Spatio-temporal characterization of the blood flow in the aortic root

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Background:
The flow profile in the aortic root constitutes a major determinant of coronary and systemic blood flow, depending on the size, shape and dynamism of the aortic root. The aims of this study are to evaluate patterns of flow in the aortic root in health, disease and following different root replacement procedures.

Methods:
A total of 54 subjects underwent phase-contrast cardiovascular magnetic resonance (PC-CMR). Of those, 29 patients with well functioning aortic valve substitutes had undergone aortic root replacement > 10 years earlier. They were divided into 3 groups: autografts (n = 13, 47±9 years), stentless porcine xenografts (n = 10, 77±8 years) and homografts (n = 6, 71±11 years). The remaining patients had bicuspid aortic valve (BAV, n = 4, 32±17 years) and obstructive hypertrophic cardiomyopathy (HCM, n = 6, 43±9 years). A cohort of 15 healthy volunteers (31±5 years) served as controls to determine normal spatio-temporal flow patterns.

Results:
The aortic root flow profiles showed differential patterns: (1) BAV patients had a high velocity jet through the narrow valve orifice; (2) HCM patients had eccentric flow patterns due to the obstruction in the left ventricular outflow tract; (3) flow through the autograft valve was triangular in shape reflecting ideal orifice shape of a trilaflet valve, similar to normal controls and (4) flow patterns through the xenografts and homografts are more disrupted than autografts. The maximum velocities for BAV, HCM, autograft, xenograft, homograft and control groups, respectively, were: 2.6±1.8 m/s, 1.6±0.2 m/s, 2.1±0.9 m/s, 1.7±0.4 m/s, 1.0±0.3 m/s.

Conclusions:
Flow profiles in the aortic root vary markedly according to the type of disease and root substitute. Among the tissue root substitute options, the Ross procedure best reproduces normal flow dynamics.