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Exploring the Utility of a 3D-Printed Multifunctional Thorax Model in the Simulation-Based Training of Tube Thoracostomy

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Abstract

Introduction: High-acuity low-occurrence (HALO) procedures require skilled performance as they are needed in the treatment of life-threatening conditions and can be associated with significant morbidity when performed incorrectly. Practitioners often have difficulty maintaining competence, however due to their infrequent occurrence. Simulation has been shown to be a valuable means to bridge the training gap. Tube thoracostomy is one example where that practitioners would benefit from simulated practice. Currently, there are a number of commercially available simulators, however they often have limited anatomical accuracy and are quite expensive. Fortunately, three-dimensional (3D) printing technologies have demonstrated the capability to produce acceptable models applicable to the practice of HALO procedures.

Purpose: The objective of this study is to develop a realistic model using 3D printing technology for the simulation-based instruction of a number of procedures, including tube thoracostomy for training of learners at various levels.

Methods: The iterative development of the thorax model will be completed in collaboration with the 3D printing team. Once developed, its utility will be tested through hands-on practice workshops. Content experts will practice chest tube insertion on the model and provide feedback through a qualitative survey; focusing on the assessment of appearance, realism, and overall value in procedural training.

Results/Conclusion: The iterative development of the multifunctional thorax model is currently ongoing and will eventually be evaluated for a number of HALO procedures. Tube thoracostomy has been chosen for the initial evaluation. We hypothesize that the 3D-printed model will provide an anatomically realistic and cost effective alternative that users find acceptable in performing HALO procedures such as chest tube insertion.

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Background
• High-acuity low-occurrence (HALO) procedures require skilled performance as they are needed in the treatment of life-threatening conditions and can be associated with significant morbidity when performed incorrectly.
• Due to their infrequent occurrence, it is often difficult to gain and maintain competency in HALO procedures.
• The placement of thoracostomy tubes is an example of a HALO procedure, often being placed for pneumothorax or hemothorax, two pathologies requiring urgent intervention.
• While a potentially life-saving procedure in an emergency situation, there are several severe complications that can occur during tube insertion, highlighting the need for procedural training.
• Simulation-based medical education (SBME) provides an effective and attainable means by which this training goal may be reached.
Existing Models
• Current simulation models for tube thoracostomy include commercially manufactured mannequins, animal models (e.g. pork ribs) and non-animal models
• Commercially manufactured mannequins while anatomically accurate are extremely costly, with one mechanical model mentioned heavily in the literature, the Trauma Man simulator, costing approximately $25000 USD per model.
• Animal and non-animal models have been created to offset cost but have issues with anatomical and procedural accuracy, with noted issues in accurate tissue feel, proper land-marking and artificial clues to safe insertion locations.
• While 3D-printing has been used for procedural teaching in medicine with great success, to our knowledge no 3D-printed model has been validated for tube thoracostomy teaching.
Objectives
• To develop a realistic 3D-printed thorax model for the simulation-based instruction of a number of procedures, including tube thoracostomy for training of learners at various levels.
• To gather feedback on the designed model with regards to appearance, realism and overall usability in procedural training.
Methods
• The development of the multifunctional thorax model is an ongoing collaborative process with MUN Med 3D.
• The model will be developed and completed to include a ribcage, intercostal musculature, skin and pleura that provides realistic tissue feel and accurate anatomy.
• Initial prototypes will be evaluated by expert physicians and their qualitative feedback will be used to optimize the thorax model to best reflect realism and clinical appearance prior to evaluation.
• Subsequent evaluation will be collected through hands-on practice workshops. Content experts will practice chest tube insertion on the model and provide feedback through a mixed-methods survey, focusing on the assessment of appearance, realism, and overall value in procedural training.
• The procedural training of tube thoracostomy has been chosen for the initial evaluation of the iterative model.
Figure 1 (L): Equipment used for tube thoracostomy including example of 3D-printed ribs and skin.
Figure 2 (Middle): Medical student using the non-animal model to practice tube insertion in a Mobile Tele-simulation Unit while being instructed by a mentor using tele-conferencing software.
Figure 3 (R): Basic non-animal model with 3D-printed ribs demonstrating correctly inserted tube.
Figure 4 (L): 3D-printing set up in MUNMED3D.
Figure 5 (Middle): Example of pork rib animal model for chest tube insertion from MUN's DIY Simulation Cookbook.
Figure 6 (R): Example of commercially manufactured model for chest tube insertion.
Figure provided by T. Renouf.
Anticipated Results
• We anticipate that our 3D-printed thorax model will provide a reasonable alternative to current high-cost commercially manufactured models as well as animal and non-animal models for tube thoracostomy; we believe our model will help overcome barriers including exorbitant cost and anatomical inaccuracies.
• We hypothesize that our model will be anatomically realistic, cost effective and a valuable training model for the procedural teaching and practice of tube thoracostomies, as evidenced by expert feedback.
Figure 7/8: Another example of a HALO procedure (Cricothyrotomy) that could benefit from 3D-printing (simple (L) and 3D-printed (above)).
Related Work
• This 3D-printed thorax model will be multifunctional, having the capability to be used and evaluated for the procedural instruction of a number of HALO procedures.
• Once completed and evaluated for accuracy in tube thoracostomy teaching, other HALO procedures will be developed for the existing model and then tested for similar feedback.
• Some HALO procedures that will be developed for this multifunctional model include:
➢ Pericardiocentesis;
➢ Needle Decompression;
➢ Cricothyrotomy;
➢ Resuscitative Thoracotomy.
References
TUCKAMORE
MUN MED3D

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