Circumferential wall shear stress predicts co-localized progressive dilation in bicuspid aortic valve patients

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Background: Bicuspid aortic valve (BAV), a congenital heart defect, is associated with ascending aorta (AAo) dilation. Whether the high prevalence of dilation in BAV patients is related to alteration of aortic blood flow and thus in wall shear stress (WSS) [1,2], which have been associated with aortic wall degeneration [3], or intrinsic abnormalities of the aortic wall, such as altered aortic stiffness [4], has not been established. Recently, a technique for the semi-automatic quantification of progressive aortic dilation maps via image registration has been introduced [5].

Purpose: To test whether ascending aorta WSS predicts co-localized progressive dilation in BAV patients.

Methods: Forty BAV patients free from moderate and severe aortic valve regurgitation (regurgitant fraction <16%) and stenosis (maximum velocity at the aortic valve <3m/s), with no previous aortic or aortic valve surgery or replacement and included in a double-blind clinical trial (BICATOR, NCT02679261) were enrolled. All patients underwent a baseline 4D flow CMR study to assess aortic hemodynamics, followed by two contrast-enhanced computed tomography angiographies to quantify progressive dilation. WSS was computed at 64 pre-specified standardized ascending aortic regions, automatically obtained dividing the ascending aorta into 8 equidistant longitudinal sections which were further divided along the circumference into 8 equal regions (I = inner, L = left, O = outer and R =

right) [2]. WSS was also projected into axial and circumferential directions, as previously described [1,2]. Progressive dilation was assessed in terms of growth rate (GR), i.e. increase in diameter divided by follow-up duration [mm/year], following a previously described methodology [5], at the same 64 pre-specified ascending aortic locations. A two-tailed p-value <0.05 was considered statistically significant.

Results: Demographic and clinical characteristics of the patients are shown in Table 1. WSS and growth rate maps are shown in Figure 1. Follow-up duration was 44.8±2.6 months. Growth rate (Figure 1A) was heterogeneously distributed, being highest (up to 0.26 mm/year) in the outer region of the mid AAo and in the inner region of the proximal-mid AAo. Circumferential WSS showed highest values in the outer region of the mid AAo (Figure 1C) while WSS (magnitude) and its axial component (Figure 1B and D) presented maximum values in the right region of the mid AAo. Maps of statistically significant association between GR and WSS values showed circumferential WSS to be correlated with GR in regions where progressive dilation was fastest, while WSS magnitude and its axial component resulted in limited associations with GR maps.

Conclusions: Circumferential wall shear stress predicts location-matched progressive dilation in bicuspid aortic valve patients.

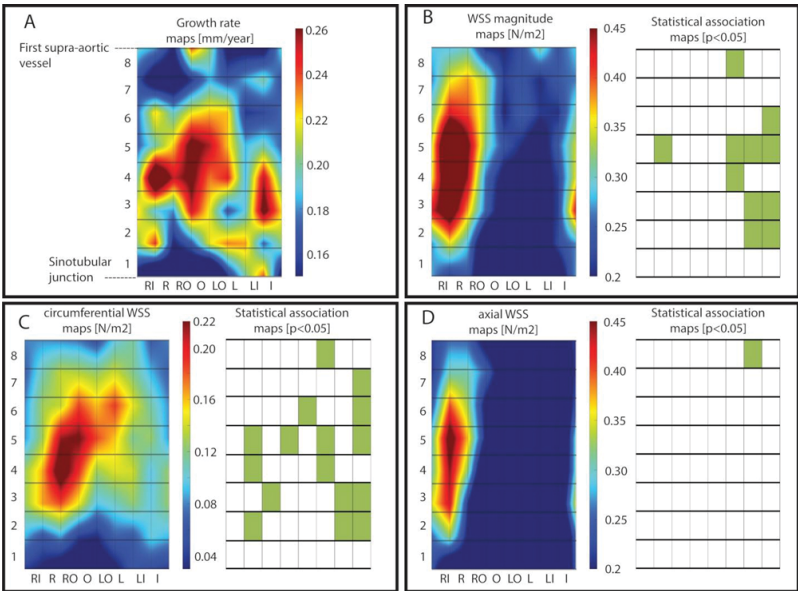|	Mean ± SD
N	40
Age [years]	51±13
Sex [% of male]	72
Body surface area [m²]	1.86±0.19
Systolic blood pressure [mmHg]	134±17
Diastolic blood pressure [mmHg]	77±11
Ascending aorta diameter [mm]	41.4±7.3
BAV type [%RL]	80

Table 1. Demographics

Figure 1. GR and WSS maps and correlations