The Evolution of Design: 
A Novel Thoracoscopic Diaphragmatic Hernia Repair Simulator

Lauren M Davis, Ellen K Hawkinson, Katherine A Barsness, MD
• Diaphragmatic Hernia (DH)
  – 1 out of 3000 live births
  – Technically challenging repair

• Few opportunities to train
  – inherent learning curve

• Simulator provides an opportunity for deliberate practice and mastery learning

• 3D printing
  – Ribs
  – Molds for organs

• Silicone modeling
  – Organs
  – Base
  – Skin
LOW FIDELITY
Failures

- **Brittle ribs:** broke with pressure from tools
- **Embedded nylon:** caused tension and fraying
- **Difficult to secure tissue:** to replicate location of defect
HIGH FIDELITY
Failures

Brittle ribs: broke with pressure from tools

Difficult to secure tissue to replicate location of defect

Eye hooks caused the tissue to fray
HIGH FIDELITY
Failures

- Rib cartridge was too soft: could not palpate
- Glass filled nylon was not durable: teeth broke off cartridge
- Cartridge sprung open: used binder clip to keep closed
MIDDLE FIDELITY
Cost Breakdown

<table>
<thead>
<tr>
<th>Prototype</th>
<th>Rib Cage</th>
<th>Rib 3-6</th>
<th>Stabilizer</th>
<th>Silicone Skin/Base</th>
<th>Silicone Tissue</th>
<th>Bovine Tissue</th>
<th>TOTAL</th>
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• Favorable responses from pediatric surgical trainees

• Simulator demonstrated evidence of content validity

• Suitable model for training CDH repair
Conclusion

- Low-cost, reusable CDH repair trainer can accurately simulate the confined space inside the chest of a newborn infant.

- Ex-vivo fetal bovine tissue blocks and silicone tissue can both be used to recreate CDH anatomy.
Next Steps

• Continue to collect validation data

• Additional features:
  – Sensors
  – Smart materials


Questions/Comments?

Thank you!