Value of 3D TEE for LAA Morphology

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THE LEFT ATRIAL APPENDAGE (LAA) IS ONE OF THE MAJOR SITES OF CARDIAC THROMBUS FORMATION. Recently, a large retrospective study found a relationship between specific types of LAA morphology and earlier thromboembolic events by means of computed tomography (CT) and cardiac magnetic resonance (CMR). In particular, minor events were seen in chicken wing LAA morphology. CT and CMR are unfavorable in terms of costs and availability, and CT confers a significant radiation exposure. In contrast, 3-dimensional transesophageal echocardiography (3D TEE) is a novel imaging tool that captures detailed anatomic information and can easily and cost effectively be integrated into clinical routine (Figures 1 and 2). Although earlier studies showed high concordance for LAA morphology data derived from 3D TEE and porcine LAA specimens, the role of 3D TEE in the clinical setting had not been evaluated.

We propose that the evaluation of LAA morphology by 3D TEE is reliable and is not inferior to CT and CMR evaluation (Table 1, Figures 3 and 4).

<table>
<thead>
<tr>
<th>Evaluation in 3D TEE</th>
<th>LAA Morphology in 2D Imaging Reconstruction (CT/CMR)</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chicken wing</td>
<td>21</td>
<td>0</td>
</tr>
<tr>
<td>Non-chicken wing</td>
<td>0</td>
<td>45</td>
</tr>
<tr>
<td>Sum</td>
<td>21</td>
<td>45</td>
</tr>
</tbody>
</table>

Assuming 2-dimensional (2D) imaging reconstruction by computed tomography (CT) or cardiac magnetic resonance (CMR) as the gold standard, 3-dimensional (3D) trans-esophageal echocardiography (TEE) shows 100% sensitivity and specificity in the differentiation between chicken wing and non-chicken wing morphology. Non-chicken wing morphology is considered to comprise those left atrial appendage (LAA) types with a higher rate of thromboembolic events.

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All transesophageal echocardiography (TEE) studies were performed using an iE33 echocardiography system with an X7-2t live 3-dimensional (3D) TEE transducer (Philips Medical Systems, Best, the Netherlands). A pyramidal 3D zoom dataset of the entire left atrial appendage (LAA) was analyzed offline (QLAB version 8, Philips Medical Systems). First, (A) frontal and (B) sagittal multiplanar reconstruction planes were arranged along the longitudinal axis of the main LAA lobe, and then the (C) horizontal plane was aligned to depict a cross section of the LAA ostium. In multiplanar reconstructions, every plane can be shifted and separately rotated around its own axis to evaluate the whole LAA morphology (LAA type and number of lobes).
FIGURE 2  Trimming of 3D Zoom Datasets

For optimal illustration of the LAA type, the pyramidal 3D zoom dataset was trimmed by using QLAB version 8 (Philips Medical Systems). In detail, (A and B) the 3D zoom dataset was cut down to the image section optimally reflecting LAA morphology, on the basis of earlier multiplanar reconstruction (see Figure 1). (C) By subsequent rotation, and (D) by optimization of gain, brightness, and contrast, the final LAA image was retrieved. Abbreviations as in Figure 1.

FIGURE 3  Comparison of LAA Morphology in CT Reconstruction and 3D TEE

LAA computed tomography (CT) angiography was performed on a 128-slice CT scanner (SOMATOM Definition AS+, Siemens, Forchheim, Germany) with administration of iomeprol 400 mg iodine/ml (Iomeron 400 MCT, Bracco Imaging, Milan, Italy). (A) 3D reconstruction was rendered at a post-processing workstation (syngo.via version 11, Siemens Healthcare, Erlangen, Germany). (B) 3D TEE methodology is described in the legends for Figures 1 and 2. The agreement in differentiating all 4 LAA types showed promising results in CT versus 3D TEE: LAA type: $\kappa = 0.83$, $p < 0.001$; number of lobes: $r = 0.88$, $p < 0.001$ (n = 33). Interobserver agreement was good for classification in chicken wing versus non-chicken wing LAA (each $\kappa = 0.93$, $p < 0.001$) and in assignment of all 4 LAA types (CT: $\kappa = 0.87$, $p < 0.001$; 3D TEE: $\kappa = 0.85$, $p < 0.001$). Agreement in number of lobes was good in CT ($r = 0.73$, $p < 0.001$) and fair in 3D TEE ($r = 0.59$, $p < 0.001$). Abbreviations as in Figure 1.
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Magnetic resonance (MR) angiography was performed on an Achieva 1.5T cardiac magnetic resonance (CMR) scanner (Philips Medical Systems) with a 32-channel SENSE phased array coil. (A) 3D angiography datasets were provided by a fast field echo sequence (repetition time/echo time [TR/TE] = 4.1/1.13 ms, flip angle [FA] = 35°, res = 1 × 1 × 1.5 cm³) and a bolus of 25 to 30 ml contrast agent (gadoteric acid 0.5 mmol/ml, Dotarem, Guerbet, Sulzbach, Germany). Automated segmentation was done with Extended MR Workspace Xplore version 2 (Philips Medical Systems). (B) 3D TEE methodology is described in the legends for Figures 1 and 2. The agreement in differentiating all 4 LAA types showed promising results in CMR versus 3D TEE (LAA type: $\kappa = 0.75$, $p < 0.001$; number of lobes: $r = 0.91$, $p < 0.001$ [n = 33]). Interobserver agreement was good in all modalities, both for classification in chicken wing versus non-chicken wing LAA (each $\kappa = 0.93$, $p < 0.001$), and in assignment of all 4 LAA types (CMR: $\kappa = 0.95$, $p < 0.001$; 3D TEE: $\kappa = 0.85$, $p < 0.001$). Concerning the number of lobes, interobserver agreement was best in CMR ($r = 0.88$, $p < 0.001$). Abbreviations as in Figure 1.

**FIGURE 4** Comparison of LAA Morphology in CMR Reconstruction and 3D TEE

- **Chicken Wing LAA Morphology in (A) MRI and (B) 3D-TEE**
- **Windsock LAA Morphology in (A) MRI and (B) 3D-TEE**
- **Cactus LAA Morphology in (A) MRI and (B) 3D-TEE**
- **Cauliflower LAA Morphology in (A) MRI and (B) 3D-TEE**