Mechanism of Component Separation of Modular Thoracic Endograft: How Can This Be Prevented?

Michael Lawrence-Brown, MD, Nedlands, Western Australia; James B. Semmens, Nedlands, Western Australia; Kurt Liffman, Victoria, Australia

NOTES

The stability and movement of modular stent grafts is subject to oscillating stresses from the pulsatile flow of blood when used for the treatment of aortic aneurysmal disease. The thoracic aorta has the potential to benefit most from endografting with respect to morbidity and mortality when compared with open repair on the basis of a risk-benefit analysis. The tortuosity that occurs with aneurysmal disease compounds the complex curves of the thoracic aorta, and this makes length assessment difficult. The lie of the endograft is also unpredictable. Optimizing the length is achieved by modular components, but they are subject to migration and separation.

Methods

A pulsatile rig model was constructed to test the forces on a graft to study the behavior when the differential pressure between the lumen of the graft and the sac aneurysm was controlled. Analytic mathematic modeling was used to understand the forces on modular grafts. For the experimental work, a transparent acrylic box was used to model an aneurysm. The box was filled with water and mean pressure controlled by a header tank. Two endoluminal stent grafts were placed inside the box via angled portholes on opposite sides of the box. The movement of the two conjoined modular endoluminal grafts, where one graft was partially inside the other, was observed. The entry angle to the portholes was variable to produce a graft system in the shape of an arch with an adjustable radius of curve. A pump produced a pulsatile flow of water through the graft where the inlet pressure was set to the approximate mean value of 100 mm Hg (~ 13,330 Pa) with systolic and diastolic pressure values of around 130 mm Hg and 80 mm Hg, respectively, with an average flow rate of about 5 L/min. The sac pressure was controlled by a second header tank.

Results

It was observed that the graft system oscillated when there was zero mean pressure difference between the graft and the aneurysm. As the pressure difference was increased, this lateral graft movement was dampened and then, effectively, disappeared. The result showed that for a 30 mm Zenith graft the modular components will separate at a differential pressure of 18 mm Hg for one stent overlap, 24 mm Hg for two stent overlaps, and greater than 50 mm Hg for three stent overlaps when the graft curved through 90°. The pulsatile excursion of the graft was observed to be inversely proportional to the differential of the pressure. When the aneurysm is excluded and the sac pressure reduces, the movement of the graft diminishes as the strain increases.

Conclusions

Movement of the graft with pulsation indicates a pressurized sac. When the pressure differential is high and the graft has functioned properly, the potential for modular separation is also highest. Thoracic endografts are subject to forces on the curve that will cause migration or separation of components. Modular components are more likely to separate if the aneurysm sac is successfully excluded, if the blood pressure is high, if the diameter of the graft is large, and if the diameter of the sac is large. Operators should aim and plan for maximum overlap of modular components when treating large or long thoracic aneurysms with modular endografts.