**An inexpensive system for competency-based pericardiocentesis training**

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**Consortium**: Other

**Introduction.** Competency-Based Medical Education (CBME) involves practicing procedures in a simulated environment before they are performed on real patients to improve patient safety and trainee comfort. Pericardiocentesis is a high-risk procedure involving the aspiration of fluid from the pericardial cavity to relieve compression of the heart. Ultrasound imaging is used to provide real-time feedback of the needle tip's position relative to surrounding organs. Commercially available pericardiocentesis phantoms are prohibitively expensive, costing over ten thousand dollars. Less expensive phantoms lack realistic physiological features and anatomical landmarks [1]. Our goal was to create a realistic, low-cost phantom to be used in conjunction with an open-source software platform for image-guided pericardiocentesis intervention training.

**Methods.** Our phantom consists of a model heart inside a gelatin-filled plastic container. To construct the heart model, a balloon is placed around a second balloon. Rubber pneumatic tubing runs out from the inner balloon and is connected to a 60 cc syringe to simulate pumping. The inner and outer balloons are filled with water of different colors. Plastic cutting board, cut to resemble the ribs and sternum, is placed on top of the gelatin. Silicon skin is then laid over the ribs. The cost to make a phantom is under $10, with a preparation time of roughly 15 minutes excluding the time needed for the gelatin to set. To test the phantom, an ultrasound machine and electromagnetic tracking system were used (Figure 1). A reference sensor was fixed underneath the phantom and a tracked needle was used to drain the effusion. A computer running the PlusServer application (www.assembla.com/spaces/plus/wiki) was connected to the electromagnetic tracker, and all tracking and image data was relayed to 3D Slicer (www.slicer.org/). In the SlicerIGT extension (www.slicerigt.org/wp/), a model representing the needle was created and visualized in 3D relative to the ultrasound image plane. The needle tip was marked with a sphere, to clearly distinguish the needle tip from the needle shaft (Figure 2).

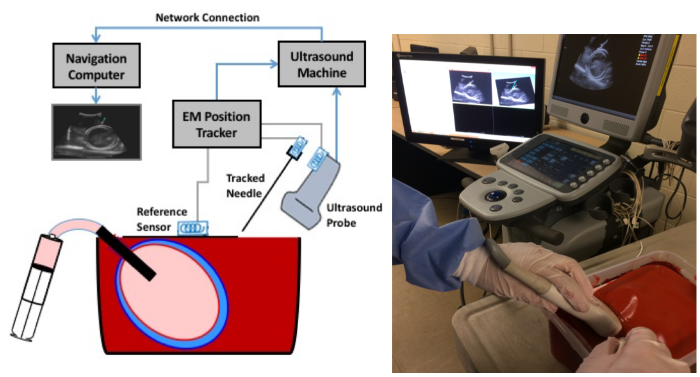


**Figure 1**. Schematic diagram of the setup (left) and photograph (right) for performing ultrasound-guided pericardiocentesis with our phantom.

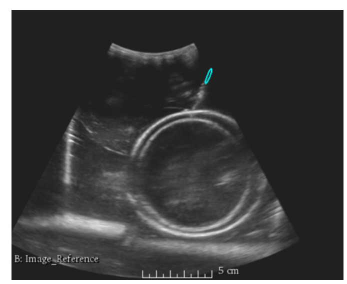


**Figure 2**. Ultrasound image of unfilled inner balloon showing use of SlicerIGT to visualize the needle during insertion.

**Results**. Our system allows for low-cost practice of ultrasound-navigated pericardiocentesis. Our phantoms appear anatomically and sonographically realistic. A beating effect of 30 beats per minute can be achieved by manually pumping the syringe. The volume of water in both balloons can be varied easily to simulate different patients. Realistic anatomical landmarks are provided by synthetic ribs and skin. The pericardium, myocardium, and myocardial decompression are clearly visible in the ultrasound. The use of different colours of water in each balloon allows users to easily determine if they punctured the pericardium or heart. Five phantoms were created, all appearing identical except for the amount of water put in the outer balloon, to simulate different degrees of difficulty for the procedure. No mechanical failure was observed during needle insertion trials; however, the phantoms are single use.

**Conclusion**. Using inexpensive materials, we have created a pericardiocentesis training phantom and demonstrated it with an open-source navigation software. The phantom is easily reproducible due to its limited cost and manufacturing simplicity, and it is expected to be a viable tool for training medical residents to perform pericardiocentesis in a simulated environment.

**Reference**. [1] Zerth, M., *et al.* (2012, Dec). An Inexpensive, Easily Constructed, Reusable Task Trainer for Simulating Ultrasound-Guided Pericardiocentesis. *The Journal of Emergency Medicine,* 43(6), 1066-1069.