2,7 Ultimately, broader and larger studies are needed to directly compare these two imaging modalities, before 3D-TEE becomes a true alternative to MSCT for pre-procedural TAVR sizing.

**Limitations**

This single-centre analysis is subject to inherent limitations. 3D-TEE and CT data were retrospectively re-analysed, to determine hypothetical CT- and 3D-TEE-derived annular diameter, from datasets. However, patient inclusion and data collection were prospective. Although our findings suggest that 3D-TEE-based annular measurements likely would increase usage of smaller valves in a greater proportion of patients, this tenet was established hypothetically and was not actually tested in a prospective trial. However, our data are consistent with other groups that have demonstrated similar results. Also, our data and most of the data assessing utility of 3D-TEE in this setting have accrued from annular dimensions determined in orthogonal planes or annular areas traced directly in the short-axis plane. Improvements in 3D-TEE software with more automated measurements and incorporation of different views of the annulus for more accurate identification and sizing might reduce the current limitations of 3D-TEE measurements. Two CT and echo readers experienced in TAVR imaging performed 3D-TEE and MSCT measurements. For each modality, readers were blinded to results of measurements from the other modality. Despite we report a good reproducibility, this could introduce some inaccuracy in the measurements. Due to the low rate of par in our study, aortic annular measurements and degree of pAR could not be directly compared. This study does not account for variation in local practices of percutaneous aortic valve implantation. Most patients in this series received Medtronic CoreValve devices, so our analysis may not apply to other TAVR devices.

**Conclusions**

Compared with MSCT, aortic annular measurements by 3D-TEE are significantly smaller. Valve selection would be inappropriate for half of intended recipients by relying solely on 3D-TEE determinations, especially at larger annular sizes.

**Conflict of interest:** none declared.

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Three-dimensional echocardiography vs. computed tomography for aortic annular measurements

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Supplementary data are available at J Am Coll Cardiol online.

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FDG-PET/CT for driveline infection in a patient with implantable left ventricular assist device

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The patient in this case was a 41-year-old man who had undergone implantable left ventricular assist device (LVAD) implantation (DuraHeart, Terumo, Japan) 8 months before due to refractory heart failure caused by hypertensive heart disease. The patient had suffered from epigastric pain for 1 week, and a plain computed tomography (CT) scan did not show any causal diseases. As it was not possible to perform a contrast-enhanced CT scan because of renal impairment, an 18F-fluorodeoxyglucose (FDG)-positive emission tomography (PET)/CT scan was performed in order to identify the focus of the pain. Abnormal FDG uptake was observed around the driveline (pre-treatment, left panel), and we therefore diagnosed a driveline infection. At the same time, the patient also suffered from high-grade fever and serum C-reactive protein (CRP) level was elevated to 4.89 mg/dL. Intravenous administration of ciprofloxacin was immediately initiated, taking into consideration the drug sensitivity of Pseudomonas aeruginosa at the driveline exit site. After the antibiotic treatment for 1 month, CRP level became negative. And, FDG-PET/CT showed significantly decreased FDG uptake (maximum standardized uptake value; 6.20 to 2.54) around the driveline (post-treatment, right panel).

LVAD implantation is an important therapeutic option for patients with end-stage heart failure. However, there are numerous potential device-related complications that are not negligible. Driveline infection is a potentially life-threatening complication, as well as impairing quality of life. Therefore, early detection of device-related infection is critical. FDG-PET/CT is highly sensitive for the detection of an inflammatory response. This is the first case report of an LVAD-related infection detected by FDG-PET/CT, and showing the change in FDG uptake before and after antibiotic therapy. For patients with suspected LVAD-related infections, FDG-PET/CT is useful for early detection of infection and evaluation of the response to antibiotic therapy.

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