Title: Simulating Ultrasound-Guided Pericardiocentesis with a Novel 3D Printed Phantom

Introduction:
With the growing impetus to provide increased patient safety, more programs are turning to simulation to teach invasive procedures to students. When learning ultrasound guided procedures with high complication risk, such as pericardiocentesis, learners can use models called phantoms to mimic sonographic anatomy. Phantoms allow users to practice image acquisition and needle placement in a low-stakes environment. Unfortunately, procedural phantoms are extraordinarily expensive, making training with them often inaccessible to many learners. Home-made phantoms, while economically practical, tend to lack durability and anatomical accuracy.

Purpose:
Our goal is to design an anatomically accurate phantom that most learners could make on their own for a relatively low price to practice ultrasound guided pericardiocentesis.

Methods:
To develop a new model, we investigated previous phantoms and other novel approaches to design an anatomically correct chest cavity. The product was created in a multistep process. In order to accurately simulate bone on sonography, the rib cage was engineered with computer-aided design and 3D-printed using polylactic acid through fused deposition modeling with a 5mm thickness. The rib cage was then enclosed in a gelatin wax casing and covered with an opaque, gelatin-glycerin skin. The heart was also 3D printed using similar specifications and filled with water. The heart was then placed in a water-filled balloon in the chest cavity to allow for a drainable pericardiocentesis with visible fluid-filled ventricles.

Results:
Ultimately, after much trial and error, we were successful in creating a life-like model for which students can practice ultrasound-guided pericardiocentesis. Using the materials and methods described above, we created a chest cavity that simulates visualization of the pericardium and chambers of the heart. We are still in the process of fine-tuning our design to make it more durable and even more anatomically correct. Over the next month, we aim to have our final model complete and plan to have several ultrasound images obtained to demonstrate our success.

Conclusion:
We hope this project can serve as a guide for other students who are interested in creating phantoms, both for pericardiocentesis or other procedures. Our difficulties reflect the many nuances of simulation, a growing field in medical education today. In the future, we plan to survey students and residents on their experience with our phantom. This will help us gain insight into user experience and ease of use. With this information, we hope to further fine-tune our phantom to create the best learning experience possible.