Haemodynamic insights into bicuspid aortic valve disease - does cusp fusion pattern matter?

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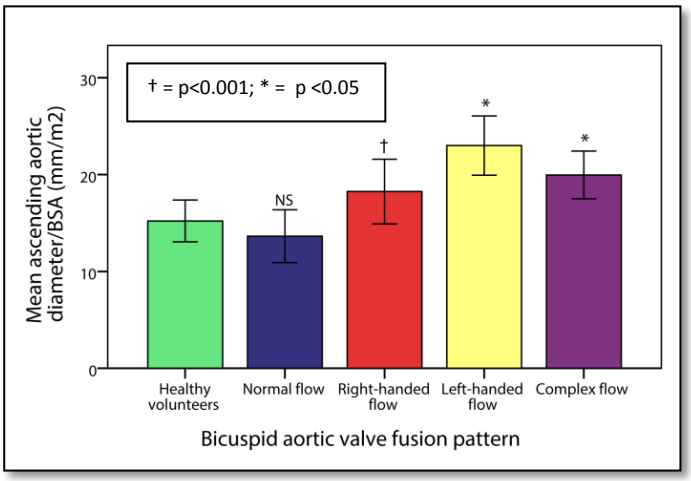
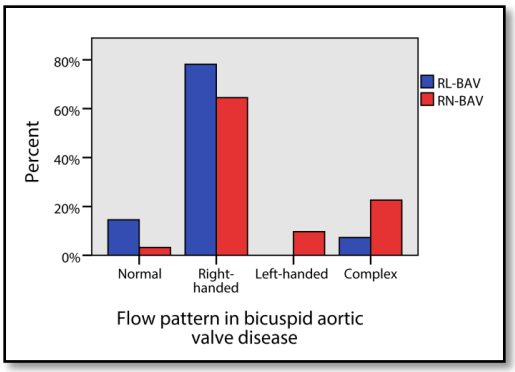
Background:
Bicuspid aortic valve disease (BAV) is associated with aortic dilation. We examined flow abnormalities and measures of vascular function in the ascending aorta. Furthermore we also assessed the impact of cusp fusion pattern on flow abnormalities.

Methods:
We prospectively enrolled 142 participants (95 patients with BAV and 47 healthy volunteers [HV]); mean age 40 years (range 8-70). Cardiac magnetic resonance was used to measure arterial strain, distensibility, pulse wave velocity (PWV), rotational flow values to quantify helical flow, flow angle and wall shear stress (WSS).

Results:
Both BAV and HV had similar aortic diameters at the sinuses of Valsalva and the proximal descending aorta. BAV had significantly larger aortic diameters at the sinotubular junction (16.6 vs 15 mm/BSA, p=0.001) and the ascending aorta (18.2 vs 15.2 mm/BSA, p<0.001). There was no difference in PWV across the aortic arch compared to HV (median 4.5 vs 4.7 m/s, p>0.05), distensibility in the ascending aorta (mean 4.1 vs 4.6 1/mmHg, p>0.05) or arterial strain (mean 0.19 vs 0.21, p>0.05). The most common flow pattern in our BAV cohort was a right-handed helical flow in 72%. A normal laminar flow pattern was observed in 11%, complex disorganised flow in 13% and left-handed flow in 4%. The normal flow pattern group had similar ascending aortic diameter, rotational flow values, flow angle and total WSS compared to the HV group (p>0.05). The right-handed flow group had significantly higher ascending aortic diameter (18.3 vs 15.2 mm/BSA, p<0.001), rotational flow values (31.7 vs 2.9 mm^2/s, p<0.001), flow angle (23.1 vs 7.0 degrees, p<0.001) and total systolic WSS (0.85 vs 0.59 N/m^2, p<0.001) compared to the HV group.



The left-handed flow group only contained 4 cases but showed a trend towards higher ascending aortic diameter (20.0 mm/BSA), rotational flow values (-49.7 mm^2/s), flow angle (30.0 degrees) and WSS (1.18 N/m^2) compared to the HV group and right-handed flow group.



When comparing the two most common BAV subtypes (right-left coronary cusp fusion pattern [RL-BAV] and right-non-coronary cusp fusion pattern [RN-BAV]) both BAV subgroups showed predominantly abnormal flow. In the RL-BAV group, 10% had normal laminar flow patterns, 80% abnormal right-handed flow and 10% complex disorganised flow. There was no left-handed flow. The RN-BAV group showed more severe flow abnormalities in general, with no normal laminar flow, a mainly right-handed flow pattern in 66%, complex disorganised flow in 24% and left-handed flow in 10%.

To determine the impact of cusp fusion pattern on aortic size, flow disturbance and WSS independent of the flow pattern, we compared BAV patients with the commonest flow pattern (right-handed flow). RN-BAV had larger ascending aortic diameters, higher rotational flow (38.5 vs. 27.8 mm^2/s, p=0.006), in-plane WSS (0.64 vs 0.47 N/m^2, p=0.008) and flow angle (29 vs 19 degrees, p=0.002) compared to RN-BAV.

Conclusion:
Marked differences in ascending aortic flow abnormalities occur with BAV but there were no differences in distensibility or pulse wave velocity. RN-BAV showed more severe flow abnormalities and larger ascending aortas. These findings are the first potentially causative indication that cusp fusion pattern is important in determining adverse aortic outcome.