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Original Research Article

Effect of the ellipsoid shape of the left ventricular outflow tract on the echocardiographic assessment of aortic valve area in aortic stenosis

Clément De Vecchi MD[a], *Jérôme Caudron MD, MSc*[a,b,c,*], *Benjamin Dubourg MD, MSc*[a,b,c], *Nathalie Pirot MD*[a], *Valentin Lefebvre MD, MSc*[a,b,c], *Fabrice Bauer MD, PhD*[b,c,d], *Hélène Eltchaninoff MD, PhD*[b,c,d], *Jean-Nicolas Dacher MD, PhD*[a,b,c]

[a] *Department of Radiology, Cardiac CT/MR Unit, Rouen University Hospital, 1 rue de Germont, 76031 Rouen, France*
[b] *Inserm U1096, Rouen, France*
[c] *University of Rouen, Institute for Research and Innovation in Biomedicine, Rouen, France*
[d] *Department of Cardiology, Rouen University Hospital, Rouen, France*

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ABSTRACT

Background: Previous studies showed discrepancies between echocardiographic and multidector row CT (MDCT) measurements of aortic valve area (AVA).
Objective: Our aim was to evaluate the effect of the ellipsoid shape of the left ventricular outflow tract (LVOT), as shown and measured by MDCT, on the assessment of AVA by transthoracic echocardiography (TTE) in patients with severe aortic stenosis.
Methods: This retrospective single-center study involved 49 patients with severe aortic stenosis referred before transcatheter aortic valve implantation. The AVA was deduced from the continuity equation on TTE and from planimetry on cardiac MDCT. Area of the LVOT was calculated as follows: on TTE, from the measurement of LVOT diameter on parasternal long-axis view; on MDCT, from manual planimetry by using multiplanar reconstruction perpendicular to LVOT.
Results: At baseline, correlation of TTE vs MDCT AVA measurements was moderate ($R = 0.622$; $P < .001$). TTE underestimated AVA compared with MDCT (0.66 ± 0.15 cm^2 vs 0.87 ± 0.15 cm^2; $P < .001$). After correcting the continuity equation with the LVOT area as measured by MDCT, mean AVA drawn from TTE did not differ from MDCT (0.86 ± 0.2 cm^2) and correlation between TTE and MDCT measurements increased ($R = 0.704$; $P < .001$).
Conclusion: Assuming that LVOT area is circular with TTE results in constant underestimation of the AVA with the continuity equation compared with MDCT planimetry. The elliptical not circular shape of LVOT largely explains these discrepancies.

Conflict of interest: The authors report no conflict of interest.

* Corresponding author.
E-mail address: Jerome.Caudron@chu-rouen.fr (J. Caudron).

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1. Introduction

Aortic stenosis (AS) is the most common valvular disease in western countries, mainly represented by calcific degenerative disease that affects 2% to 7% of the population older than 65 years.[1] Surgical aortic valve replacement is the reference treatment in patients with reasonable operative risk. The decision to perform surgery is based on clinical symptoms and the severity of stenosis.[2] Currently, transthoracic echocardiography (TTE) is the noninvasive reference method for evaluating AS severity. Severe AS is defined by TTE criteria as follows: aortic valve area (AVA) < 1 cm^2 or AVA <0.6 cm^2/m^2 body surface area or mean transvalvular gradient >40 mm Hg, or peak transvalvular velocity > 4 m/s or any combination.[1,2]

The AVA can be assessed by TTE (AVA^{TTE}) with the use of the continuity equation (Fig. 1),[3] in which the left ventricular outflow tract (LVOT) is considered circular. Recently, cardiac multidetector row CT (MDCT) gained acceptance in the assessment of the AVA. It was found that MDCT could accurately evaluate aortic valve planimetry (AVA^{MDCT}).[4] Several studies showed good correlation between AVA^{MDCT} and AVA^{TTE}.[5–8] However, AVA as evaluated by echocardiography and the continuity equation was shown to be underestimated compared with CT planimetry. Finally, CT studies have shown that LVOT was ellipsoidal in its short axis.[9,10]

The aim of this study was to evaluate the effect of the noncircular shape of the LVOT in assessing AVA in patients with severe AS.

2. Methods

2.1. Patients

This retrospective study involved 49 patients from July 2010 to July 2011. All patients had severe AS documented by TTE, catheterization, or both. None of those patients was eligible for conventional surgery, then transcatheter aortic valve implantation (TAVI) was decided.[11]

Medical records were studied, and patients could be included if MDCT and TTE were available and considered interpretable. Patients were excluded in cases of balloon aortic valvuloplasty, and when delay between TTE and MDCT exceeded 90 days.

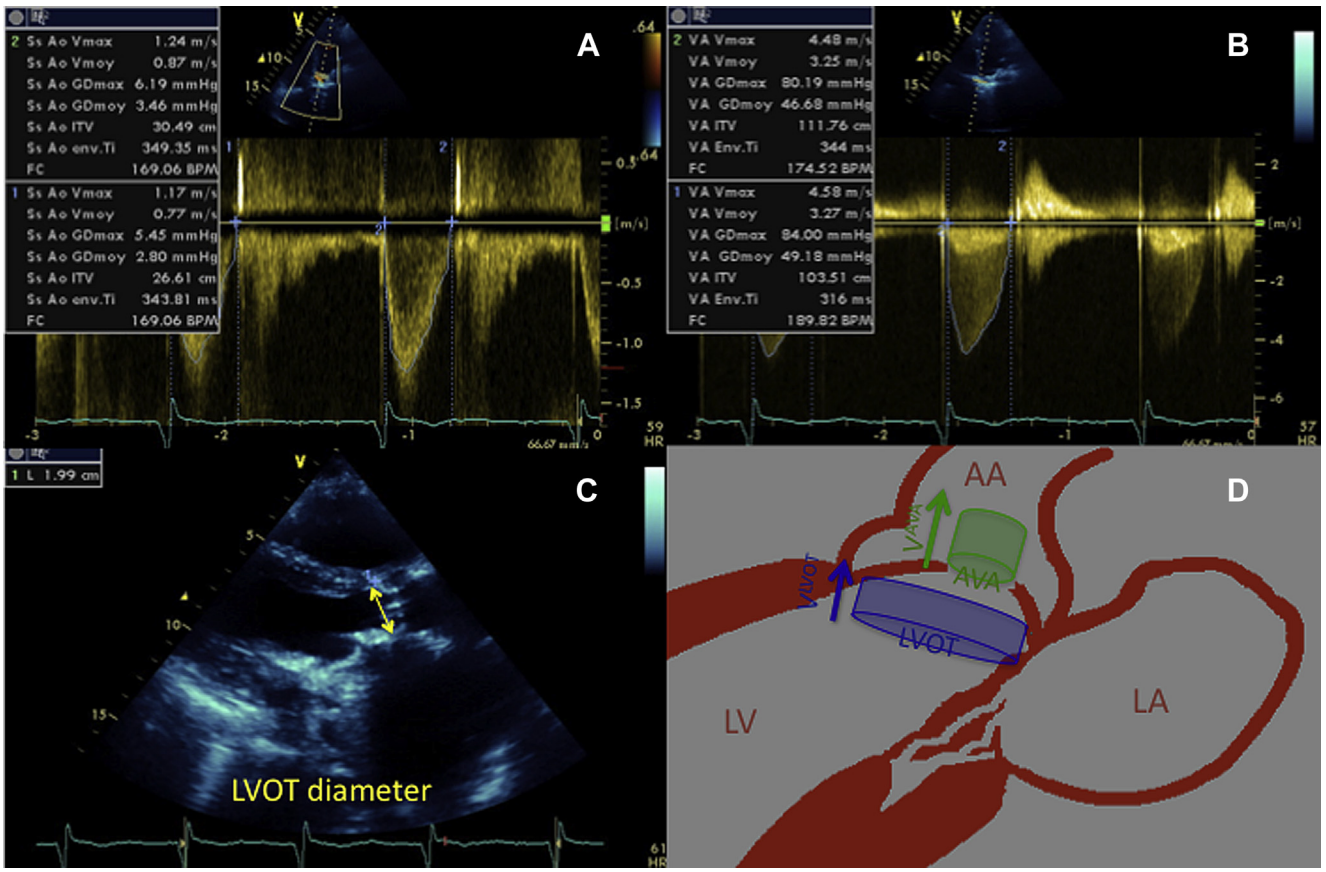

Fig. 1 – Transthoracic echocardiography measurement of the aortic valve area by using the continuity equation. (A) Pulsed-wave Doppler recording of the LVOT flow obtained from an apical 5-chamber view. (B) Continuous-wave Doppler flow at the vena contracta (ie, at the aortic stenosis level). (C) Measurement of the LVOT diameter on a 2-dimensional parasternal long-axis view. (D) Schematic diagram of continuity equation which is defined as $V^{LVOT} \times$ LVOT area $= V^{AVA} \times$ AVA. The blue and green arrows in panel D represent the direction of blood flow at the level of LVOT (blue arrow) and aortic valve (green arrow). AA, ascending aorta; AVA, aortic valve area; LA, left atrium; LV, left ventricle; LVOT, left ventricular outflow tract; V^{AVA}, maximal blood flow velocity at the aortic valve; V^{LVOT}, maximal blood flow velocity at left ventricular outflow tract.