Cooling Device for 3D-Transesophageal Ultrasound

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Abstract

Our client has been using a prototype of a new 3-D transesophageal ultrasound probe in pigs to image an injection catheter in the left ventricle. The injection catheter and imaging method are being tested as a method to deliver stem cells to damaged heart tissue. The continuous imaging that is required to determine the placement of the injection catheter and the stem cells causes the probe to overheat and turn off until it has cooled down enough to prevent any tissue damage. We have designed a device to cool the ultrasound probe so that he could image for a longer period of time without tissue damage. This project would have commercial potential as this is a novel use of 3-D ultrasound.

Background

- Current research is being conducted involving the injection of stem cells into dead heart tissue
- Research will determine to what extent stem cells can regenerate damaged or dead cardiac cells
- Our client uses a three-dimensional ultrasound probe to continuously image the pig's heart while he makes injections
- Imaging is necessary so that our client can determine the injection locations in the pig's heart

Figure 1. Ultrasound image of a left ventricle

Motivation

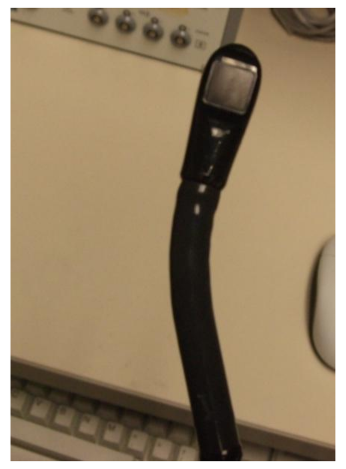

Figure 2: Current Probe: Philips Model # X7-2T

- Client's procedure can last for long periods of time (up to eight hours)
- Extended use of the ultrasound probe causes it to overheat
- The probe has a built-in mechanism that causes it to turn off when its internal temperature reaches 42.5 °C
- Probe shuts off to prevent tissue damage to patient

Client Requirements

- **Sufficient Cooling:** The cooling device should provide continuous cooling and prevent the internal temperature of the probe from reaching 42 °C for the entire injection procedure (up to eight hours)
- **Size**: The cooling device should not protrude more than 1 cm from the ultrasound probe
- **Portability**: The cooling device should be able to detach from the probe
- **Durability**: The cooling device should be re-usable and be able to withstand the potentially acidic conditions within a pig's esophagus
- **Safety**: The cooling device should not cause any tissue damage to the patient

Final Design

Reservoir Cooling Device

- Device consists of polyvinyl tubing, Tygon tubing, and polyethylene film
- The polyvinyl tubing was cut in half and sealed within the polyethylene film
- Polyvinyl tubing provides support while tape wrapped around holds device to probe
- Polyethylene provides flexible surface for cooling where the device contacts the probe
- Tygon tubing is used to connect the reservoir to a saline bag
- Gravity is used to provide flow from the saline bag through the cooling device

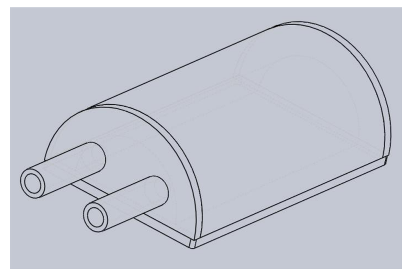

Figure 3: Reservoir cooling device in SolidWorks

Figure 4: Prototype of reservoir cooling device

Dimensions

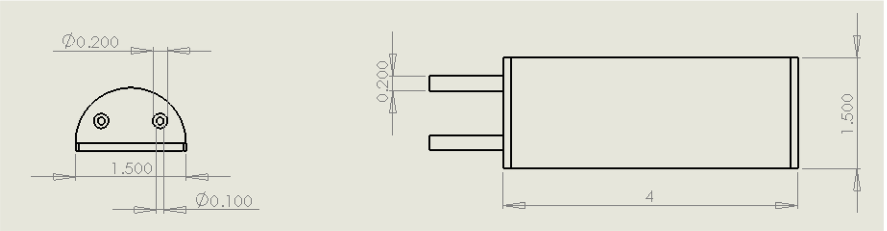

Figure 5: Dimensions of prototype in cm

Budget

Material/Product	Price
Polyethylene Film	$ 18.74
Polyethylene Spray Adhesive	$ 12.97
Vinyl Tubing	$ 3.40
Total	$ 35.11

Testing

In Vitro Testing

- Probe placed in a container of raw beef surrounded by a water bath kept at 37 °C
- Internal probe temperature readings were taken every 30 seconds
- Performed testing under two conditions: One with the cooling device and a control without it

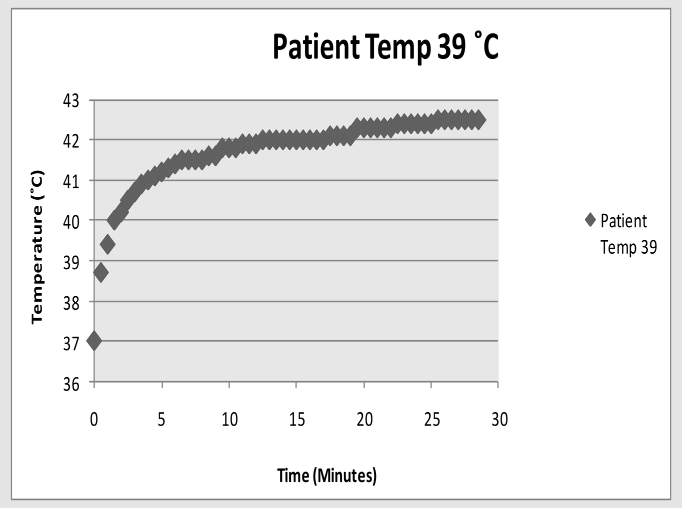

Figure 6: Control graph of in vitro testing with a subject temperature of 39 °C

Testing (continued)

- In vitro testing showed that our device provided enough temperature reduction in order to prevent the ultrasound probe from shutting off

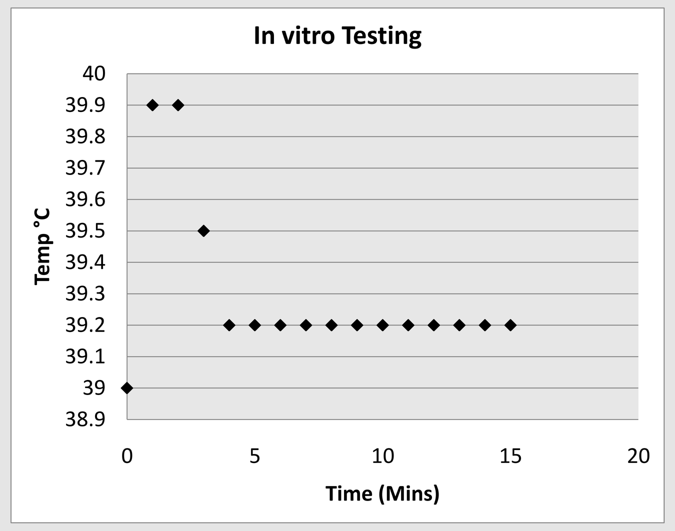

Figure 7: Graph of in vitro testing with cooling at a bath temperature of 39 °C

Animal Testing

- Cooling device was attached to probe using surgical tape
- Our client recorded the temperature of the probe at random times during procedure
- The cooling device sufficiently cooled the ultrasound probe, as the probe did not overheat and shut off during the procedure
- The cooling device along with the surgical tape was too large, which caused the bleeding in the pig's throat
- The cooling device was not completely watertight

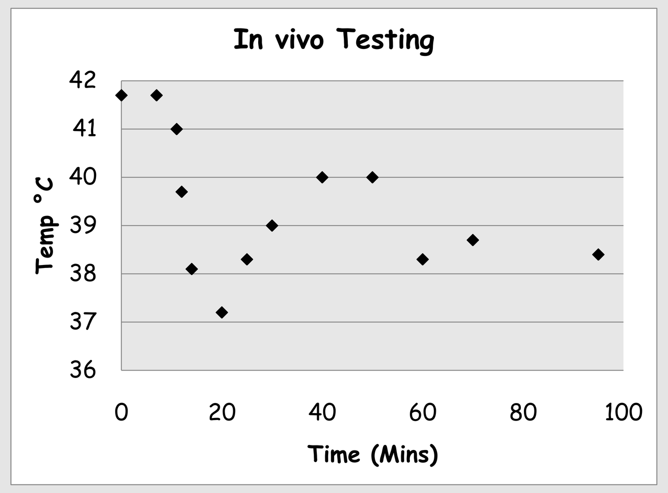

Figure 8: Graph of animal testing with cooling device attached to ultrasound probe

Future Work

- Improve method of attachment
  - Surgical tape is convenient but may lead to complications due to rough edges and increased probe diameter
- Determine a method for heat sealing the entire cooling device to further ensure structural integrity
- Perform additional testing

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