A Novel Approach to Determine Aortic Valve Area with Phase-Contrast Cardiac Magnetic Resonance

Troger F[1], Lechner I[2], Reindl M[2], Tiller C[2], Holzknecht M[2],

Pamminger M[1], Reinstadler SJ[2], Bauer A[2], Metzler B[2], Mayr A[1], Klug G[2].

[1] University Clinic of Radiology, Medical University of Innsbruck, Austria
[2] University Clinic of Internal Medicine III, Cardiology and Angiology, Medical University of Innsbruck, Austria

Purpose

Echocardiography is regarded the standard diagnostic measure to diagnose and grade aortic valve stenosis (AS). However, especially in the evaluation of AS patients with low-flow states, this method showed diagnostic inaccuracies. Phase contrast cardiac magnetic resonance imaging (PC-CMR) may overcome these limitations by simultaneously determining flow volumes and velocities across the stenotic valve. This study aims to validate
PC-CMR in the characterization of aortic valve stenosis (AS) and to compare these data to invasively determined features of AS.

Methods

PC-CMR was performed in 50 patients with moderate or severe AS (n=50; age 71 years, interquartile range (IQR): [66 - 78], 48% of patients with low-flow states). All of them were referred to invasive evaluation of AS by cardiac catheterization. Additionally, transthoracic echocardiography (TTE) was performed. Aortic valve area (AVA) was determined by PC-CMR (AVA_{CMR}) via plotting momentary flow across the valve against momentary flow velocity. AVA_{CMR} at different time points over the entire cardiac cycle was compared to invasively determined AVA, calculated according to the Gorlin-formula. Stroke volumes (SV) were determined by the Fick-principle, pressure gradients according to the modified Bernoulli-equation.

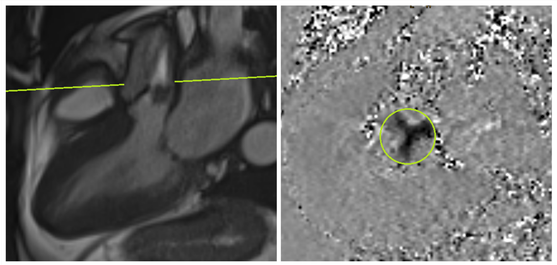

Figure 1: *Cine-3-Chamber CMR of a patient with severe aortic stenosis (left) and phase contrast-CMR of the aortic valve (right) in the shown layer.*

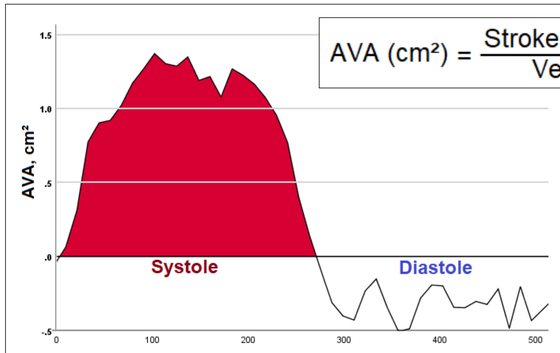

Figure 2: Calculation of AVA with simultaneous measurement of flow volumes and flow velocities across the aortic valve. *According to the formula given above AVA can be calculated continuously over the whole cardiac cycle.*
The graph shows an example of 50 phases across the whole cardiac cycle of a patient with a mean AVA of 0.92cm² and a stroke volume of 44ml by CMR.

Results

SV by PC-CMR showed a good correlation with Cine-CMR without significant bias (r: 0.730, p<0.001; $SV_{PC\text{-}CMR}$: 86±31ml; SV_{Cine}: 85±19ml).

Mean AVA_{CMR} during the whole systolic phase showed a significant correlation (r: 0.544, p<0.001) with invasive AVA with a small bias (AVA_{CMR}: 0.78 cm², IQR: [0.60-0.96] versus $AVA_{INVASIVE}$: 0.70 cm², IQR: [0.52-0.87], bias: 0.08 cm², p=0.017).

Intermethodical correlation and bias of AVA as measured by TTE (AVA_{TTE}) and $AVA_{INVASIVE}$ were similar to AVA_{CMR} (AVA_{TTE}: 0.81cm²; IQR: [0.64-0.96] versus $AVA_{INVASIVE}$: 0.70 cm², IQR: [0.52-0.87], r: 0.580 p<0.001, bias 0.11 cm², p<0.001).

Conclusion

PC-CMR with continuous determination of flow volumes and flow velocities is able to determine AVA in patients with severe aortic stenosis with good correlation and virtually no bias to invasively determined AVA.