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EDITORIAL COMMENT

Classical methods to measure aortic valve area in the era of new invasive therapies: still accurate enough?

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Aortic stenosis is the most common native valve disease, with increasing prevalence among the ageing population of the Western countries [1, 2]. Aortic valve replacement is the only effective treatment for patients with severe, symptomatic aortic stenosis [3]. However, there are certain groups of patients who are denied surgery because of high risk of operative mortality [4]. Particularly, older age and left ventricular dysfunction have been related to high operative risk and poor outcome after aortic valve replacement [5, 6].

In order to provide to these high-risk patients a less-invasive therapy, but as effective as surgical aortic valve replacement, several transcatheter aortic valve replacement (TAVR) techniques have been developed in the last years [7–13]. Safety and feasibility of different TAVR strategies were evaluated in preclinical studies [7] and, after the first-in-man experience in 2002 [8], different generations of either balloon-expandable or self-expandable valve prosthesis have been investigated in up to 1,000 high-risk patients with severe symptomatic aortic stenosis [9–14]. Currently, two different transcatheter implantation strategies are being used: the retrograde transfemoral approach and the transapical approach, proposed in patients with extensive calcification and tortuosity of the iliac arteries. The results are encouraging, with implantation success rate about 90% in experienced centres, either using a transfemoral or transapical approach [10, 13, 14]. Significant hemodynamic and clinical improvements have been reported for both balloon- and self-expandable devices [10, 13, 14]. In addition, mortality rates at 30-day follow-up range from 5% to 18% and 12-month survival rate is about 70–80%, being the majority of the late deaths due to co-morbidities [10, 13, 14]. Last, but not least, TAVR has a non-depreciable frequency of complications, the majority of them associated to vascular access (vascular injury 10–15%) and device positioning and deployment (paravalvular leakage (30–50%), cardiac tamponade (7%), arrhythmias (4%), coronary artery occlusion (5%) and prosthetic valve embolization (10%)) [9–14]. All these procedural-related complications may be circumvented with a careful selection of potential candidates, procedural risk assessment and detailed evaluation of the aortic valve anatomy and vascular access.

According to the first consensus recently reached by the European Association of Cardio-Thoracic Surgery and the European Society of Cardiology representatives, patient selection for TAVR should include confirmation of aortic stenosis severity, clinical evaluation and operative-risk analysis and, assessment of feasibility and exclusion of contraindications for TAVR [15].

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With regard to aortic stenosis severity assessment, transthoracic 2-dimensional (2D) echocardiography is routinely used for this purpose. Current guidelines define severe aortic stenosis when aortic valve area is less than 1 cm^2 [3]. The aortic valve area is usually assessed by the 2D derived continuity equation, although it is subjected to important assumptions that can lead to error [16]. The continuity equation assumes a circular geometry of the left ventricular outflow tract (LVOT) and considers a laminar flow of uniform velocity across the LVOT. Particularly, in elderly patients with severe aortic stenosis, an asymmetrical basal septal hypertrophy ("sigmoid septum") occurs frequently and may result in irregular geometry of the LVOT. In addition, the flow through the LVOT usually is non-laminar due to hyperdynamic function or anatomic obstruction, and consequently flow velocities are not uniform. Finally, the measurement of flow velocity at the LVOT is strongly dependent on the pulsed-wave Doppler sample area position, introducing another error to the aortic valve area calculation [16].

Current 3-dimensional (3D) imaging techniques enable the exact characterization of the LVOT geometry and avoid the geometrical assumptions subjected to 2D continuity equation [17, 18]. Previous work by Burgstahler et al. [19], demonstrated, with the use of magnetic resonance imaging, the elliptical shape of the LVOT in patients with and without aortic stenosis. In addition, two studies used 3D echocardiography and confirmed the elliptical geometry of the LVOT in patients with varying degrees of aortic stenosis, being more pronounced in those patients with basal septal hypertrophy [17, 18]. Consequently, the aortic valve area calculated by 3D echocardiography, taking into account the elliptical geometry of the LVOT, agreed better with the anatomical standard used as a reference (aortic valve area calculated by 3D planimetry), whereas the 2D continuity equation consistently underestimated the aortic valve area [17, 18]. This finding has important clinical implications, since patients with aortic stenosis may have different grades of severity depending on the method used to calculate the aortic valve area and, subsequently, the therapeutic management may change.

In addition, the assessment of the feasibility of TAVR comprises the exact sizing of the aortic annulus, the assessment of coronary anatomy and the sizing and characterization of peripheral arteries [15]. An accurate sizing of the aortic annulus may minimize the risk of paravalvular leakage and prosthesis migration after implantation. Furthermore, since bicuspid anatomy and extensive calcification of the aortic cups have been related to misdeployment of the prosthesis [20], the detailed characterization of the valve anatomy and calcification extent could be crucial in selection of TAVR candidates to ensure the success of the procedure.

Among 3D imaging techniques, multi-slice computed tomography (MSCT) enables a comprehensive evaluation of the aortic valve and its relation with surrounding structures, providing accurate measurement of the aortic annulus diameters, detailed evaluation of the aortic valve anatomy and valve calcifications [21]. Furthermore, the relation between the aortic annulus and the ostium of the left coronary artery can be exactly evaluated with MSCT, and subsequently, potential life-threatening procedural-related complications, such as occlusion of the ostium of the left coronary artery by a bulky aortic cusp, can be avoided [12].

In the current issue of the Journal, Doddamani et al. have assessed the LVOT geometry and area using 64-slice MSCT. For this purpose, 30 patients with normal left ventricular volumes and ejection fraction and normal aortic valve anatomy and function were scanned. The LVOT area was calculated considering circular geometry, similarly to 2D echocardiography, or elliptical geometry, measuring the longest and the shortest diameters of the LVOT at the transversal plane. These two LVOT area estimates were compared to the LVOT area obtained by planimetry. The authors observed in the majority of the patients an elliptical geometry of the LVOT rather than circular geometry, as the median LVOT eccentricity index of 0.18 also reflected. Consequently, the LVOT area estimate was consistently smaller when circular geometry was assumed, whereas the LVOT area estimate, when LVOT was considered elliptical-shaped, showed better agreement with the planimetry-derived LVOT area.

This study, along with the aforementioned studies [17–19], indicates the potential errors that can be made in aortic valve area calculation by considering circular geometry of the LVOT. In aortic stenosis patients, the accurate estimate of the aortic valve area is crucial since the therapeutic decision depends not only on the presence of symptoms but also on the severity of the aortic stenosis. High-risk patients with severe, symptomatic aortic stenosis are potential candidates for TAVR and the exact characterization of the aortic valve anatomy and geometry becomes extremely important in order to increase the success rate and to reduce the probability of procedural-related complications. In this challenging novel therapeutic field, MSCT provides a comprehensive assessment of the aortic valve and may be of great value for the selection of TAVR candidates.

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