VetMed: Feline Cystocentesis Teaching Model

Team Members: Emily Johnson, Quinton Heney, Gwendolyn Johnson, Abigail Johnson
Client: Melissa Shear
Advisor: Ed Bersu

Abstract

Urine sample collection is a common diagnostic taken by veterinarians [1]. Because of this, a quick method to obtain a sterile sample is necessary. That is where cystocentesis comes in. Cystocentesis is a routine procedure used to withdraw urine by inserting a needle through the skin and into the bladder [2]. This procedure is delicate, meaning it is possible to damage internal structures if the needle is inserted incorrectly. Therefore, there is a need for a helpful teaching model that allows veterinary students to practice this procedure. There are very few teaching models on the market. One teaching model, developed by the Universidad de Buenos Aires, includes a filled water balloon placed inside a stuffed animal that students practice withdrawing a "urine sample" from. The second model, the Cystocentesis Trainer, is a clipped balloon that sits in a covered tray and it functions similarly to the first model. Due to the lack of teaching models, most veterinary students gain practice by working on cadavers or live animals. This is helpful in some cases, but cadavers often have empty bladders, which is unrealistic. To solve this problem, a teaching model will be constructed that allows students to practice this procedure in a low-risk environment. Because most veterinary students have the skills needed to withdraw liquid from the body, the final design is composed of an electrical component that notifies students whether they have correctly entered the bladder or made a mistake by hitting another organ while keeping animals safe and building students' confidence.

Introduction

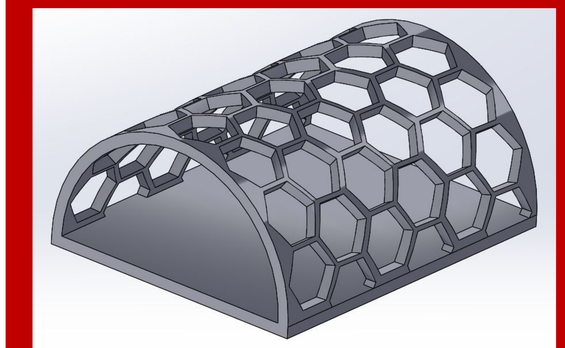
- Cystocentesis is a procedure in which a syringe is inserted through the abdominal wall and into the bladder so a sterile urine sample can be collected and tested.
- Very quick but delicate procedure and the cat can be standing or lying dorsally.

Motivation

- Canadian vet association survey shows 76% of veterinary school graduates indicate a lack of confidence and/or competence performing certain procedures due to lack of hands-on training [3].
- Very few models are available that allow students to practice cystocentesis
- Laceration of organs during cystocentesis can cause uroabdomen, hemorrhage, or fatality.

Final Design

The design consists of a cage. 3D printed at the Makerspace with PLA, which holds aluminum foil modeled body parts of various sizes. These parts include two kidneys, the spinal cord, the small intestines, and the bladder. The bladder has also been encased in silicone rubber to insulate it from the other circuitry elements. The cage is to have a large sheet of EcoFlex, 25.4 cm x 16.5 cm x 7.6 mm, laid on top, and then be inserted into a stuffed animal that resembles a cat. The wires that run from the aluminum foil parts will exit the stuffed animal and enter an aluminum box, 11.4 cm x 6.4 cm x 5.7 cm, and will activate the red or green light when the circuit is completed.



Bladder Representation
- Aluminum base and ecoflex can be handled in a manner similar to palpation
- Approximate size of a full bladder

Structural Element
- Stuffed animal is the size of an average cat in the abdominal region
- Cage is representative of the size of the abdomen when taut
- Hole cut in hexagons for better access to bladder

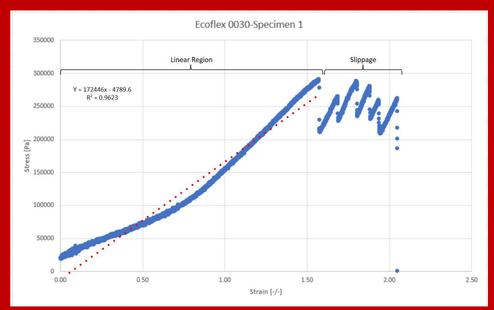
Other Organs
- Anatomically accurate sized kidneys and educated approximations made on the vein and small intestine

Testing

Mechanical properties of the skin of a cat were unable to be found. Human skin was used as a basic replacement.

Material	Mean Ultimate Tensile Strength [MPa]	Mean Elastic Modulus [MPa]	Mean Failure Strain [-/-]
Human Skin [4]	27.2	98.97	25.45
Ecoflex 0030*	0.296	0.12203	3.36
Ecoflex Gel-- Trial Unit	-**	0.05674	1.27

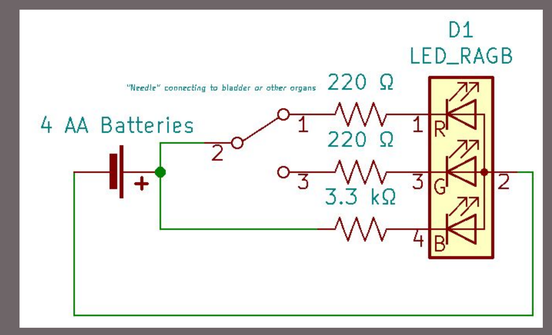
*Ecoflex 00-30 was unable to be tested to failure as slippage occurred prior, the stress is the highest recorded. The failure strain is the average strain across the trial when the slippage occurred
** Discontinuities in the trial gel caused high variations of stress thus the absence of the data



Discussion:
- EcoFlex Gel-- Trial Unit failed in a brittle manner with no plastic region. No deformation to the shape should occur over time
- It is expected that the elastic modulus of the skin of a cat would be higher due to the stiffness of the additional hair follicles. Additionally, the failure stress and mean ultimate tensile strength are expected to be lower.
- Addition of muscle and other tissue will lower each of the human skin data points as the elastic modulus of muscle is approximately 0.012 MPa [5]
- EcoFlex 00-30 best represented the overall desired properties
- Compressive testing to determine about of force necessary to puncture EcoFlex with a needle unable to be safely tested
- Replicated the approximate pressure of the needle insertion into a cadaver-- three-person consensus

Circuitry Element

Shown below is the circuit diagram for our final design. This diagram consists of four AA batteries to supply six volts. When turned on, the LED on the box will display a blue light. Additionally, upon the completion of the circuit by the needle on one of the aluminum foil parts, the LED will instead display a green or red light, depending on whether the needle connected to the model bladder or not.



Future Work

Addition of 3D printed bones for structural purposes
- Using CT scans to obtain needed bones and then printing them in the MakerSpace
- Inclusion of the spine, pelvis, ribs, and leg bones
- Removal of 3D printed "rib cage" to allow for palpation of the bladder

Interchangeable Bladders
- Varying sizes to mimic a full and near-empty bladder to simulate numerous potential cystocentesis situations

Liquid Filled Bladder
- To allow students to completely practice the procedure from start to finish

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The Green Room Baby

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