**Mechanical Bladder: Controlled Fluid Outlet System**

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**Background Information**

- Each year, there are about 1,600 babies born with spina bifida, 17,000 spinal cord injuries, and 68,000 bladder cancer patients with compromised bladder function.

- Treatments for spina bifida include an bladder augmentation procedure in which a piece of intestine or appendix is used to increase the bladder volume.

- Treatment for bladder cancer patients and spinal cord injuries includes urostomy and orthotopic neobladder reconstruction.

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**Urine Pathway**

1. Inlet from kidney (designed year 2). Urine stored in 650mL reservoir
2. Controlled outlet through solenoid valve

**Air Pathway**

1. Air pockets separated from urine by PTFE membrane filter (internal) with high air permeability and high water entry pressure
2. Air travels through tubes that connect at top of bladder. Air outlet connected to container out of body

**Control and Measurement System**

Mobile app allows user to:
- Control solenoid valve
- View current bladder volume using a system of conductive pins stuck into the silicone

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**Validation**

1. **Membranes**
   - Calculation: under the pressure of a full bladder the membrane would remain impermeable to urine
   - \( P_{\text{membrane}} \approx 31.03 \text{ kPa} \gg P_{\text{urine}} = 1.12 \text{ kPa} \)
   - **Significance:** membranes will not leak
   - Physical Testing: a 50mL test tube was filled with water and sealed with the membrane over.
   - Result 1: Over 24 hour period no water leaked through the membrane
   - Result 2: A draining test was done to prove air could move through the membrane during voiding

2. **Outlet**
   - Computational Fluid Dynamics Model
   - 3D ANSYS model showed that voiding by gravity of a full bladder (650mL) would be under set time constraint (30s)

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**Electrical System Results**

- Original Design Containing 13 pins, resulted in limitations
- Redesign included 6 pins and is able to detect volume in 5 orientations at 50 and 80 percent capacity

**Prepared Methods**

1. Join silicone bladder and electrical system
2. Physical pin/sensor placement and testing
3. Test flow rate for solenoid voiding mechanism

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**Conclusions And Future Work**

**Conclusions**

1. The Sterlitech PTFE membranes did not leak when properly sealed onto the silicone bladder and allowed sufficient air flow for voiding purposes
2. The six pin electrical system worked and displayed expected volume on the App
3. The redesign of the bladder’s geometry was required for implementation of a venting mechanism

**Future Work**

- Increase pins in electrical system for more specified bladder volume
- Add additional features to electrical system to comply with assessed failure modes and effects analysis
  - e.g. automatic emptying, additional alarms and alerts to user
  - Redesign geometry of hard outer shell
  - In vitro, in vivo, and biocompatibility testing
- Utilize smaller, custom solenoid valve for final product

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**References**


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**Prototype Membrane Testing Results**

- Initially, three-fifths of membranes were not completely sealed
- New method sealed all membranes