FLOW PHENOMENA IN AAA STENT GRAFTS AND RELATIONSHIP TO DEVICE FAILURE

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The possibility of treating deadly abdominal aortic aneurysms with transluminally deployed endografts offers great potential benefit for patient care. Trauma associated with the procedure is greatly reduced compared to open surgery, as is the cost. Unfortunately, the ability to isolate an aneurysm from blood pressure for a prolonged period has provided too great a challenge for many endograft designs. There are at least four categories of failure modes for AAA stent grafts. Type I failures occur when the proximal or distal end of the device fails to seal, allowing direct pressurization of the aneurysm sac. Type II failures occur when collateral circulation, often via communications between small arteries in the abdomen and the inferior mesenteric artery, develops and allows pressurization of the sac. Type III failures refer to a structural failure of the stent graft, which can occur as a leak in the junctions between different endograft components, or a hole in the graft fabric. Type IV failures categorize continued porosity of the graft fabric. Endograft design evolution is aiming toward solutions for these problems, but the process is hindered by a lack of understanding of the challenges presented by the harsh mechanical environment. The fluid mechanical environment in healthy and aneurismal aortas is well known from numerous published reports. The techniques used to identify flow phenomena associated with disease development in the aorta were used to determine the effects of endograft design on flow disturbances at the level of the renal arteries. The motivation for this study was the fact that most endograft designs displace the aortic bifurcation proximally. In the extreme case tested here, the bifurcation point was displaced up to the level of the renal arteries. Flow visualization revealed a higher degree of flow disturbance. However, there are significant flow disturbances at this location even in healthy arteries. Thus, it was determined that this is not likely to lead to clinical failures. Further analysis of the flow environment in the aorta reveals other phenomena that are more likely to be involved in endograft failure. The cyclic nature of aortic blood flow subjects stent grafts to time-varying forces that can cause fatigue and wear in the stent graft components. The fact that many designs place metal in direct contact with thin fabric makes this a particularly grave concern. Estimations of the forces involved reveal that the inlet and outlet pressures by far outweigh shear stress, momentum transfer and gravity in determining the forces on the stent graft. The orientation of the inlet and outlets is an important parameter as well, since the forces from pressure will be primarily directed normal to these surfaces. The degree to which vessel geometry changes due to normal physiologic movement such as hip flexion is not known, although we have performed preliminary measurements using MRI angiography. The results indicate that changes in vessel curvature of approximately 50% occur with mild hip flexion. The implications on hemodynamics and endograft stress are not yet known. This information is likely to be crucial in developing the next generation of AAA stent grafts.