Department of
Biomedical Engineering
UNIVERSITY OF WISCONSIN–MADISON

Neonatal 22-23-Week Premature Infant Simulation Mannequin

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Client: Dr. Timothy Elgin

The Team

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Figure 1: Team photo

Problem Statement & Client Information

There are currently no 22-23 week neonatal simulation mannequins on the market, though it is vital for medical professionals to practice the skills needed to resuscitate an infant at this age. This simulation mannequin must be able to be intubated, support central umbilical line placement, and include IV access. Including a chest cavity and rib structure that allows for additional training in thoracentesis and pericardiocentesis would be ideal.

Dr.Elgin: Neonatal physician

UW Dept of Pediatrics

Figure 2: Infant born at 23 Weeks [1]

Background & Prior Work

- 22-23 Week Premature Infants
  - Approximately 1 ft long
  - Weigh between 0.9-1.1 lbs
  - Skin is gelatinous, sticky, and can tear easily
  - Doctors often do not attempt resuscitation
- Prior Group's Model
  - Skin is more accurate than models on the market
  - Needs limbs for IV insertion
  - Needs improved chest cavity for accurate intubation

Figure 3: Prior Group's Model

Competing Designs

- Trucorp TruBaby X [2]
  - 5 month old infant mannequin
  - Notable feature:
    - Fluid pockets
- Universal Medical C.H.A.R.L.I.E. [3]
  - Resembles an infant at birth
  - Notable feature:
    - Electronics
- Laerdal Premature Anne
  - 25-week premature infant mannequin
  - Closest to the goal of our project
  - Improvements to be made:
    - Size
    - Skin

Figure 4: Premature Anne [4]

Summary of PDS

Client Requirements:

1. Length < 30.5 cm
2. Ability to practice medical procedures
3. Weight around 400-500 grams
4. Expandable lungs

Design Requirements:

1. Life in service : 3-5 years
2. Features must resemble that of a 22-23 week premature infant
3. Needs to be reproducible (both in products used and cost)
4. No discomfort to the person using the mannequin

PDS

IV Insertion & Electronic Resuscitation

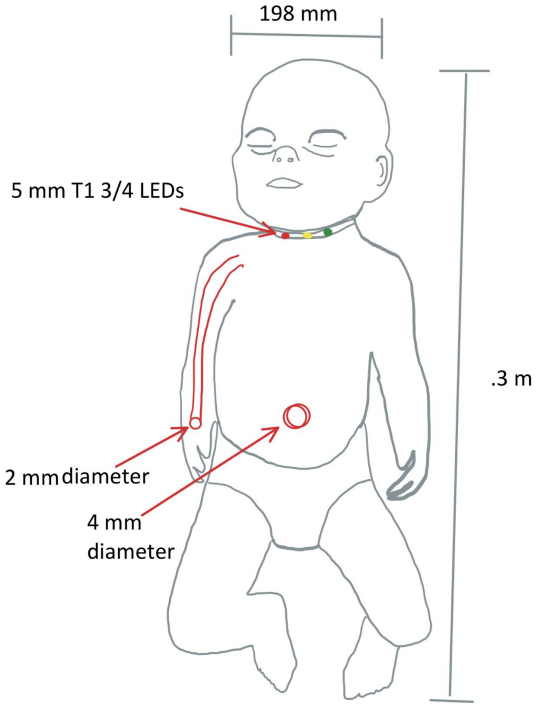
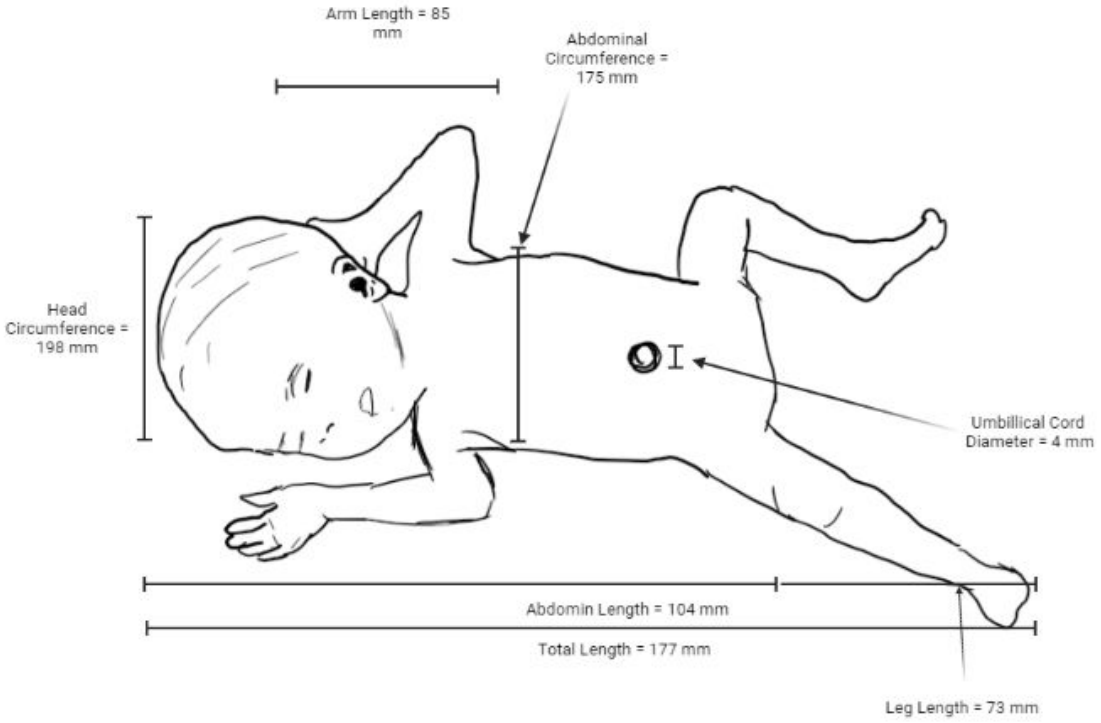


Figure 5: Design 1 Drawing

Components:

- LEDs connected to chest cavity [5]
  - Green=proper resuscitation
  - Yellow=approaching incorrect technique
  - Red=improper resuscitation
- IV line
  - Allows insertion of 2mm IV line
- Silicone skin material
- Umbilical line insertion

Realistic Chest Cavity With Intubation



- Gelatinous, elastomer skin.
- Airbrushing on skin for realism
- Electronics mimic rise and fall of breathing infant.
- Light signal if intubation is done incorrectly (pressure sensor)
- IV insertion holes
- Cables through body to mimic veins
- Limbs with realistic, movable joints

Figure 6: Design 2 Drawing

Fluid Pockets Model

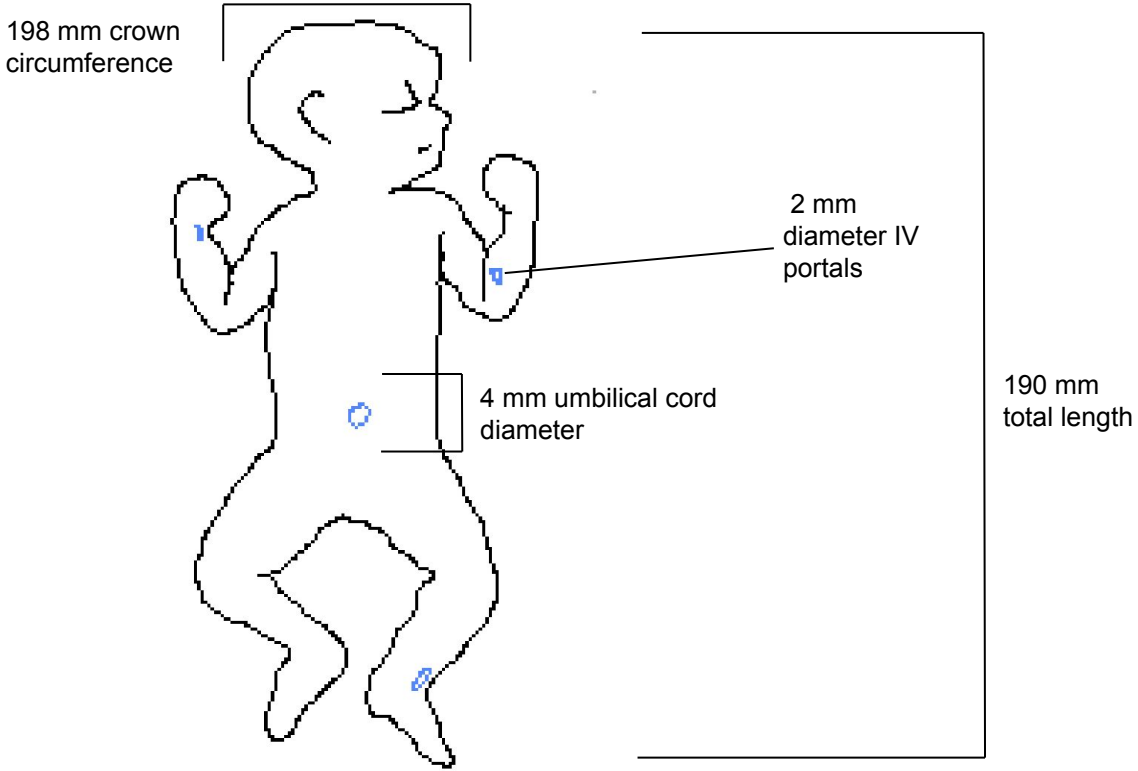


Figure 6: Design 3 Drawing

- The skin is made from a gelatinous and elastomer polymer
- We would include electronic that would mimic the rise and fall of a breathing infants chest (likely with a servo motor)
- Liquid-proof “pockets” under each IV insertion and the umbilical cord insertion.

Design Matrix Criteria

Criteria	Weight	Description
Texture	25	Accurate portrayal of neonatal skin
Usability	25	Effectiveness for educational use
Cost	25	Cost-effective production
Size/Weight	15	Accurate portrayal of neonatal dimensions
Realism	5	Accurate portrayal of real neonatal infants
Feasibility and Reproducibility	5	Can we fabricate it during this semester?

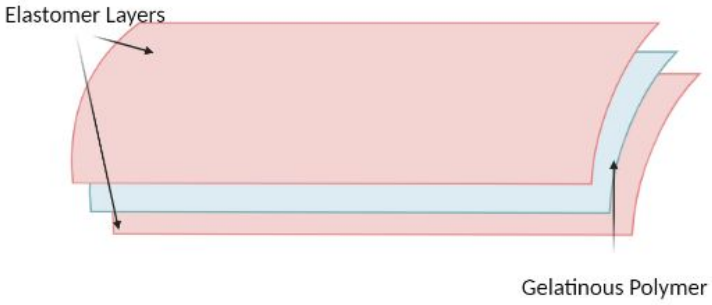
Figure 7: Preliminary Design Matrix Definitions

Design Matrix

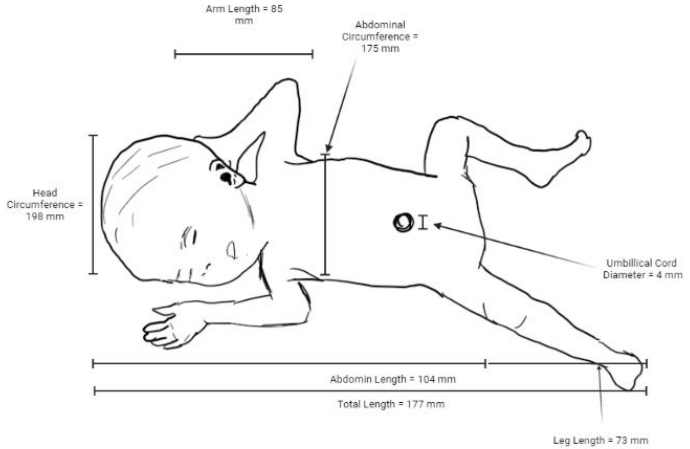
	Design 1: Model with IV Insertion & LED Resuscitation Component	Design 2: Realistic Chest Cavity Model w/ Intubation	Design 3: Model w/ Fluid Pockets
Texture(25)	3/5 (15)	5/5 (25)	4/5 (20)
Usability(25)	4/5 (20)	2/5 (10)	3/5 (15)
Cost(25)	2/5 (10)	3/5 (15)	2/5 (10)
Size/Weight(15)	3/5 (9)	2/5 (6)	3/5 (9)
Realism(5)	4/5 (4)	5/5 (5)	4/5 (4)
Feasibility/ Reproducibility (5)	3/5 (3)	2/5 (2)	2/5 (2)
Total (100)	61	63	60

Figure 8: Preliminary Design Matrix

Chosen Preliminary Design



Skin: Polymer Composite



Features: Accurate Intubation & Rise and Fall Chest Cavity

Figure 8: Polymer Composite diagram

Future Work

This semester:

- Perfecting/modifying the skin
- Creating new molds
- Intubation
- Addition of limbs (for IV access)
- Thoracic cavity mobility
- Usability testing

Beyond this semester:

- Vein system
- Distress signals/pain sensors
- Pulse
- Different thoracic cavity movements
- Programming software
- Pressure sensor (lights)
- Fluid pockets

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References

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[2] “Trubaby x: Infant CPR manikin: Pediatric manikin,” *Trucorp*, 16-Aug-2022. [Online]. Available: https://trucorp.com/product/trubabyx/. [Accessed: 05-Oct-2022].

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Questions?