Canadian Journal of Cardiology 35 (2019) 1600–1603

Training/Practice
Contemporary Issues in Cardiology Practice

Inexpensive, High-Fidelity Model to Simulate Ultrasound-Guided Pericardiocentesis for Cardiology Resident Training

Daniel J. Belliveau, MD, Andrew Moeller, MD, MASc, MEd, and Sarah Ramer, MD

Queen Elizabeth II Health Sciences Center, Halifax, Nova Scotia, Canada

ABSTRACT

Adult cardiology residency training programs require residents to become proficient at many procedural skills, including pericardiocentesis. However, in many programs, opportunities to perform this procedure are limited. Expensive mannequins have been developed to assist with teaching this skill, however, the associated cost make them impractical for many programs. We hypothesized that a low-cost, high-fidelity pericardiocentesis model could be constructed using items easily accessible to any consumer. We describe a pericardiocentesis model made from pork skin, pork ribs, gelatin, a plastic bag, and an avocado. Total cost was less than CAD$40.00 and preparation time was approximately 60 minutes. The model was evaluated with a survey by 14 senior cardiology and critical care residents as well as 3 experienced senior cardiologists. Imaging results from the ultrasound revealed that the target fluid was easily visualized and all trainees were successful in aspirating fluid. The model was durable and withstood more than a dozen punctures, demonstrating its ability to train multiple residents. Respondents to the survey reported the model as highly realistic. All cardiology residents agreed or strongly agreed that the model should be incorporated into their formal curriculum. This study shows that a low-cost, high-fidelity model can be constructed and easily implemented into the formal curriculum of adult cardiology residency programs. It allows residents the opportunity to practice pericardiocentesis in a low-risk setting on a high-yield device.

RÉSUMÉ

Les programmes de résidence en cardiologie chez l'adulte exigent des résidents qu'ils acquièrent les compétences nécessaires pour effectuer de nombreuses interventions, dont la péricardiocentèse. Toutefois, dans bon nombre de programmes, les occasions d'effectuer cette intervention sont rares. Des mannequins très chers ont été mis au point pour faciliter l'enseignement de cette intervention, mais leur coût représente un obstacle pour de nombreux programmes. Nous avons émis l'hypothèse qu'il serait possible de créer un modèle de péricardiocentèse très réaliste et à faible coût en utilisant des produits que tout consommateur pourrait facilement se procurer. Nous décrivons un modèle de péricardiocentèse créé à partir de peau de porc, de côtes de porc, de gélatine, d'un sac en plastique et d'un avocat. Le coût total a été inférieur à 40 $ CA et la préparation a nécessité environ 60 minutes. Le modèle a été évalué par un sondage auquel 14 résidents d'expérience en cardiologie et en soins intensifs ainsi que 3 cardiologues chevronnés ont répondu. Les résultats de l'échographie ont révélé que le liquide cible était facile à visualiser et que tous les résidents avaient réussi à l'aspirer. Le modèle était durable et pouvait être soumis à plus d'une douzaine de ponctions, démontrant ainsi qu'il peut être utilisé pour former plusieurs résidents. Les personnes sondées ont signalé que le modèle était très réaliste. Tous les résidents en cardiologie étaient d'accord ou fortement d'accord pour que le modèle soit inclus dans leur programme de formation. Cette étude montre qu'un modèle peu coûteux et très réaliste peut être créé et facilement inclus aux programmes officiels de résidence en cardiologie chez l'adulte. Il offre aux résidents l'occasion de s'exercer à effectuer une péricardiocentèse dans un contexte peu risqué sur un modèle à haut rendement.

Cardiac tamponade is a medical emergency that can rapidly lead to hemodynamic instability and death.[1] Ultrasound-guided pericardiocentesis has become the standard bedside therapy to prevent hemodynamic collapse of these patients. As such, pericardiocentesis is a skill all cardiology residents are expected to master during their residency training. However, opportunities to perform this procedure can be sparse and introduction to the technique often occurs in high-acuity scenarios. Synthetic simulators do exist but are prohibitively expensive for many training programs. We hypothesized that a simple model could be constructed using inexpensive, locally sourced items to create a high-fidelity simulation experience.

Methods

A pericardiocentesis model was constructed using locally obtained items. Total cost to make a single model was less than

Received for publication March 10, 2019. Accepted May 24, 2019.

Corresponding author: Dr Daniel J. Belliveau, 1796 Summer St Room 2132, Halifax, Nova Scotia B3H 3A7, Canada. Tel.: +1-902-473-2423; fax: +1-902-473-7044.

E-mail: Danielj2.belliveau@nshealth.ca

See page 1603 for disclosure information.

https://doi.org/10.1016/j.cjca.2019.05.029

Figure 1. Construction of the model. (**A**) Layered pork skin and pork ribs. (**B**) Ziplock bag with water and avocado added. (**C**) Model completely covered in gelatin. (**D**) Model has been rotated and draped and is ready for use.

CAD$40. Items used were pig skin, pork ribs, a zip-lock bag, an avocado, gelatin, food colouring, and a disposable roaster.

The model was created as follows:

1. In a disposable container, pork skin was laid face down.
2. Pork ribs were laid on top of the skin (Fig. 1A).
3. An avocado was placed in a zip-lock bag and the bag was filled with water. Food colouring was added to the water before sealing the bag.
4. The bag containing the avocado was laid on top of the pork skin (Fig. 1B).
5. Three and a half litres of gelatinized water was boiled according to package instructions. The water was allowed to cool for approximately 30 minutes, then poured over the pork and zip-lock bag (Fig. 1C).
6. The model was refrigerated overnight. The next morning, a spatula was used to loosen the gelatin from the sides of the container.
7. The model was turned upside down, allowing the model to fall from the container. Before use, the model was draped with sterile towels (Fig. 1D).

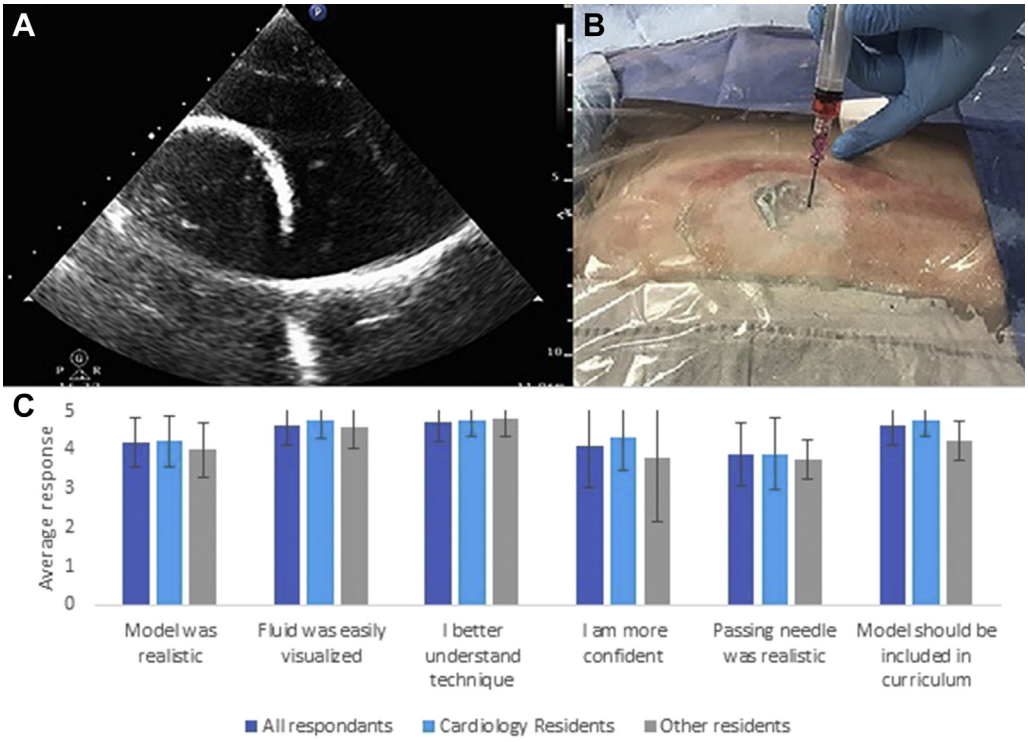

Figure 2. (**A**) Ultrasound image obtained from the model. The circular avocado is seen adjacent to the target fluid. (**B**) Successful aspiration of target fluid. (**C**) Questionnaire results of evaluation of the pericardiocentesis model. Statements were rated on a scale of 1 (strongly disagree) to 5 (strongly agree). Error bars represent SDs.

Participants received a brief lecture regarding the pericardiocentesis technique and orientation to the model before use. The ultrasound image they were expected to generate from the model was demonstrated. All evaluators had the opportunity to assess the model during a single 3-hour session. Participants using the model first visualized the target fluid and avocado using ultrasound (Fig. 2A). They then advanced a syringe-topped needle toward the target fluid (Fig. 2B) until it was successfully aspirated.

The fidelity of the model was assessed using an unvalidated 6-item questionnaire administered to residents as well as 3 "expert" reviewers who had an opportunity to work with the model.

Results

The inexpensive model was successfully completed in approximately 1 hour. All participants (14/14) were successful in visualizing the target fluid collection on ultrasound imaging and subsequently aspirating the target fluid. The avocado was not damaged during any aspiration attempt. The model held up well to repeated punctures without significant leakage from the bag, which simulated the pericardium.

The questionnaire was completed by 9 cardiology residents, 3 cardiology staff who served as expert reviewers, and 5 other residents (2 cardiac surgery, 1 anaesthesia, 1 critical care, and 1 internal medicine). Of the individuals surveyed, only 3 had previously trained for pericardiocentesis in a simulated setting. All 3 expert reviewers and 6 cardiology trainees had previous experience performing pericardiocentesis. Survey results are outlined in Figure 2C.

General comments were also requested on the survey. Eight individuals independently commented favourably on the realism of the model. Two others commented positively about the ability to practice the procedure in a no-risk setting. Two respondents stated that the pig skin was difficult to pass a needle through whereas 1 person stated the model was too cold.

Discussion

In this article, we describe the successful creation and implementation of a novel, inexpensive pericardiocentesis model that yields a high-fidelity learning experience. Participants who evaluated the device had very positive feedback overall, especially among the cardiology residents surveyed. According to those results, the ability to visualize target fluid and learn the steps of pericardiocentesis were the strongest features of the model. General comments received as part of the questionnaire were positive remarks on the realism of the model. Residents believed strongly that this model should be incorporated into their formal curriculum, especially those in cardiology programs.

This model has several strengths compared with other previously described models. Several inexpensive models have been developed for the teaching of pericardiocentesis[2-5] to emergency medicine residents. To our knowledge, this is the first device specifically developed for and evaluated by cardiology trainees. Our model is unique in using ribs to simulate an apical approach. To generate a quality ultrasound image of the target, learners had to first find an appropriate window between ribs. This is an important step of ultrasound-guided pericardiocentesis, especially from an apical approach. The

participants then had to direct the needle through the rib space and were able to use ultrasound to guide the needle to the target. This process better approximates the true pericardiocentesis experience compared with other published models.

Limitations of this model include decreased durability, because the biologic material used to create the model can only be used for a single day. Although the model held up well for several hours, prolonged time at room temperature would likely lead to an inferior experience. Other limitations include the inability to mimic the kinetic motion of the simulated heart, absence of intercostal nerves and vessels, and cool temperature of the pig skin.

Overall, we believe this model provides residents an opportunity to practice pericardiocentesis on a high-fidelity model in a safe, low-acuity setting. The relative ease to create the model and low cost make it readily accessible to any training program to help enhance cardiology resident training.

Disclosures

The authors have no conflicts of interest to disclose.

References

1. Adler Y, Charron P, Imazio M, et al. 2015 ESC guidelines for the diagnosis and management of pericardial diseases. The Task Force for the Diagnosis and Management of Pericardial Diseases of the European Society of Cardiology (ESC) endorsed by: the European Association for Cardio-Thoracic Surgery (EACTS). Eur Heart J 2015;36:2921-64.

2. Campo Dell'orto M, Hempel D, Starzetz A, et al. Assessment of a low-cost ultrasound pericardiocentesis model. Emerg Med Int 2013;2013:376415.

3. Daly R, Planas JH, Edens MA. Adapting gel wax into an ultrasound-guided pericardiocentesis model at low cost. West J Emerg Med 2017;18:114-6.

4. Zerth H, Harwood R, Tommaso L, Girzadas DV Jr. An inexpensive, easily constructed, reusable task trainer for simulating ultrasound-guided pericardiocentesis. J Emerg Med 2012;43:1066-9.

5. Sullivan A, Khait L, Favot M. A novel low-cost ultrasound-guided pericardiocentesis simulation model: demonstration of feasibility. J Ultrasound Med 2018;37:493-500.