Designing, Prototyping and Testing a Novel Urinary Catheter with Tesla Valves and a Microporous Membrane

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Catheter associated urinary tract infections (CAUTIs) result in 13,000 deaths in the US annually. The Foley catheter design promotes biofilm formation - the underlying cause of CAUTIs. In Phase 1, a multi-lumen catheter was developed with a side channel for delivery of biocides into the catheter lumen and a one-way valve to prevent biocide from entering the bladder. The goals of Phase 2 were to modify the multi-lumen catheter to solve the issue of valve failure due to crystallization and to improve the biocide delivery to the biofilm adhesion layer. To achieve these, a Tesla Valve was incorporated into the catheter. As it has no moving parts, crystallization does not affect its function. The catheter was created with microporous silicone to uniformly distribute biocide throughout the catheter and for direct delivery of biocide to the adhesion layer. The microporous membrane was tested using yeast and CO2 measurement. As biocide diffused across the membrane, CO2 production decreased, indicating membrane functionality. The Tesla Valve catheter device was tested with a 3D-printed bladder. An alkaline fluid (pH 11.5) was instilled into the catheter as a biocide. An acidic fluid (pH 6.5) was instilled into bladder to simulate urine. The pH of the solution in the bladder and of the catheter discharge was measured. Alkaline pH was recorded in the discharge fluid, indicating successful delivery of biocide through the microporous membrane. Acidic pH was maintained in the bladder, demonstrating the effectiveness of Tesla Valve as a one-way valve. Further testing of the novel catheter can be done in a lab using biofilm prior to the clinical use. This design can be applied to other catheters like peripherally inserted central catheter (PICC) lines where biofilms form as well.

Awards Won:

First Award of $5,000