Placenta Extraction Model

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Abstract

The placenta is used to transfer nutrients between mother and fetus during pregnancy. Once the baby is delivered, the placenta is no longer needed and is expelled from the uterus. In 3% of cases, the placenta does not detach and the physician must use his or her hand to manually extract the placenta. As manual extraction is rare, many doctors in rural areas or developing countries do not have experience with this procedure. Current birthing models are expensive and complex, yet do not include manual placenta extraction, so this project aims to create an inexpensive add-in uterus and retained placenta. The uterus and placenta were molded from silicone, attached using neodymium magnets, and embedded with A1302 Linear Hall Effect Sensors to create a model of manual placenta extraction with visual feedback.

Introduction

Client: Dr. Lee Dresang, St. Marys Hospital

- Professor of Family Medicine at UW-Madison SMPH
- Advanced Life Support in Obstetrics (ALSO) program
- Proposal: supplement a current birthing model with manual extraction capabilities

Placenta

- Connects to fetus via umbilical cord
- Exchange site between mother and fetus
- Normally expelled after 30-60 min after delivery
- Retained placenta can lead to postpartum hemorrhage

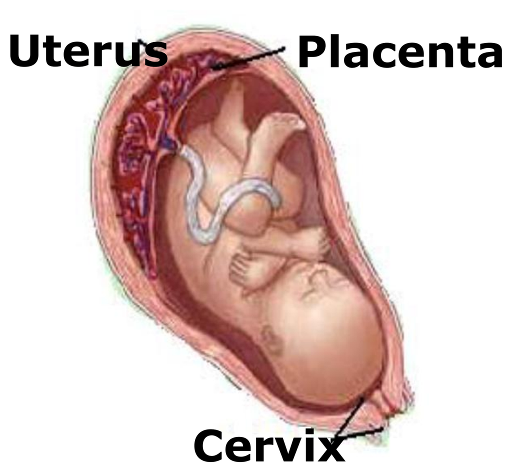

Figure 1: Typical placenta orientation

Figure 2: Current simulator used in client's training program

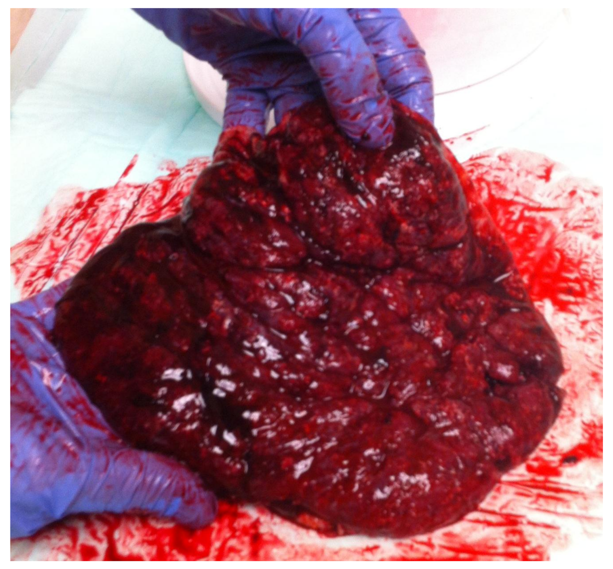

Figure 3: Uterine attachment side of a placenta

Design Criteria

- The model must:
  - Be low in cost and compatible with currently used birthing simulator
  - Incorporate both a uterus and a retained placenta
  - Realistically mimic the uterus and placenta tissues
- Provide feedback about success of extraction

Testing

Testing Procedure

- Arduino, sensors, and circuitry connected, and Arduino serial output used to record voltages
- Baseline voltage measured with sensor only, then normalized with calipers
- Magnet affixed to caliper in consistent polarity
- Voltage output measured at set distances
- Used n = 5 measurements per distance and n = 2 sets for the magnet per sensor
- Two conditions used:
  - Magnet only
  - Magnet with 4.5 mm silicone/power mesh between sensor and magnet

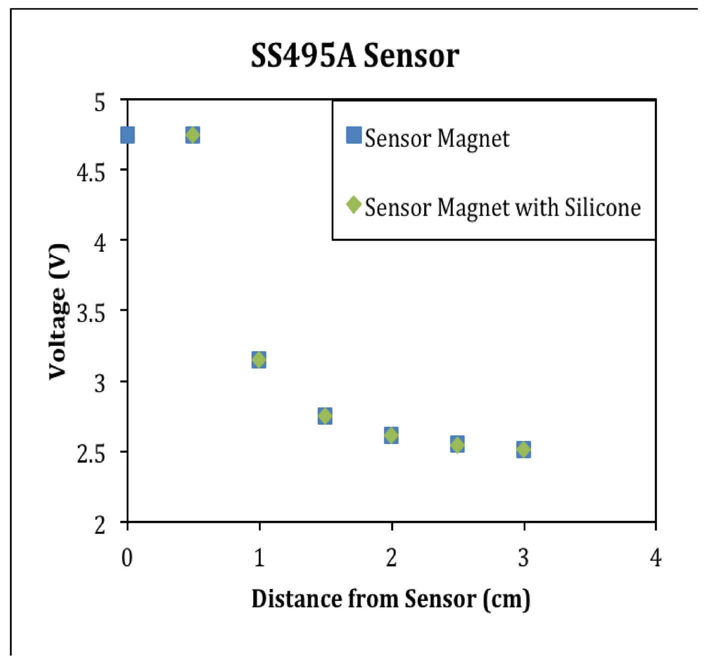

Figure 4: Sensor output voltage vs. magnet distance from center for the SS495A sensor

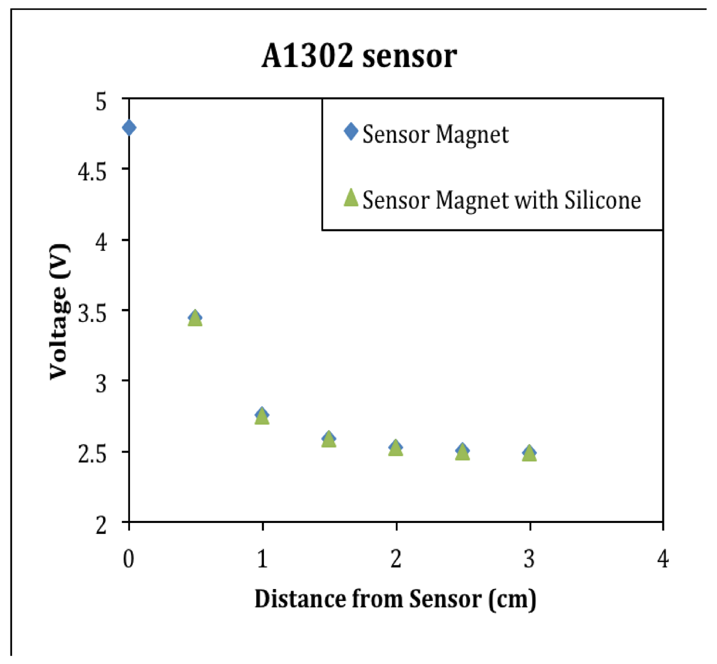

Figure 5: Sensor output voltage vs. magnet distance from center for the A1302 sensor

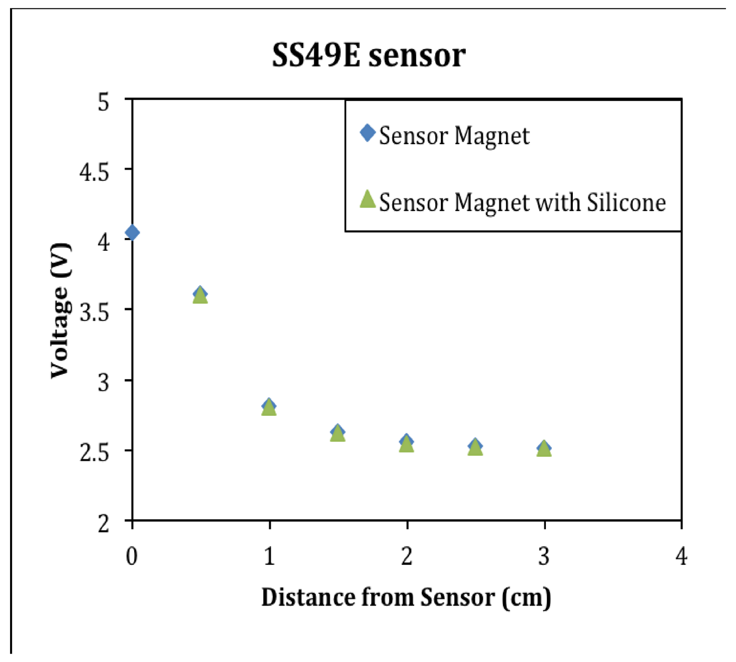

Figure 6: Sensor output voltage vs. magnet distance from center for the SS49E sensor

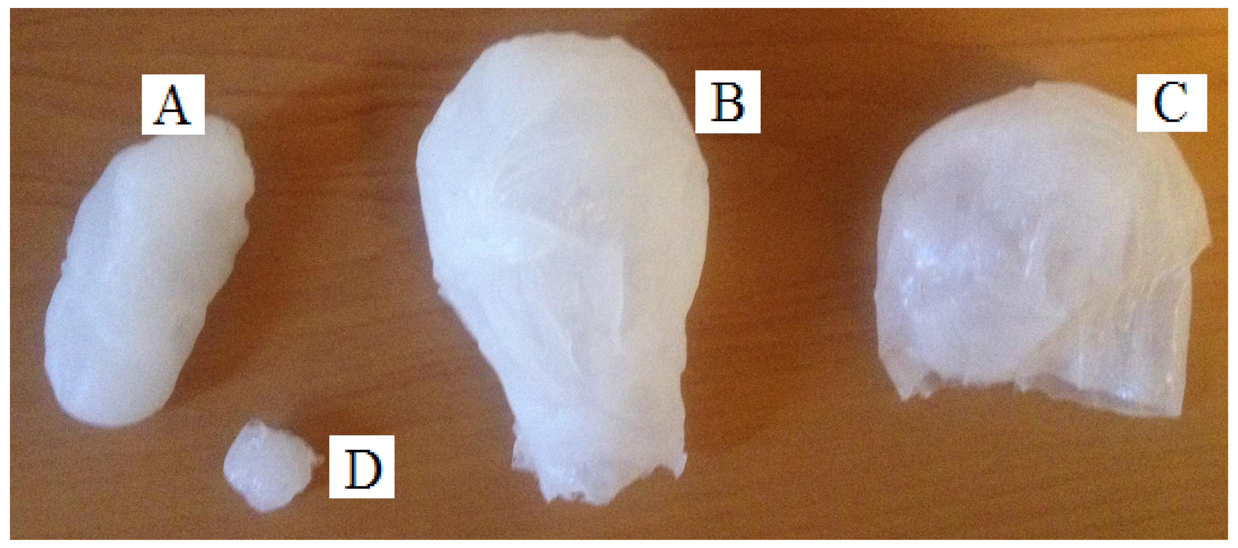

Figure 7: Miniature Uterus Models
Three small-scale uterus models composed of different silicone mixtures. A) DragonSkin and Slacker in 1:1 ratio with two drops of TinThix. B) DragonSkin with two drops of TinThix. C) Ecoflex with two drops of TinThix. D) A section of part A with a thin coating of A-564.

Silicone molding: Uterus and Placenta

- Ecoflex and DragonSkin were chosen to have properties closest to the uterus and placenta
- Clay was used to create small models using different combinations of Slacker and TinThix
- DragonSkin creates the best structural support and will be used for the uterus
- Ecoflex has a lower Young's Modulus and will be used for the placenta
- Magnets of different strengths were then embedded within the uterus and the placenta to determine the optimal combination

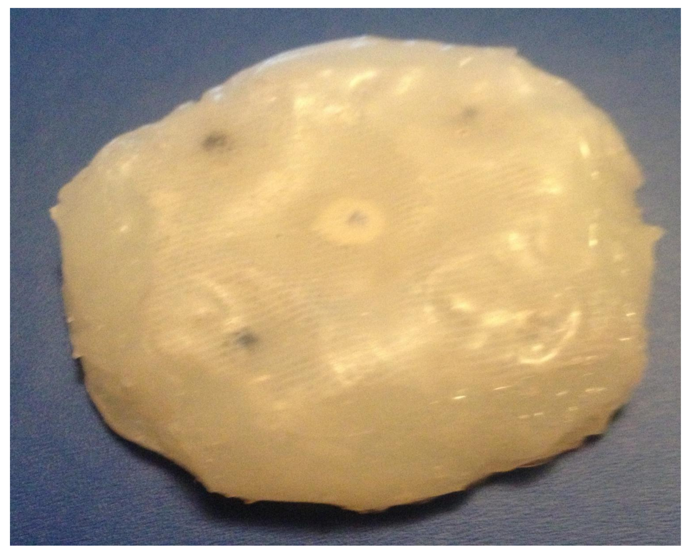

Figure 8: Miniature Placenta with embedded magnets

Current Prototype

Figure 9: The upper ¼ of the uterus with embedded magnets and open slots to house the sensors.

Figure 10: The sensor will be placed within a cavity and a plug of silicone will be placed on top of the sensor in order to secure the sensor in the uterine wall.

Figure 10: The color mapping algorithm is capable of displaying color values ranging from dark red to dark blue. A test frame displays the color corresponding to the voltage output of the sensor; red corresponds to a magnet directly over the sensor and dark blue to the sensor sensing no magnetic field.

Future Work

- Determine optimal orientation for magnets and sensors
- Devise placenta accreta mechanism
- Cast final placenta and uterus
- Implement portable power source
- Further develop color map and final visual display
- Gather data from medical personnel
- Patent

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References

[1] "ALSO® - Advanced Life Support in Obstetrics" The College of Family Physicians of Canada. Web. 21 Oct 2012. <http://www.cfpc.ca/also/>.
[2] "Functions and Roles of the Placenta." Pregnancy Calendars. Web. 20 Oct 2012. < http://www.pregnancy-calendars.net/>.
[3] "Placenta Previa". Mayo Clinic. Web 21 Oct 2012. <http://www.mayoclinic.com/health/placenta-previa/DS00588>.
[4] "The Fetal Life-Support System: Placenta, Umbilical Cord, & Amniotic Sac". American Pregnancy Association. Web. 20 Oct 2012. <http://www.americanpregnancy.org/duringpregnancy/fetallifesupportsystem.html>.
[5] "Management of the Third Stage of Labor." Medscape Reference. Web. 22 Oct 2012. <http://emedicine.medscape.com/article/275304-overview>.
[6] Weeks A. "The Retained Placenta." Best Practices & Research Clinical Obstetrics & Gynaecology 2008; 2(6): 1109-1117.