Department of Biomedical Engineering
University of Wisconsin - Madison

# Neonatal 22-23-Week Premature Infant Simulation Manikin

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# Client Description and Problem Statement

## Client

- Dr. Timothy Elgin, DO, MSc
- Division of Neonatology and Newborn Nursery at the UW-Madison Department of Pediatrics

*Figure 1:* 22-Week Premature Infant [1]

## Problem Statement

- Currently no affordable 22-23-week premature infant manikins on the market
- Medical personnel cannot practice resuscitation techniques before real event

# Background and Prior Work

## 22-23-Week Premature Infants

- Survival rate at 22 weeks: <10% [2]
- Survival rate at 23 weeks: 1-64% [2]
- ~ 30.5 cm in length
- Weigh ~ 400-500 g
- Skin is gelatinous, sticky, and can tear easily

## Prior Groups' Work

- Both need work on:
  - Addition of limbs for IV access
  - Chest cavity for intubation and compression
  - More realistic skin


*Figure 2:* BME Design Spring 2023 Final Prototype

*Figure 3:* University of Iowa Design Team Prototype [3]

# Product Design Specifications

## Functional Requirements

- Intubation
- IV access
- Central umbilical line
- Rib cage and chest cavity

## Physical Requirements

- Weight: 300 g -500 g
- Length: 30.5 cm
- Accurate texture and thickness of skin

# Competing Designs

## Premature Anne

- 25 weeks gestation
- Intubation, compressions, IV access, umbilical cord
- Cost: $2,999 - $6,899

*Figure 4:* Premature Anne [4]

## Micro-Preemie Manikin

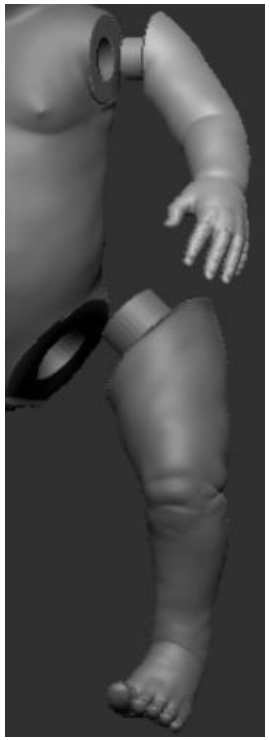
- 22-23 weeks gestation
- Intubation, compressions, umbilical cord
- Cost: unknown

*Figure 5:* Micro-Preemie Manikin [5]

# Design Decision #1: Addition of Limbs to the Previous Prototype

# Attachment Designs

## Ball and Socket



Limbs insert to sockets on existing body.

Allows rotation similar to human body. Detachable.

*Figure 6:* Ball and Socket Design [6]

## Glue

Glue adheres limbs to existing body.

Does not permit rotation, limbs not detachable.

*Figure 7:* Attached by Glue Design [6]

## Mold File

Limbs are molded with body.

Requires stationary, non-detachable limbs.

*Figure 8:* Combined into One File Design [7]

# Design Matrix 1 Criteria

| | | |
|---|---|---|
| **Future Usage** | How easy can the manikin be modified | **20** |
| **Usability** | How easy is it to reproduce and operate | **20** |
| **Durability** | How long will the limb stay connected to the body | **20** |
| **Ease of Fabrication** | How easy is it to make | **15** |
| **Accuracy** | How similar do the limbs function compared to human limbs | **15** |
| **Safety** | Will it cause harm to the user | **5** |
| **Cost** | Cost for limbs and possible replacements | **5** |

# Design Matrix 1: Limb Attachment

Table 1: Limb Attachment Design Matrix

| **Criteria:** | **Design 1:** Ball and Socket | | **Design 2:** Glued | | **Design 3:** Combined w/ Body Mold | |
|---|---|---|---|---|---|---|
| Future Usability (20) | *4/5* | 16 | *5/5* | 20 | 2/5 | 8 |
| Reproducibility (20) | *3/5* | 12 | *4/5* | 16 | 5/5 | 20 |
| Durability (20) | *2/5* | 8 | *3/5* | 12 | 5/5 | 20 |
| Ease of Fabrication (15) | *3/5* | 9 | *4/5* | 12 | 3/5 | 9 |
| Accuracy (15) | *5/5* | 15 | *3/5* | 9 | 3/5 | 9 |
| Safety (5) | *4/5* | 4 | *4/5* | 4 | 5/5 | 5 |
| Cost (5) | *4/5* | 4 | *4/5* | 4 | 5/5 | 5 |
| Total: 100 | 65 | | **77** | | 76 | |

**Chosen Design**

**Glued Limb Attachment**

- Compatible with future work
- Reproducible
- Durable

# Design Decision #2: Skin Materials

# Skin Material Designs

## Polydimethylsiloxane (PDMS)

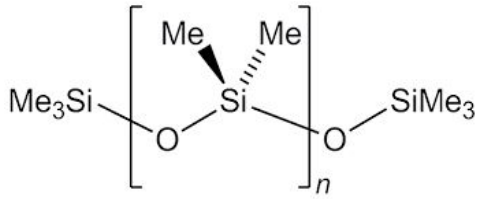



*Figure 9:* PDMS Compound Formula [8]

- Stable, nontoxic elastomeric polymer [8]
- Sticky, pliable

## Polyvinyl Chloride (PVC)

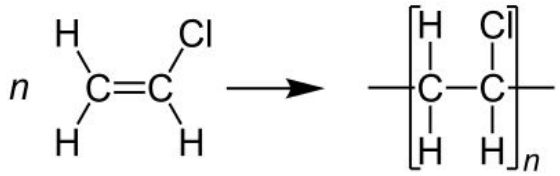



*Figure 10:* PVC Compound Formula [9]

- Synthetic plastic polymer [9]
- Tacky, durable, flexible

## Hand-Painted Silicone

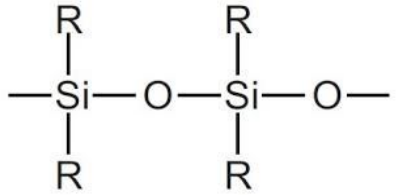



*Figure 11:* Silicone Polymer Compound Formula [10]

- Synthetic polymer [10]
- Flexible, long lasting
- Commonly used in competing designs

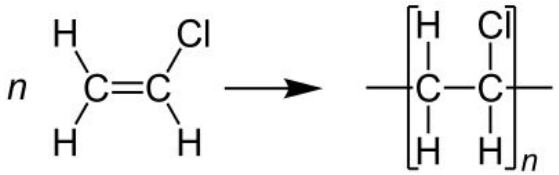
# Design Matrix Criteria

| | | |
|---|---|---|
| **Stickiness** | Accuracy of skin texture | **20** |
| **Elasticity** | Ability to mold, conform, and stretch | **20** |
| **Ease of Fabrication** | Ability to manufacture initial model and replacement grafts | **20** |
| **Safety** | Toxicity and chemical properties | **15** |
| **Durability** | Ability of material to properly function throughout lifespan | **10** |
| **Cost** | Expenses for initial model and replacement grafts | **10** |
| **Appearance** | Pigmentation capabilities | **5** |

# Design Matrix 2: Skin Material

Table 2: Skin Material Design Matrix

| **Criteria:** | **Design 1: Polydimethylsiloxane (PDMS)** | | **Design 2: Polyvinyl Chloride (PVC)** | | **Design 3: Hand-Painted Silicone** | |
|---|---|---|---|---|---|---|
| Stickiness (20) | 5/5 | 20 | 4/5 | 16 | 4/5 | 16 |
| Elasticity (20) | 5/5 | 20 | 5/5 | 20 | 5/5 | 20 |
| Ease of Fabrication (20) | 4/5 | 16 | 4/5 | 16 | 4/5 | 16 |
| Safety (15) | 5/5 | 15 | 5/5 | 15 | 3/5 | 9 |
| Durability (10) | 3/5 | 6 | 4/5 | 8 | 5/5 | 10 |
| Cost (10) | 2/5 | 4 | 5/5 | 10 | 5/5 | 10 |
| Appearance (5) | 4/5 | 4 | 5/5 | 5 | 5/5 | 5 |
| **Total** | 85 | | **90** | | 86 | |




**Chosen Design**

**Polyvinyl Chloride**

- Elastic, inert, cheap
- Plasticizers allow various properties to be modified

# Fabrication and Future Work

## This Semester

- Improve skin materials
- Replaceable skin patches
- Addition of limbs

## Fabrication Plans

- 3D print molds, fill with EcoFlex
- Fabricate skin in wet lab

## Future Semesters

- Vein system for IV access
- Intubation and respiration technology
- Fluid pockets
- Electronics
  - Pressure sensors for CPR
  - Pulse
  - Pain sensors

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- Angela Gangstad

# References

*any quantitative information without references came directly from the client, Dr. Elgin*


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# Questions?