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Feasibility and relevance of right parasternal view for assessing severity and rate of progression of aortic valve stenosis in primary care☆

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ABSTRACT

Background: Right parasternal view (RPV) is important in assessing the severity of aortic stenosis (AS). However, the feasibility and relevance of RPV in primary care is unresolved. Moreover, information regarding the role of RPV in the evaluation of the hemodynamic progression of AS is lacking.
Methods: Consecutive patients with peak aortic valve velocity (V_{max}) ≥2.5 m/s were prospectively enrolled in a primary care echocardiographic laboratory. Aortic Doppler parameters were evaluated from apical view and RPV.
Results: The total number of enrolled patients was 330 (aged 81 ± 11 years, 47% female, left ventricular ejection fraction 64 ± 9%). The RPV was feasible in 275 (83%). V_{max} and Mean Gradient were significantly higher and aortic valve area was significantly lower from RPV as compared to apical view ($p < 0.0001$ for all). Reclassification of severity towards either moderate or severe AS occurred in 13–26% of patients, according to different criteria, when evaluated from RPV. Among 108 patients (40%) undergoing multiple examinations the rate of progression was lower from the apical approach than from the RPV (0.19 ± 0.20 m/s/year vs. 0.24 ± 0.27 m/s/year, respectively; $p = 0.03$), and was fast (>0.3 m/s/year) in 17 patients (16%) from the apical window vs. 26 patients (24%) from RPV ($p < 0.0001$).
Conclusion: Implementing RPV is feasible in primary care and results in a substantial reclassification rate through the entire spectrum of AS severity. Our data also suggest a potential role of Doppler interrogation from multiple windows to improve AS progression assessment.

1. Introduction

Aortic valve stenosis (AS) is a common disorder which is often managed in the primary care setting during the long-term asymptomatic phase characterizing its natural history [1,2]. Decisions on management rely on the accurate assessment of stenosis severity, ventricular function and symptomatic status [3,4]. Doppler echocardiography plays a pivotal role in the non-invasive hemodynamic evaluation of these patients. The accurate evaluation of severity and progression of AS is thus needed to tailor the management, to schedule the proper follow-up strategy, and to refer for further evaluation after correct interpretation of the symptomatic status [5].

Although it has been previously emphasized that multiple acoustic windows are mandatory to properly determine the highest transvalvular velocity [6], this approach may not be systematically adopted, particularly in the non-referral, outpatients' facilities. Apical view and right parasternal view (RPV) most frequently yield the highest peak aortic valve velocity (V_{max}) though, more rarely, subcostal or supra-sternal windows may be required [4,6–8]. Available data regarding the feasibility and significance of RPV, however, have been reported by tertiary referral centers, in relatively small and selected cohorts (mainly with severe AS only), resulting into different rates of feasibility (ranging from 33 to 85%) [10–12].

Thus, the feasibility and relevance of RPV for the hemodynamic assessment of AS in a non-referral setting are unresolved. Moreover, there are no data regarding the relevance of RPV in the assessment of the rate of progression [8–12], a relevant prognostic factor in the natural history of AS in asymptomatic individuals, independently from its severity, and clinical setting [5,13]. Thus, this study was aimed to prospectively assess the feasibility of the RPV approach in a large group of consecutive AS outpatients with a wide range of hemodynamic severity evaluated in a primary care setting, and its impact both on the evaluation of severity and rate of hemodynamic progression.

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2. Methods

All consecutive outpatients referred by their general practitioners for an echocardiographic examination, which is booked through the Central Booking office to the echocardiographic laboratory of the Cardiology Service of the CMSR-Veneto Medica who presented a thickened aortic valve and a $V_{max} \geq 2.5$ m/s were prospectively evaluated between January 2008 and December 2012. A pre-determined echocardiographic protocol for acquisition of images, storage of the data, review and measurements, performed by a board certified echo-cardiologist with more than 15 years of experience, with commercially available ultrasound systems was adopted. As previously reported [5], left ventricular (LV) volumes, and ejection fraction (EF) were measured using biplane Simpson's method. The LV mass (in grams) was calculated using the Devereux formula and indexed for body surface area (BSA). Left ventricular outflow tract (LVOT) diameter was measured in systole from the parasternal long-axis view. LVOT time-velocity integral (TVI) was recorded with pulsed Doppler from the apical five-chamber view just proximal to the valve orifice and used to calculate stroke volume (SV) which was indexed for BSA. V_{max}, aortic valve TVI, and transaortic Mean Gradient (MG) were measured during the same examination from the five-chamber apical view with the patients on left side decubitus, and from RPV with the patients on the right-side decubitus, by continuous wave Doppler using two different probes for each patient i.e. the combined imaging and Doppler transducer and the non-imaging dedicated continuous Doppler transducer (i.e.: pedal probe) [14]. Similarly, with both combined and non-imaging probes, suprasternal and right supraclavicular approaches were used after proper positioning of the patient [13]. In each projection, the average of two to five measurements was recorded [3,14]. In addition, periodical evaluations for inter- and intra-observer variability were performed between the two physicians (SN, BP) practicing in the centre.

Grading of AS severity was defined based singularly either on V_{max} and MG or by aortic valve area (AVA), calculated using the continuity equation and indexed by body surface area (AVAi). The impact of RPV on each of the four grading parameters (V_{max}, MG, AVA, and AVAi) was independently evaluated.

A subanalysis of the RPV role was conducted on patients with severe AS according to AVA < 1 cm^2 calculated from apical 5-chamber view, preserved EF (≥50%), and paradoxically low MG (≤40 mm Hg) and stroke volume index (≤35 ml/m^2) [15]. The rate of progression based on V_{max} was analyzed in a subgroup of patients referred for multiple echocardiographic examinations. Mean progression of aortic jet velocity (expressed as m/s/per year) was calculated by dividing the difference between the last and first echocardiographic examination by the interval between the examinations and was graded as slow or fast according to a cut-off value of 0.3 m/s increase per year [2,5]. Informed consent was obtained from each patient; the Internal Review Board approved the study protocol and the work has been carried out in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki).

2.1. Statistical analysis

Statistical analysis was performed using the software package SPSS 22 (SPSS Inc., Chicago, Illinois). Discrete data were summarized as frequencies, and continuous data were expressed as means and standard deviations. To assess normality distributions of the measured variables a Kolmogorov-Smirnov's test was used. The χ^2 test was used for comparison of categorical variables, and the pair or unpaired 2-tailed Student *t*-test test were used to test differences among continuous variables.

Agreement between the classification of severe stenosis by using V_{max}, Mean Gradient, AVA and AVA index from the apical and right parasternal windows was assessed using Cohen's Kappa (agreement: <0.4, pr-fair; 0.4–0.6 moderate, 0.6–0.8 good; >0.80, very good).

A Bland-Altman analysis was performed to assess the differences in echocardiographic parameters between the apical window and right parasternal window. The relationship between the apical window and right parasternal window was also evaluated by using Deming regression analysis.

The intraclass correlation coefficient (ICC) with 95% confidence interval (CI) was used to measure overall interobserver agreement for the echocardiographic parameters both at the apical and right parasternal windows.

3. Results

3.1. Patient characteristics and feasibility of RPV

During the study period, 330 AS patients were consecutively assessed (Table 1): 140 (47%), were female, the vast majority (307; 93%) showed preserved EF (>50%), and no AS-related symptoms (313, 94%). As far as cardiovascular risk profile is concerned, 247 (75%) patients had systemic hypertension, 119 (36%) hypercholesterolemia, 86 (23%) diabetes, 83 (25%) history of coronary artery disease, and 23 (7%) were current smokers.

Apical five-chamber view approach was feasible in all patient, whereas RPV was feasible in 275 (83%) patients. There were no differences in demographic, clinical, and echocardiographic characteristics between patients with or without RPV ($p > 0.2$ for all). In all the patients, V_{max} by the non-imaging dedicated continuous Doppler transducer resulted significantly higher ($p = 0.01$) than that obtained by the usual combined imaging and Doppler transducer from the RPV ($p < 0.0001$). Overall, in 214/275 (78%) patients V_{max} was higher when detected from RPV vs. apical view. Similarly, MG was higher from RPV vs. apical view in 219/275 (80%) of cases. In only 1 patient, V_{max} was higher from the right supraclavicular view than from any other approach (included as RPV in the subsequent analysis).

3.2. Grading of AS severity

On average, each criterion for AS severity was significantly different if assessed from the apical or from the RPV (Fig. 1A). The impact of RPV on severity reclassification is substantial for each of the 4 parameters across all spectra of severity, (Fig. 2): for instance, 30 patients with mild AS based on V_{max} were reclassified upward as moderate (28/30, 93%) or, more rarely, severe AS (2/30, 7%) from RPV, with an overall prevalence of severe AS changing from 28% to 38% ($p < 0.0001$). Moreover, patients with 3 or 4 criteria for severe AS (i.e.: $V_{max} > 4$ m/s, Mean Gradient > 40 mm Hg, AVA < 1 cm^2, or AVA index < 0.6 cm^2/m^2) were 68/275 (25%) from the apical window and 102/275 (37%) from the RPV ($p < 0.0001$). According to this composite criterion, only one patient was classified severe by the apical window approach and not severe by the RPV, whereas 35 patients were severe by the RPV, but not by apical window.

The deltas for V_{max}, MG, AVA and AVAi values between the apical window and RPV were analyzed by the different severity subgroups (Table 2). No homogeneous pattern was detected across the 4 parameters.

The agreement between the apical window approach and the RPV was overall good for all the 4 criteria. After dividing patients into mild, moderate, and severe according to V_{max} or MG, the agreement between the two approaches resulted good as well for V_{max} (Kappa = 0.67, $p <$ 0.0001), and AVA (Kappa = 0.68, $p < 0.0001$), but moderate for MG (Kappa = 0.59, $p < 0.0001$). The Deming regression equation, describing the relationship between V_{max} measured by RPV and apical window, overall showed a slope of 1.11 (95% CI 1.04 to 1.18) and an intercept of −0.17 (95% CI −0.40 to 0.06) (Fig. 1B). The slope was 3.29 (95% CI 2.24 to 5.33) with an intercept of −6.04 (95% CI −1.72 to −3.14) in patients with mild AS, whereas in the group of moderate severity the slope was 1.48 (1.27 to 1.74) and the intercept was −1.49 (95% CI −2.38 to −0.77). In patients with severe AS, the regression analysis showed a slope of 1.20 (95% CI 1.04 to 1.50) and an intercept of −0.70 (95% CI −2.01 to 0.00). Accordingly, the Bland-Altman plot showed that the mean difference (bias) for V_{max} was 0.24 m/s (95% CI: 0.20 to 0.28 m/s) between the two approaches. The Bland-Altman plots for V_{max} as well as for MG, AVA and indexed AVA are displayed in Supplementary Fig. 1.

Table 1
Clinical and echocardiographic characteristics of the overall population.
The displayed aortic parameters (V_{max}, MG, AVA, AVA-I) are obtained by apical view.

Variables	All patients ($n = 330$)
Age (years)	81 ± 11
Body surface area (m^2)	1.79 ± 0.20
Body mass index (kg/m^2)	27.6 ± 4.9
Systolic blood pressure (mm Hg)	145.8 ± 19.5
Diastolic blood pressure (mm Hg)	78.7 ± 10.6
Heart rate (bpm)	71.2 ± 12.2
Left ventricular ejection fraction (%)	64 ± 9
V_{max} (m/s)	3.45 ± 0.72
MG (mm Hg)	28 ± 14
AVA (cm^2)	1.13 ± 0.39
AVA-index (cm^2/m^2)	0.63 ± 0.21
LV mass index (g/m^2)	121 ± 29
Stroke volume (ml)	68.1 ± 17.8
Stroke volume indexed (ml/m^2)	47.6 ± 9.6

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