

Laryngeal Bioreactor

Kyle Anderson, Peter Guerin, Rebecca Stoebe, Dan Thompson

Department of Biomedical Engineering Advisor: Dr. Tracy Puccinelli Client: Dr. Nathan Welham

Abstract

Organ donation and tissue grafts are often used when tissues are removed due to trauma or disease. Tissue engineered organs have the patential to overcome several obstacles associated with organ donation, such as limited supply and immune rejection. We have created a novel bioreactor for the decellularization and recellularization of laryngeal tissue composed of polycarbonate and other sterilizable materials. It is fitted with electronics that have been seen to consistently control the pumps that supply the bioreactor with media, and turn the larynx to vary its exposure to media and air. Future work with this device involves testing its effectiveness in decellularization and recellularization procedure

Background & Motivation

Larynx and Treatment Background

- Larynx: Complex organ in airway that houses vocal cords
- Laryngeal cancer affects 136,000 individuals worldwide each year (1)
- Very low success of complete larynx transplant due to immune rejection of allograph (2)



Figure 2: Tissue-engineered trachea (5)

- Tissue Engineering Background engineered larvnx
- Tissue engineered tracheal cartilages and vocal folds grown in vitro (4,5)

Previous Work

Previous Laryngeal Bioreactor Design

- Previous BME 400 team
- Bioreactor holds larynx in a stable, vertical position
- Showed successful decellularization
- · Several problems with design

Design Criteria

Client Requirements for Design

- · Single bench top unit for decellularization and recellularization
- Allow separate environments for inner lumen and organ exterior
- · Provide researcher access to larynx
- · Sterilizable and operable in refrigerator and incubator
- · Allow variable access of the tissue to air and media

Final Design Larynx

25×15×15 on

Bioreactor Final Design

- Inner cage houses larvnx
- Five 13 cm long polycarbonate rods-larynx sutured to bottom rod Rods connected to semi-circular sheets fo
- stability and removal Cage attached to rods on either side
- to allow turning of larynx Pumps perfuse through larynx inner lumen and vasculature separately
- Drainage area underneath device



Figure S: Bioreactor Circuitry

attachmen Drain plug

Figure 4: SolidWorks image of final design

Electronics and Automation

Pump Automation

- Composed of Arduino Uno with low pass filter
- External control interface programs circuit
- Allows variation of inner lumen pump during decellularization and recellularization:
 - Media & air exposure times
 - Flow rates

Laryngeal Turning Automation

- · Composed of Arduino Uno with EasyDriver and stepper motor
- Requires 10 volt input power
- External control interface programs pumps
- Allows variation of laryngeal position in bioreactor:
 - . Media & air exposure times
 - Amount of laryrx exposed to media & air
 - Speed of turning laryrx

Pump Testing **Pump Testing and Results**

- Correlated pump-displayed RPM flow rate to standard mL/min flow rate
- Assessed pump ramp up flow rate times based on time to fill current tubing
- Arduino IDE pulse width modulation (PWM) correlated to output voltages and pump flow rates for client use

igure 7: How Bate Verification Testing

Average Flow Rate vs PWM (Large Pump) Andalso cetpet (PWM)

Turning Testing

Turning Testing and Results

Tube

Motor Housing

Drainage Area 3cm

Cage

- Motor must consistently turn 180'
 - This will verify that tissue



attached to cage can be entirely wetted by bioreactor prototype Rigure 8: Turning Testing

Results Discussion

- RPM linearly and consistently correlates to standard mL/min flow rate
- Initial flow rates are 5-10 mL/min slower than longterm flow rates due to time to fill tubing
- Programmed PWM consistently results in same output voltage and flow rate
 - · Linear relationship between PWM and flow rate
 - · Enables predictable programming of device
- Motor consistently turns 180° over long periods
- · Thorough wetting of entire cage can be achieved

Budget Details Cost Bioreactor Raw Materials: Polycarbonate \$110 Pumps: Langer Instruments peristaltic pumps \$1,295 Electronics: Arduino Uno, Stepper Motor, Stepper \$113 Driver, etc. Miscellaneous: Hardware, seals, glue, etc. Total Cost \$1,538

Future Work

- Remake and improve prototype
- Improve circuitry, automation and user interface
- · Fluid testing, mechanics analysis
- · Mechanical strength testing of device
- Decellularization testing, recellularization testing
 Histological Staining, RNA Assays

References

Acknowledgements . Dr. Yutaka Toya

- Dr. Tracy Puccinelli Dr. Nathan Welham
- Michole Rauch References