Prolonging the Useful Lifetime of Artificial Lungs

Over 26 million Americans suffer from pulmonary disease, resulting in more than 150,000 deaths annually. Lung transplantation remains the only definitive treatment for many patients, but has meager survival rates and only approximately 1,700 of the 2,200 patients added to the lung transplant wait list each year are transplanted. Extracorporeal gas exchangers have been used as an alternative to mechanical ventilation in acute respiratory failure and as a bridge to transplantation in chronic respiratory failure. Current gas exchangers are limited by their high resistance and low biocompatibility that lead to patient complications and device clot formation. Therefore, there exists a dire need for improved devices that can act as destination therapy.

To accomplish the goal of destination therapy, this dissertation discusses three studies that were performed to pave the way. First, I examined clot formation and failure patterns of two common clinical devices (Maquet’s CardioHelp (CH) and Quadrox (Qx)) to further our understanding of their limitations with respect to long-term support. Overall, it was demonstrated that the Qx devices fail earlier and more frequently than CH devices and result in a significantly greater reduction in platelet count, and that a four-inlet approach is beneficial. Next, I determined the optimal sweep gas nitric oxide (NO) concentration that minimizes platelet binding and activation while ensuring that blood methemoglobin (metHb) concentrations increase less than 5%. Miniature artificial lungs were attached to rabbits in a pumped veno-venous configuration and run for 4 h with NO added to the sweep gases in concentrations of 0, 100, 250, and 500 ppm (n=8 ea.). 100 ppm significantly reduced the amount of platelet consumption (p < 0.05), reduced platelet activation as measured by soluble p-selectin (p < 0.05), and had negligible increases in metHb and will thus be used in future experiments. Last, I tested the Pulmonary Assist Device (PAD) which was designed for long term use as a bridge to transplantation and destination therapy. Benchtop experiments were performed that confirmed that it meets our design and performance goals. From here, we are equipped to commence with 30-day PAD testing in sheep.