Evaluating Design of Abdominal Aortic Aneurysm Endografts in a Patient-Specific Model Using Computational Fluid Dynamics

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Computer modeling of blood flow in patient-specific anatomies can be a powerful tool for evaluating design of implantable medical devices. In this study, we focused on assessing the design of three different endografts, which are commonly used to treat patients with abdominal aortic aneurysms (AAAs). Once implanted, the endograft may shift within the patient's aorta creating an endoleak and allowing blood to flow into the aneurismal sac. One potential cause for this type of endoleak is the pulsatile forces experienced by the endograft over the cardiac cycle. We used contrast-enhanced computed tomography angiography (CTA) data of a patient with an AAA to build patient-specific models using 3D segmentation. This 3D technique is better able to capture anatomical details than traditional methods using pathlines and lofting of vessel cross sections. The baseline model constructed from the patient's pre-operative CTA data was then altered using custom software to reflect two different designs of endografts. An additional model was built from the patient's CTA data after treatment with a novel endograft. In all, models characterizing three distinct endograft designs were created, with each model representing a different location at which the device bifurcated into two limbs. Computational fluid dynamics (CFD) was used to simulate blood flow, utilizing patient-specific boundary conditions. Pressures, flows, and displacement forces were calculated over the models' domains. The computed blood pressures matched well with the patient's measured systolic and diastolic pressures. Average volumetric blood flow at each vessel outlet was very similar across all models, indicating that there is a minimal impact on volumetric flow distribution to surrounding vasculature after endograft treatment, regardless of endograft geometry. The magnitude of the displacement force was similar for all devices, although there were some differences in the direction of individual component forces. This indicates that design may influence the displacement force experienced by an implanted endograft, but no device design offers a clear advantage for minimizing displacement force.

Control of a Powered Lower Limb Prosthetic Device

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A powered lower limb prosthesis using a four-bar linkage mechanism was previously optimized, designed, and fabricated. Preliminary bench testing was conducted to demonstrate that it is capable of reproducing the normal ankle moment of a nonamputee. This paper focuses on the control aspect of this prosthesis. A finite state controller, which includes a state selector and a lower level controller, is proposed. Three sets of sensors and a sensing schematic will be used to determine the state of the device. Proportional-integral-derivative (PID) torque or position control will be used to realize the lower level control. Future testing will be done on lower limb amputees to prove the feasibility of this control schematic.