A Design Framework of Unloaded Leaflet Shape for the Ovine Pulmonary Valve Single Leaflet Replacement Surgery

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Tissue engineered pulmonary valve (TEPV) has been suggested as a potential approach for replacement congenitally defective pediatric heart valves. As with all heart valves, the leaflet shape during systole and diastole is essential to the normal function of PV. In this work, we present a design framework on optimal unloaded shape of TEPV leaflet for single leaflet replacement surgery by incorporating key experimental data within a finite element (FE) simulation framework. The mechanical properties of the material for leaflet replacement are measured by biaxial tensile and flexural deformation modes. The scaffold construct is modeled as a transversely isotropic hyperelastic material using a generalized Fung-type constitutive model. The quasi-static deformation of leaflet from open to close is simulated by finite element method using explicit time integration. The optimal shape of leaflet is determined by minimizing the surface distance between the deformed leaflet shapes obtained from FE simulation of TEPV and the native ovine PV shape as obtained from microCT imaging. This study aims to provide an approach toward designing the shape of leaflet for PV replacement surgery.

Innovative Renal Cooling Device for Use in Minimally Invasive Surgery

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Over 58,000 patients suffer from renal cell carcinoma annually in the United States. Treatment for this cancer often requires surgical removal of the cancerous tissue in a partial nephrectomy procedure. In open renal surgery, the kidney is placed on ice to increase allowable ischemia time; however, there is no widely accepted method for reducing kidney temperature during minimally invasive surgery. A novel device has been designed, prototyped, and evaluated to perform effective renal cooling during minimally invasive kidney surgery to reduce damage due to extended ischemia. The device is a fluid-containing bag with foldable cooling surfaces that wrap around the organ like a taco shell. It is deployed through a 12 mm trocar, wrapped around the kidney and secured using bulldog clamps. The device then fills with an ice slurry and remains on the kidney for up to 20 min. The ice slurry is then removed from the device and the device is retracted from the body. Tests of the prototype show that the device successfully cools porcine kidneys from 37 °C to 20 °C in 5 minutes.