Time-resolved three-dimensional phase contrast MRI evaluation of bicuspid aortic valve and coarctation of the aorta

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A 41-year-old man with a bicuspid aortic valve (BAV) and coarctation of the aorta, as visualized by 2D phase contrast cardiovascular magnetic resonance imaging (CMR) (Figure 1D, Supplementary data online, Videos S1) and contrast enhanced MR angiography (Figure 1A), was referred for evaluation by time-resolved 3D phase contrast (4D flow) CMR to assess the flow velocity through the coarctation and provide aortic flow characterization. Findings of the comprehensive examination demonstrate the complex haemodynamic patterns that emerge throughout the aorta secondary to the commonly associated focal pathologies of BAV and aortic coarctation. Velocity streamlines show the formation of flow jet patterns with a strong right-handed helix in both the ascending aorta and distal to the coarctation (Figure 1B and C, Supplementary data online, Videos S1, S3, and S4). Quantitative analysis reveals highest velocity through the coarctation (2.35 m/s) as well as a high velocity flow jet along the postero-lateral wall of the ascending aorta secondary to BAV with fusion of right- and left-coronary leaflets. These flow derangements are likely to alter flow-dependent haemodynamic parameters such as wall shear stress, a parameter known to affect vessel remodelling. Based on the CMR findings in this case, the patient does not meet the criteria for surgical intervention at this time and conservative medical management will be continued. A repeat CMR study including 4D flow will be performed in 2 years to trend the ascending aortic diameter and monitor the evolution of aortic flow patterns and velocity.

The ability to visualize and quantify flow-dependent parameters in patients with valvular and vascular disease is vital to an improved understanding of the complex pathophysiological mechanisms that result in clinically significant events such as aneurysm formation and dissection. The current case highlights the capability of 4D flow CMR to provide clinically relevant quantitative data and also illustrates the broad impact of focal aortic pathologies (BAV, coarctation) on global haemodynamics in the thoracic aorta that suggests a potential mechanism for the development of secondary aortopathy. As future studies correlate flow-related parameters with clinical outcomes, 4D flow CMR is likely to be an increasingly valuable tool in risk stratification, treatment selection and post-intervention assessment in cardiovascular patients.

Figure 1: Image collection showing the (A) contrast enhanced MR angiography of the thoracic aorta, (B) right-posterior view of the thoracic aorta, (C) LAO view of the thoracic aorta and (D) 2D cine MRI of BAV.

Supplementary data are available at European Heart Journal – Cardiovascular Imaging online.