2015

A Treatment for Menorrhagia and Irregular Menstruation: Free Flowing Cryo-fluid Endometrial Ablation

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CHEMICAL AND LIFE SCIENCE

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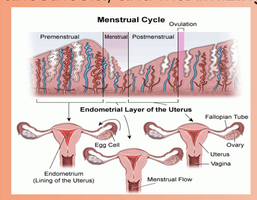
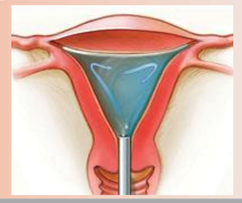
CAPSTONE DESIGN EXPO 2015

Background

- Menorrhagia is a condition defined by abnormal menstrual bleeding where flow is greater than 80 mL per cycle, 50 mL more than the average. 20% of women report suffering from this.
- Menstruation is caused by the shedding of the endometrial layer down to the regenerative basal layer; in order to permanently end menorrhagia, the basal layer must be destroyed.
- Current therapies aren't optimal for patients because the treatments are too invasive, expensive, painful or lack complete coverage of the uterus.
- A free flowing cryo-fluid system is an attractive solution to Menorrhagia due to cold's numbing properties removing need for anesthesia, and maximizing coverage of the uterine wall.





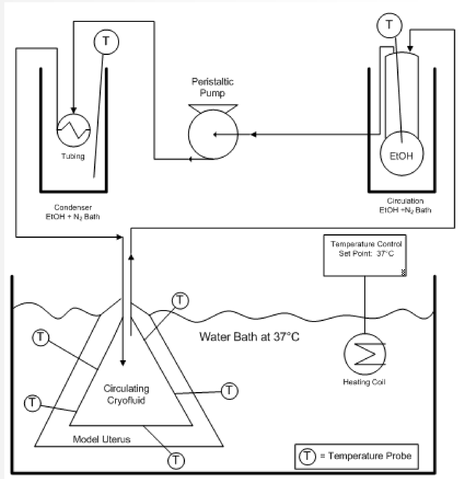
Hypothesis

- If sub zero temperature ethanol is flown into a model uterine cavity, the heat transfer that occurs will overcome body temperature and destroy cells to a depth of 2mm, preventing regeneration.

Aims

- To provide a proof concept for an in-office procedure for the treatment of Menorrhagia by using free flowing ethanol at cryo temperatures
- To reduce temperatures inside the model uterus to below the 0˚ C required for cell death, without freezing the cryofluid
- Maintain cold bath temperatures between -110˚ C and -79˚ C
- Find ideal cold bath temperatures based on composition, and ethanol flow rates to achieve freezing temperatures inside the model (overcoming body temperature at 37˚ C)

Design



Key Features:
- Insulated tubing
- Condenser (Second coiling bath) applied after pump (peristaltic)
- Liquid nitrogen and ethanol bath
- Free flowing 100% ethanol
- Metal coil in which ethanol is pumped through submerged in second bath
- Model made with Permagel mold
- Cp=1.67 kJ/kg·K (Permagel)
- Cp=0.36 kJ/kg·K (Uterus)

Heat Transfer

Spherical Model

Steady State Heat Equation*: $\frac{d}{dr}(r^2\frac{dT}{dr})=0$

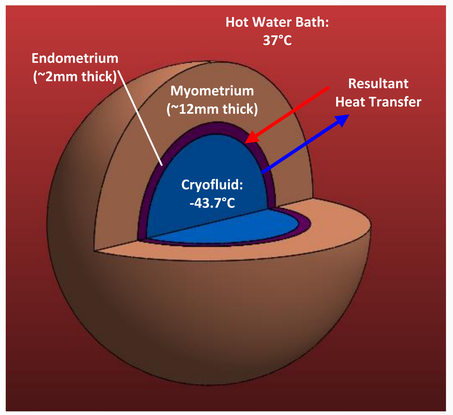
$$\text{Solve}: T(r)=\frac{C_1}{r}+C_2$$

Using Boundary Conditions: $T(r_1)=T_1 \quad T(r_2)=T_2$

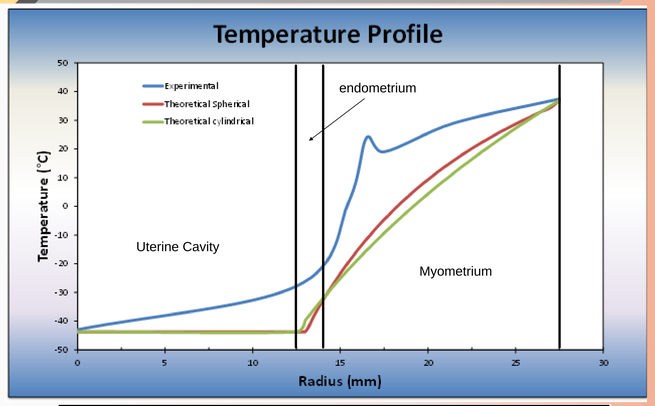
Governing Temperature Profile Equation:

$$T(r)=T_1+\frac{T_1-T_2}{\frac{1}{r_1}-\frac{1}{r_2}}\left(\frac{1}{r}-\frac{1}{r_1}\right)$$

*assumed steady state



Results



	Circulation Bath Temperature Range (°C)	Condenser Bath Temperature Range (°C)	Hot Bath (°C)	Average Model Initial Temperature (°C)	Average Final Temperature at 3 mm (°C)	Coldest Temperature Achieved (°C)	Flow Rate Range (ml/min)	Time to Reach Equilibrium (min)
Test Information	-65.6 : -96.1	-69.9 : -101.8	37.0	38.0	1.2	-0.9	102 : 204	35

Conclusions & Future Work

- Cryoablation by free flowing liquid is a feasible treatment option for Menorrhagia.
- Sub -80˚ C ethanol can be successfully flowed in a closed system to create a -43˚ C environment inside a Permagel model.
- Due to the Permagel model's differing heat capacity from the endometrium, it is believed that using these cold bath temperatures in a human uterus would achieve cell death at the goal depth of 2mm.
- Flow rate adjustments were inconclusive due to peristaltic action increasing at cold temperatures causing extreme fluctuation in readings.
- Due to modeling with a steady state equation, experimental unsteady state results naturally vary from calculations.
- Cytotoxicity of ethanol on cells should be investigated. Possible treatment time could be reduced.
- Testing on tissue models with correct heat capacities will provide more definite results.

Acknowledgements:
All Advisors and our Sponsor
Dr. Nastassja Lewinski and the Lewinski Lab from the School of Engineering
Dr. Ellen Brock and MCV's Human Simulation Lab

VCU School of Engineering

Make it real.

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