Biomechanical Properties of the Aortic Root are Distinct from Those of the Ascending Aorta

Objective: Although treated similarly in guidelines, aneurysms of the aortic root may behave differently from those of the ascending aorta. We aim to define the biomechanical properties of the aortic root in both aneurysmal and normal states, as compared to the ascending aorta.

Methods: Aortic aneurysms were excised at the time of surgery, from the non-coronary sinus in the root (N=39), and from the ascending aorta (N=80). Normal root and ascending aortic tissue were taken as controls from donors that were not accepted for transplantation (N=6). Biaxial tensile testing was performed to derive modulus of elasticity (E, stiffness) and energy loss (EL, viscoelastic hysteresis). Peel testing was performed to determine delamination strength (DS); greater strength implies less susceptibility to dissection. Adjusting for baseline differences resulted in 28 pairs of root and ascending aneurysms matched on age, sex, hypertension, valve-type, and size. Histological analysis was used to quantify of components of the aortic wall.

Results: Normal aortic root demonstrated similar E (p=0.29), but increased EL (p=0.05) compared to normal ascending aorta. Aneurysmal aortic root biomechanics was not statistically different from that of normal roots in terms of E (p=0.09) and EL (p=0.71). In contrast, in the ascending aorta, aneurysms had less favorable biomechanics than normal aortas with higher EL (p<0.01) and lower DS (p=0.001). The strength of root aneurysms to resist dissection (DS) had an inverse correlation with age (Rs=-0.55, p=0.004) and energy loss (Rs=-0.41, p=0.03), and was lower in patients with hypertension (p=0.02). DS in the aortic root did not correlate with size (Rs=-0.003, p>0.99) or valve-type, whereas it did in the ascending aorta. Matched comparison found that root aneurysms, compared to ascending aneurysms, had higher EL (p<0.001) and greater DS (p=0.01). Aneurysms of the aortic root compared to aneurysms of the ascending aorta had greater proportion of elastin (p<0.001) and smooth muscle cells (p<0.001). In the root, more favorable biomechanics were observed (i.e., lower EL) in aortas with higher elastin (Rs=-0.58, p<0.001) and lower smooth muscle cell content (Rs=0.40, p=0.02).

Conclusions: The aortic root differs biomechanically from the ascending aorta in both normal and aneurysmal states. The strength of the aortic root tissue to resist dissection is inversely related to age, but is otherwise difficult to predict by clinical variables including size.

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Viscoelastic Hysteresis of the Aortic Root and the Ascending Aorta

Energy Loss (%)

- Root - Control
- Root - Aneurysm
- Ascending - Control
- Ascending - Aneurysm

* p<0.05  ** p<0.01