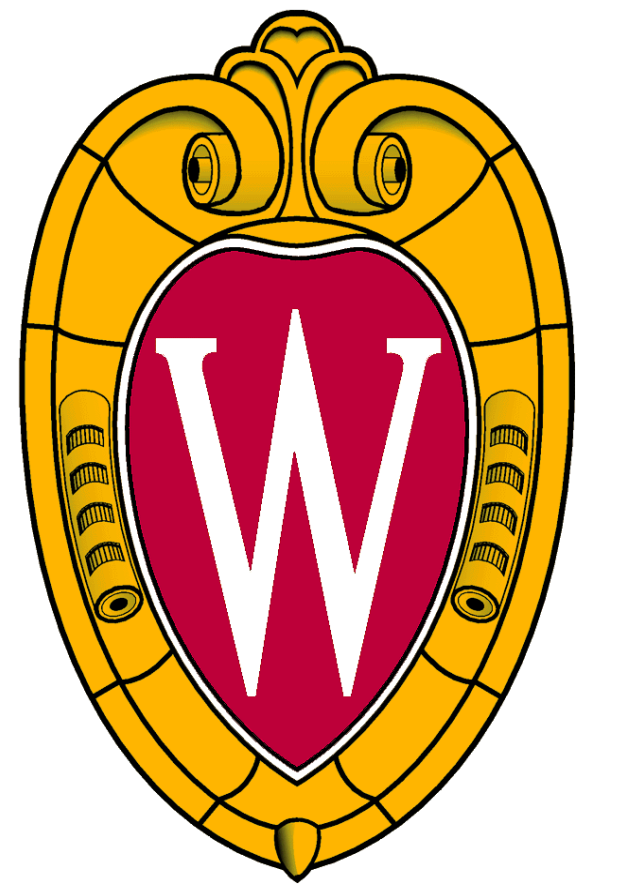




Safety System for Double Volume Exchange Transfusions



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Introduction

- Hyperbilirubinemia: temporary condition caused by high concentrations of bilirubin in the blood
- Bilirubin is formed when red blood cells break down¹
- Premature babies do not have fully developed organs
- Bilirubin can act as a neurotoxin and cause brain damage²
- Effects up to 50% of newborn babies
- Hyperbilirubinemia treatments:
 - Phototherapy
 - Double volume exchange transfusion
- Double volume exchange transfusion:
 - Exchange twice the baby's blood volume for donated blood
 - Total blood approx. 500 mL
 - Procedure done infrequently
 - Requires 3 medical personnel
 - Drawn/withdrawn from syringe at 10 mL increments
 - Approx. 4 hours to complete
 - Unintuitive four-way stopcock



Figure 1: The setup of double volume exchange transfusions.



Figure 2: Four-way stopcock used in the transfusion.³

Design Criteria

- Increase safety of the transfusion
- Sterile
 - Disposable, autoclave compatible, or withstand alcohol
- Comfortable
 - Lightweight, compact, handheld
- Accurate
 - Eliminate incorrect use of four-way stopcock
- Size
 - All components must fit within space of the patient bed



Figure 3: The stopcock base next to the baby on a typical patient bed. The baby is completely covered during the procedure and space limitations are an important consideration to the design.

Final Design

Stopcock base top

- Radius and height = 0.02 m
- Clearly identifiable ports
 - Labels
 - Colored attachments
- Comfortable handle for the user
- Arrow to ensure clockwise rotation
- Attached by rubber bands

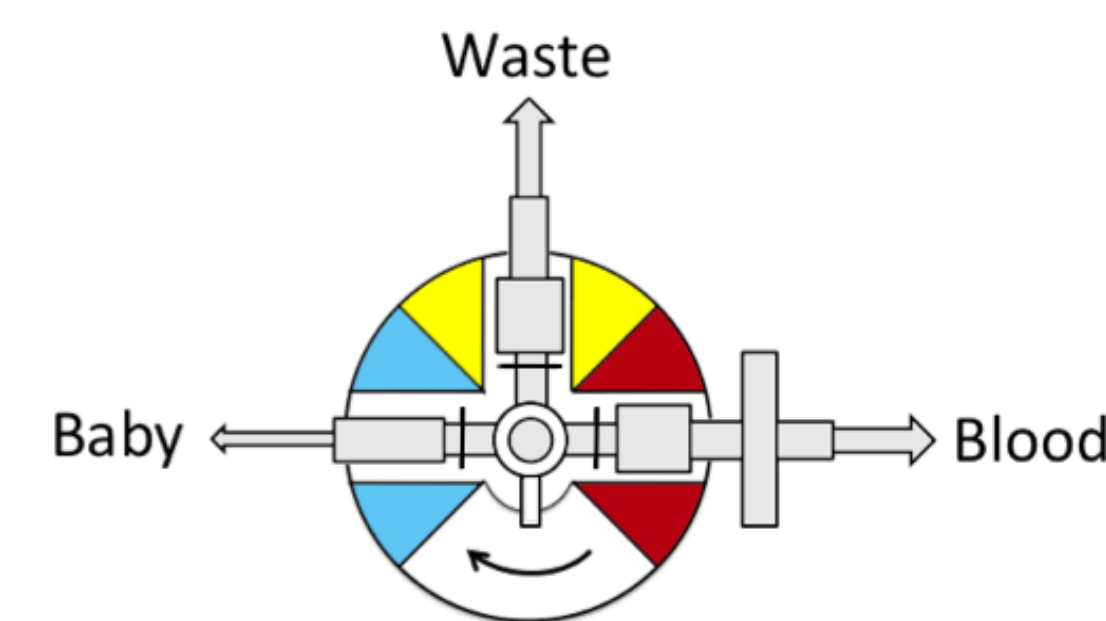


Figure 4: Initial design of the top view of the stopcock connected to the base.

Stopcock base bottom

- Spherical ball with flat bottom
- Radius = 0.04 m
- High versatility and stability
- Current rapid prototype in ABS

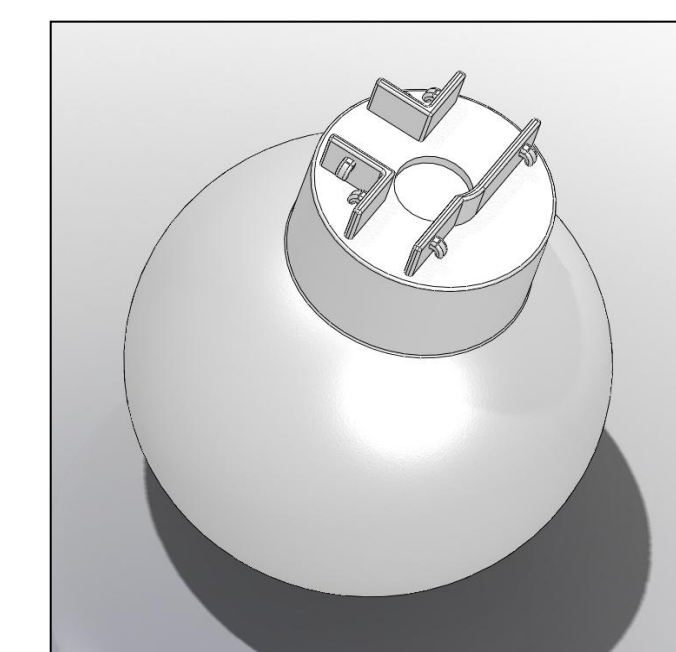


Figure 5: SolidWorks image of the stopcock base.

Counter system

- Measures amount of blood withdrawn from the baby
- Scale that measures in grams
- Can convert to mL
 - 1 g of blood = 0.943 mL
- Weight of empty waste bag is subtracted from weight of the bag

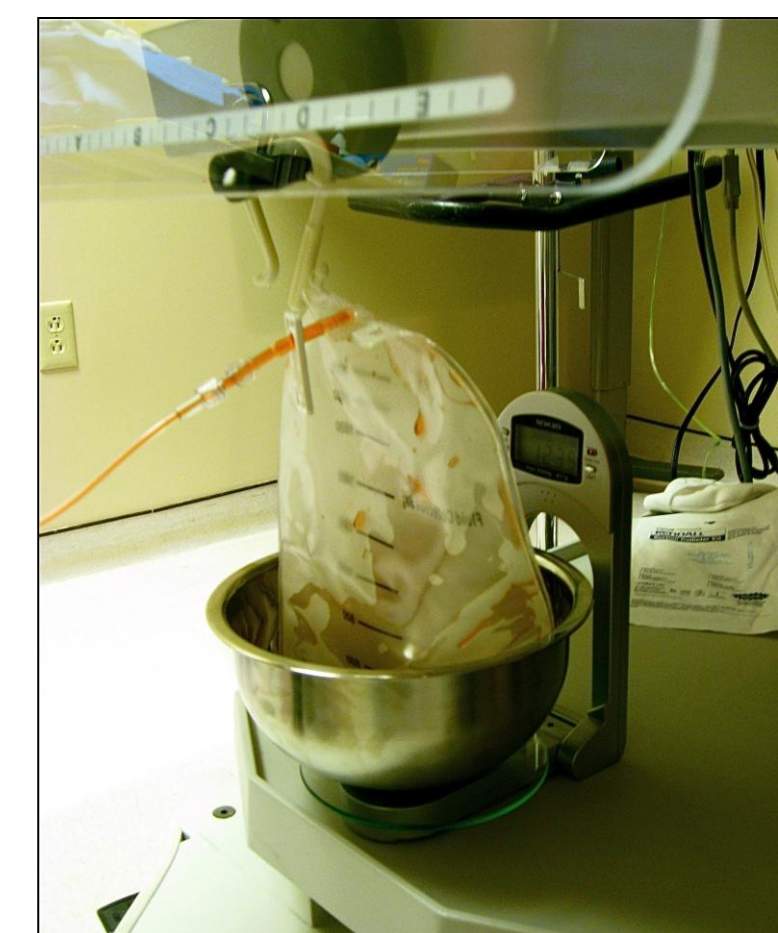


Figure 6: Scale located underneath the patient bed

Air embolus detector

- Utilizes ultrasound technology to detect air in the line to the baby
- Ordered from Intratek
- Outputs a light signal when air is detected
- Standard IV tubing is not compatible with device
- Device could not be obtained at this time



Figure 7: Air embolus detector from Intratek.⁴

Audible alarm

- Converts the visual output of the detector to an audible sound
- Buzzer will sound until reset

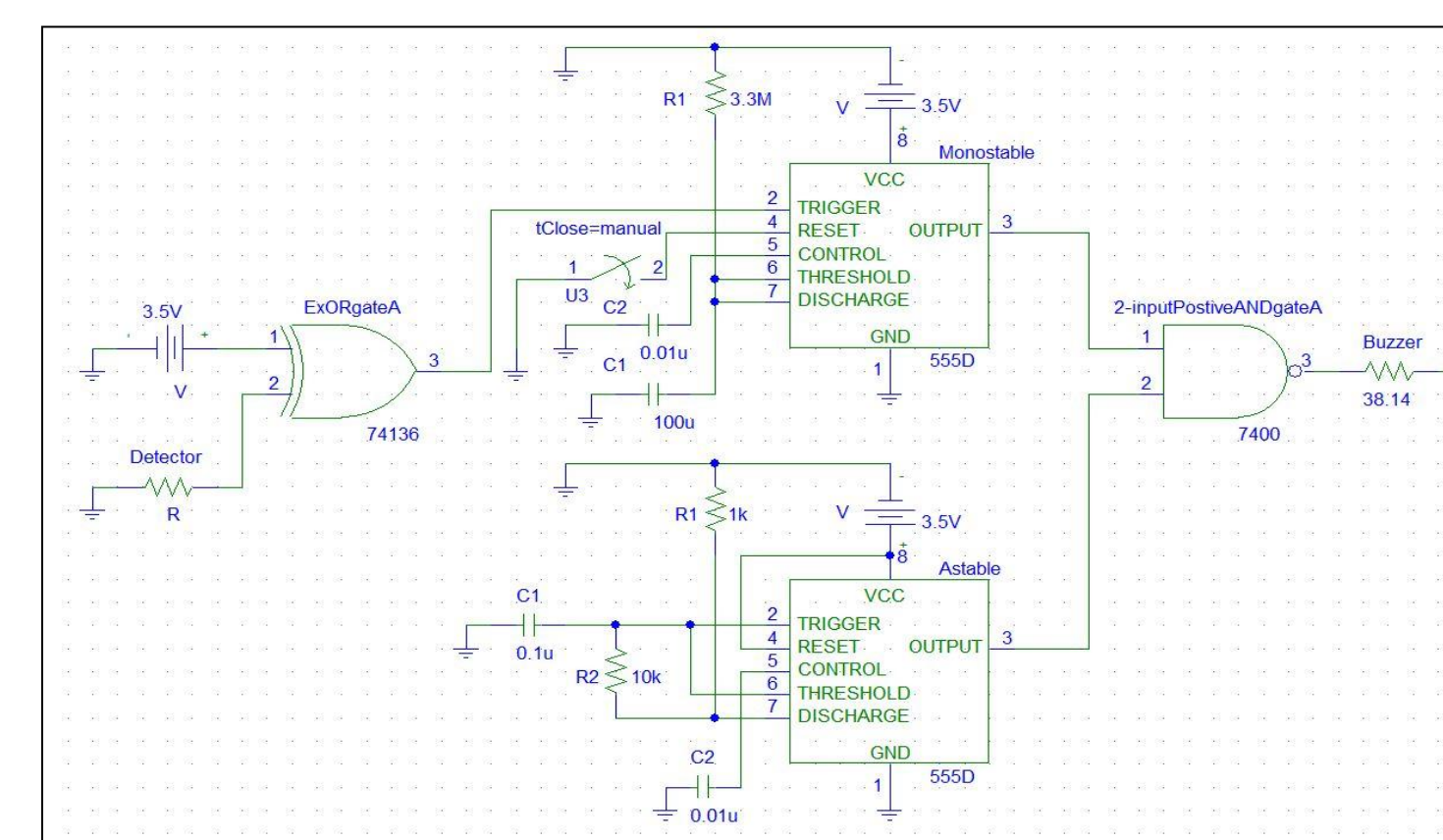


Figure 8: Schematic of the audible alarm system generated on PSPICE.

Testing & Results

- Testing performed at the Meriter Simulation Center
- The system was surveyed by medical personnel familiar with the transfusion

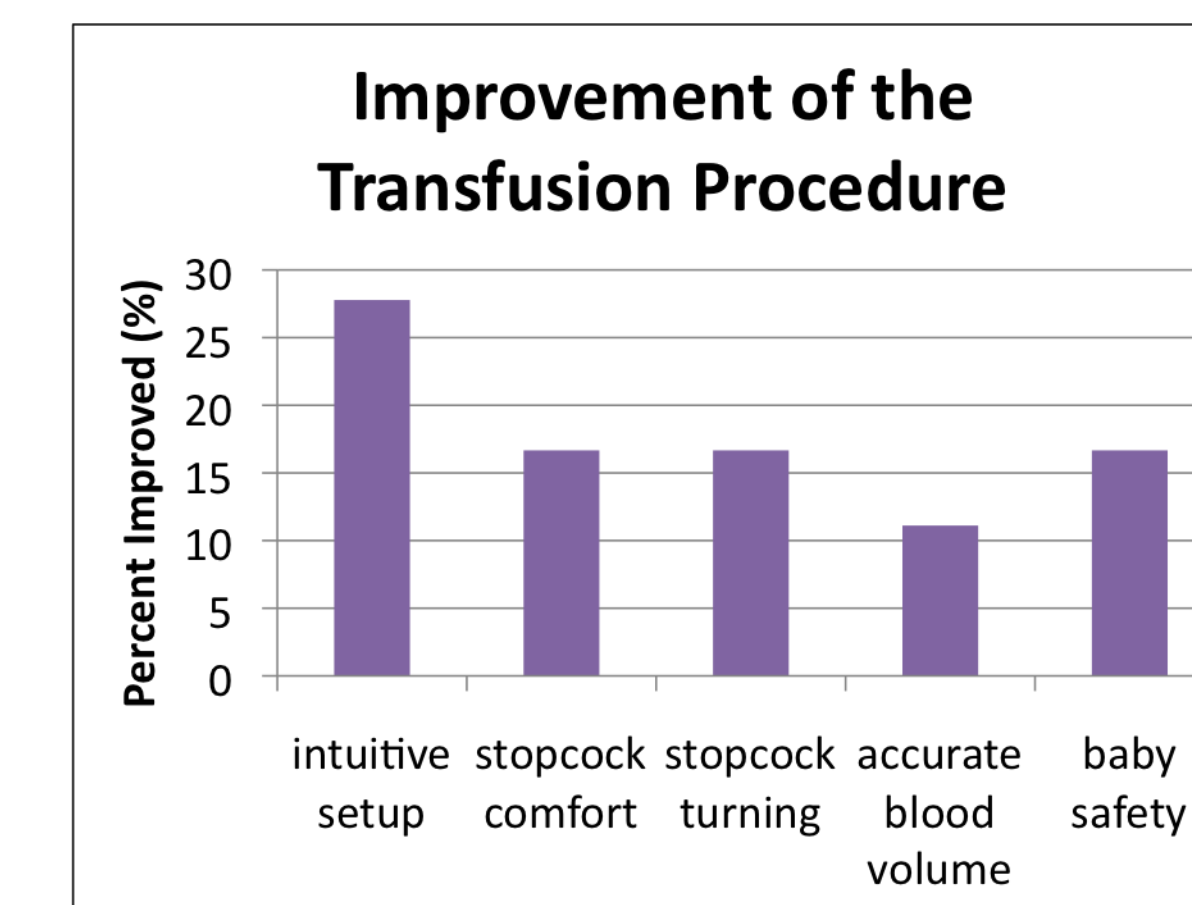


Figure 9: The improvement of various components to the procedure after our designs were implemented.

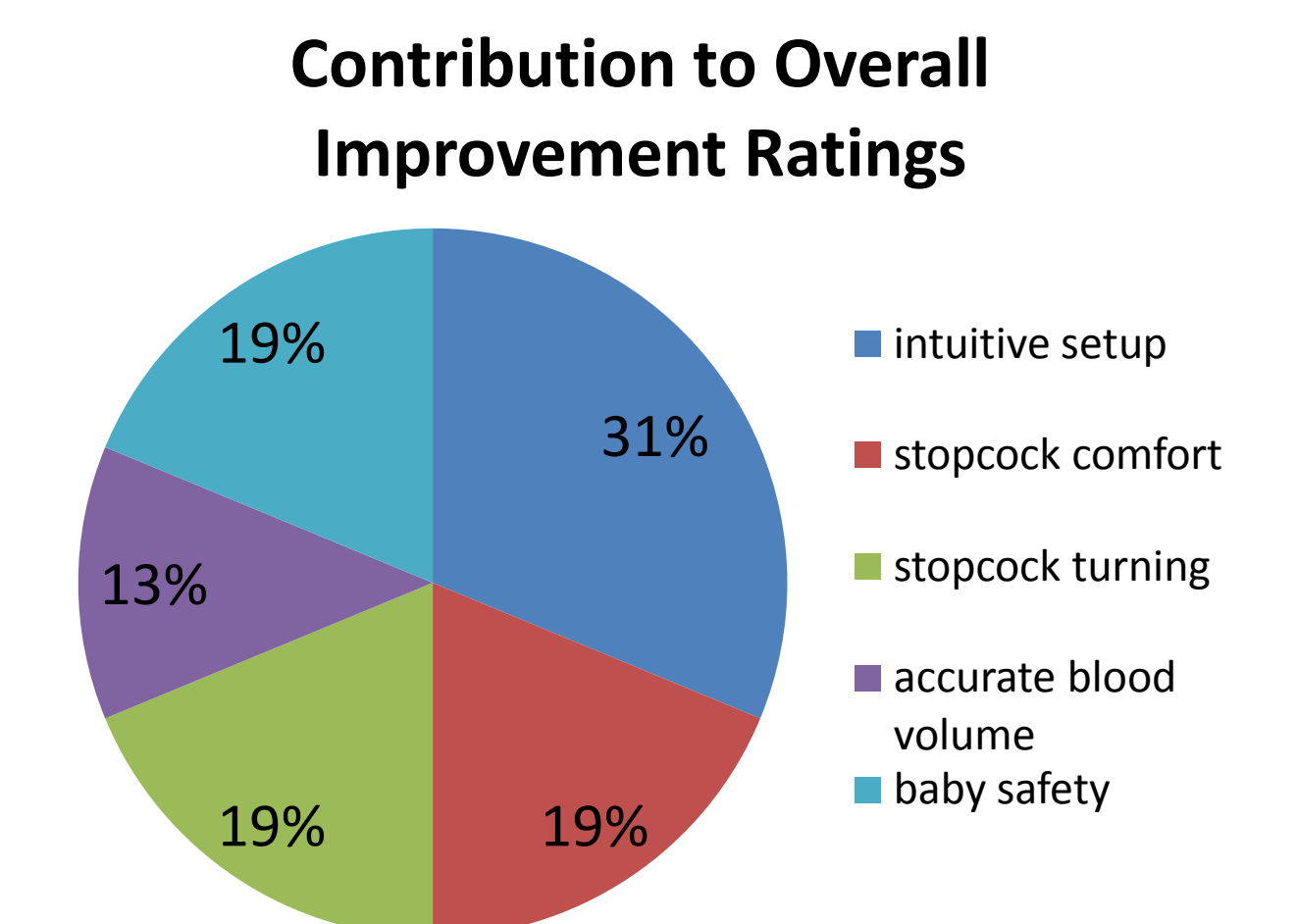


Figure 10: The total improvement was redistributed to determine each component's contribution.

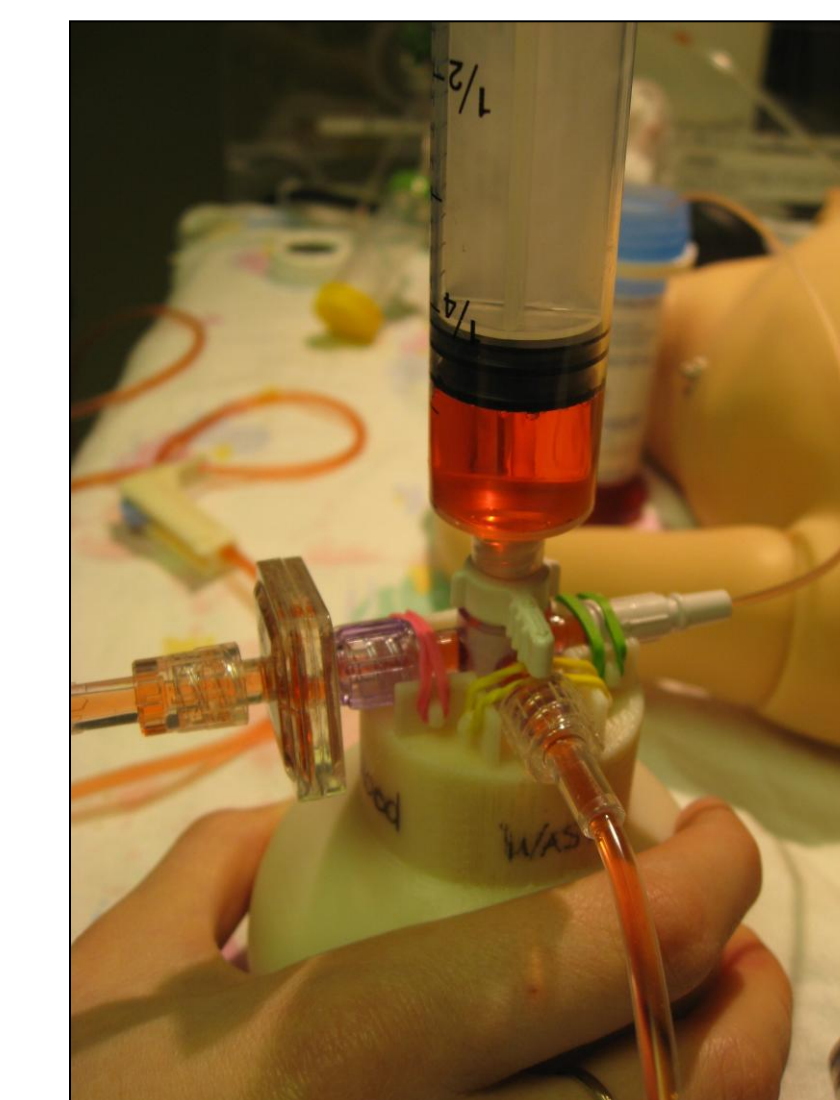


Figure 11: Four-way stopcock secured on the stopcock base with colored rubber bands.

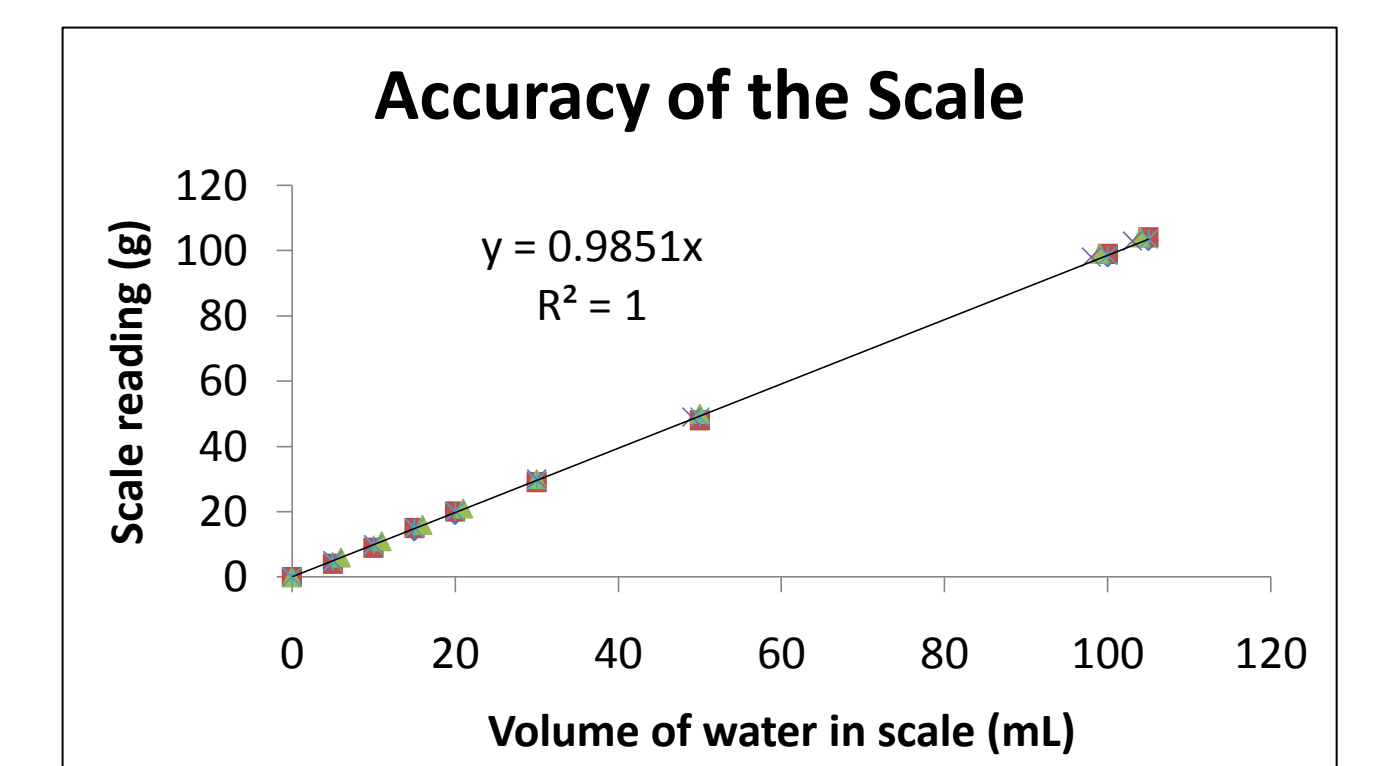


Figure 12: The scale for the counter system was very accurate to fit in a linear regression.

Future Considerations

- Non-standard tubing for the air detector was found but new adapters are needed to connect to the current tubing
- Order the AD9 air embolus detector
- Order the stopcock base in polypropylene from FirstCut
 - Polypropylene stronger and autoclave compatible

Acknowledgements & References

- Client Julie Kessel, M.D.
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- Jonathan Baran

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 [4] "AD8/AD9 Sensors." *Intratek*. N.p., 09 Mar 2011. Web. 21 Apr 2011. http://intratek.com/html/products.aspx?prod_id=1.