Disagreement between Cardiovascular Magnetic Resonance and Echo-Doppler Transvalvular Pressure Gradients

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Introduction: Based on current guidelines for the evaluation of aortic stenosis (AS) severity, patients are candidates for valve replacement surgery if they have a valve effective orifice are (EOA) < 1.0 cm^2, transvalvular pressure gradient (TPG) ≥ 40 mmHg and symptoms [1]. Transthoracic echocardiography (TTE) is widely used to evaluate AS severity. However, there are often discrepancies among the TTE measurements. Cardiovascular magnetic resonance (CMR) may be used to corroborate stenosis severity. The aim of this study is to examine the agreement of TTE and CMR for the estimation of TPG and EOA in patients with AS.

Table 1. Patients' Characteristics

	Mean ± SD
Age (years)	62 ± 17
Male gender n(%)	29(76)
Heart rate (bpm)	65 ± 12
Weight (Kg)	76 ± 13
Height (cm)	169 ± 10
Body surface area (m^2)	1.88 ± 0.19
Body mass index (Kg/m^2)	26 ± 3
Valve morphology	
Tricuspid n (%)	26 (68)
Bicuspid n (%)	9 (24)
Indeterminate n (%)	3 (8)

Methods: Seven (7) healthy subjects and 31 patients with mild to severe AS (0.72 cm^2 ≤ EOA ≤ 1.73 cm^2) were included in this study. TTE measurements were performed according to the ASE guidelines [2]. CMR study was performed within 4 weeks after TTE study with the use of a 1.5 Tesla scanner. A standard ventricular function examination was performed for acquisition planning. Phase-Contrast (sQFlow Phase SENSE) retrospective examination was performed in standard short-axis planes in the left ventricular outflow tract (LVOT) at -12 mm upstream from the aortic valve annulus and in the ascending aorta at +6 mm and +10 mm downstream of the annulus. CMR imaging parameters consisted of: ET (2.76-3.05ms), flip angle (15°), phase (24), pixel spacing (1.32-2.07 mm), RT (4.6-4.92ms), thickness (10mm), matrix (256x208). Aortic TPG and valve EOA were computed using Bernoulli's equation and continuity equation [1]. We calculated the corrected mean pressure gradient (MPG) by including CMR measurements in the following formula (combination of Bernoulli formula and continuity equation): EOA=(CO/SEP*HR)/ (44.3*MPG^0.5) [3,4].

Results: Thirty-one patients with mild to severe AS (77% men, age 67±12 years) and seven healthy subjects (71% men, age 34±8 years) were studied using TTE and CMR, Table 1. TTE overestimated VTI_{LVOT} (21±4 vs. 15±4 cm, p<0.001) and there was a good concordance between TTE and CMR for estimation of VTI_{Ao} (61±22 vs. 57±20cm and 61±22 vs. 53±19cm, p=0.02). Overall there was a good correlation and concordance between TTE-derived and CMR-derived EOA (1.52±0.68 vs. 1.60±0.74, r=0.92, bias=0.07, limits of agreement:-0.483 to 0.623 and 1.52±0.68 vs. 1.70±0.74, r= 0.88, bias=0.17, limits of agreement:-0.537 to 0.877 for 6mm and 10mm planes respectively). Figure 1 shows the fitted curves for TTE, CMR with measures at 6 mm and CMR with measures at 10 mm. Aortic TPG and mean/peak TPGs ratio were underestimated by CMR compared to TTE (Fig 2). The MPG predicted with the proposed formula correlated well with the MPG measured by TTE, r=0.76 for MPG_{Ao06} and r=0.722 for MPG_{Ao10} (Figure 3) and had a good concordance bias=-2.0mmHg, limits of agreement:-8.3 to 4.3 and bias=-3.4mmHg, limits of agreement:-10.0 to 3.3, for MPG_{Ao06} and MPG_{Ao10} respectively.

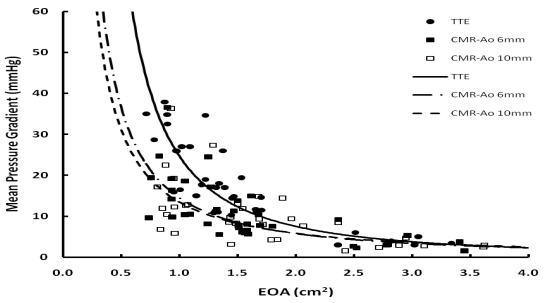

Figure 1. Mean transvalvular pressure gradient as a function of EOA. Filled circles are TTE measurements and the solid line represents the corresponding curve fit. Filled squares are CMR measurements at 6mm upstream from the aortic valve and the dashed line represents the corresponding curve fit. Non-filled squares are CMR measurements at 10mm from the aortic valve and the dashed single dot represents the corresponding curve fit.

Discussion and Conclusion: EOA and TPG are the two main parameters used to assess AS severity. There is a good concordance between EOA measured by CMR and that measured by TTE. However, CMR underestimates the TPG compared to TTE. EOA measured by CMR can be used to confirm AS severity grading by TTE in case of inconsistencies. However, CMR underestimates TPG. The proposed model could be an issue to manage this difference.

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References: 1. Bonow RO et al. Circulation 2006; 114:e84-e231. 2. Quinones et al. JASE 2002; 167-184. 3. Dumesnil JG et al. AJC 1991; 67: 1268-1272. 4. Minners J et al. Heart 2010; 96: 1463-1468.

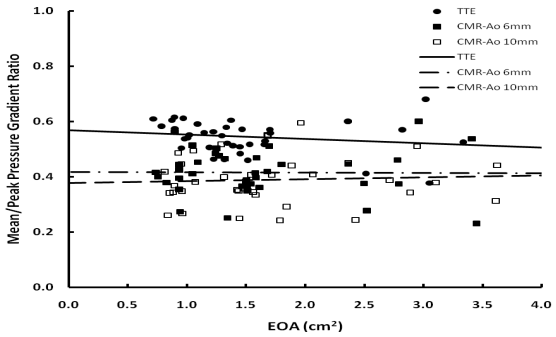

Figure 2. Mean/Peak transvalvular pressure gradients ratio as a function of EOA. Filled circles are TTE ratios and the solid line is the corresponding TTE curve fit. Filled squares are CMR ratios at 6mm and the dashed single dot is the corresponding curve fit. Non-filled squares are CMR ratios at 10mm and the dashed line is the corresponding curve fit.

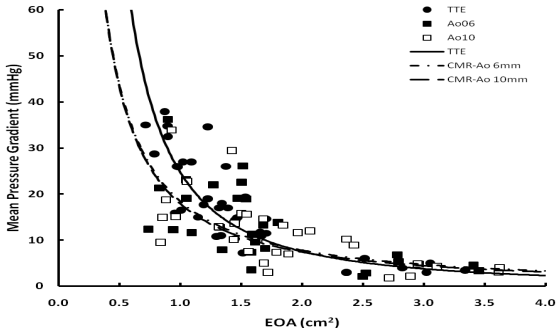

Figure 3. Predicted mean pressure gradients. Filled circles are MPGs measured by TTE. Filled and non-filled squares are MPGs corrected from CMR measurements at 6mm and 10 mm upstream from the aortic valve respectively. The solid line is the corresponding curve fit for TTE, the dashed line is the corresponding curve fit for CMR at 6mm and the solid single dot line is the corresponding curve fit for CMR at 10mm from the aortic valve.