Methods

A low-cost reusable phantom for ultrasound-guided subclavian vein cannulation

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Abstract

Guidelines support the use of ultrasound (US)-guided central venous cannulation in the intensive care unit. Traditional techniques based on anatomical landmarks are blind procedures and inexpert USG procedures may be hazardous. Commercially available phantoms for simulation and training are expensive. The technique of making a low-cost reusable gelatin phantom which simulates subclavian vein anatomy is described. Techniques to improve eye-hand skills with this phantom are described. This phantom is easy to make, inexpensive and easily renewable.

Keywords: Central venous cannulation, gelatin phantom, subclavian vein, ultrasound-guided

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Introduction

The use of ultrasound (US)-guided central venous cannulation (CVC) has increased in intensive care units (ICU). Guidelines on its use, reviews of safety and efficacy have been published.[1] The use of simulators and models for training in insertion of US-guided CVCs have been suggested.[2] In critical care units, the subclavian site for CVC insertion has a lower rate of infection,[3] but a higher rate of mechanical complications like pneumothorax/hemothorax.[4] The use of US-guided subclavian CVC insertions has been strengthened by recent large case series with a very low incidence of pneumothorax and adverse events.[5]

Insertion of CVC with the use of external anatomical landmarks is a blind procedure.[6] Insertion of CVC under US guidance without adequate training on phantoms or simulators may be hazardous. Inattention to traditional landmarks due to the use of ultrasound may result in a "double-blind" procedure. Training in Indian ICUs is likely to be hampered by the high cost of phantoms (Blue Phantom ™) and lack of easy availability.[7] We are describing the construction of a low-cost reusable phantom customized for subclavian cannulation, for use in the Indian ICU.

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Materials and Methods

A rectangular plastic box 20 x 12 cm with a depth of 6 cm was chosen. Plastic tubes 1 cm and half cm in diameter, and 18 cm in length were used to simulate the subclavian vein and artery, respectively. The tubes were filled with blue and red ink to simulate arterial and venous puncture. The tubes were placed at the bottom of the box parallel to each other but with some overlap to mimic abnormal anatomy. Fifteen grams of gelatin were sprinkled over 30 ml of cold water and left unstirred till spongy. This was dissolved in 1.2 l of simmering water till clear. Twenty grams of coarsely ground finger millet (*Eleusine coracana*) flour was added to the water and stirred to obtain uniform consistency. This was done to increase opacity and echogenicity of the phantom. The mixture was poured into the box over the plastic tubes, and allowed to set overnight in a refrigerator. A plastic rod of 7-cm length and irregular shape (to mimic the clavicle) was put on top, vertically over the position of the tubes and covered with a firmer clear gelatin made with only 200-ml water and 10 g of gelatine. Care was taken to avoid air bubble formation during preparation and pouring of the gelatin. Cling film was applied on the surface of the mixture to retain integrity of the gelatin during manipulation and insertion of needles.

Use of the model

A 7 Mhz, Sono Site MicroMaxx® probe was used to identify the tubes in the phantom. Staff were trained to use the probe and image the tubes in the longitudinal axis [Figures 1 and 2]. The following points were emphasized when using the phantom:

Hand position

The CVC needle was held in the dominant hand and the probe in the nondominant hand. The plane of the needle and the plane of the ultrasound beam had to be the same to visualize the needle track [Figure 2]. The needle insertion point had to be in the midcoronal line of the probe. Due to the presence of the clavicle over the simulated subclavian vein, angulation of the probe was often necessary.

Needle angulation and tracking

Depressing the angle of attack and advancing the needle, sliding and gently rocking the needle were demonstrated as techniques to improve the visibility of the needle and bringing it into the ultrasonic plane[8] [Figure 3].

Vessel puncture

Vessel puncture was demonstrated by aspiration of appropriately colored fluid. Imaging the entire needle through a longitudinal scan was emphasized, as this minimized inadvertent traversing of vital structures in real life.

In this model the persistence of needle tracks has been shown to be neglible even with multiple attempts. Needle tracks after multiple attempts were easily abolished by gentle heating of the phantom in a microwave and allowing it to reset in a refrigerator overnight.

Discussion

We have been able to construct easily and economically a reusable phantom for training staff in US-guided subclavian CVC. The use of a gelatin model is not new and has been described as early as 1980 by Burlew *et al*.[9] Gelatin models suffer from lack of opacity, echogenecity and tactile feel. The lack of echogenecity in gelatin models increases needle visualization and can lead to false confidence as the same visualization is not obtained *in vivo*. These drawbacks have been extensively discussed in a review by Hocking

Figure 1: Practice session with gelatin phantom showing position of probe and needle

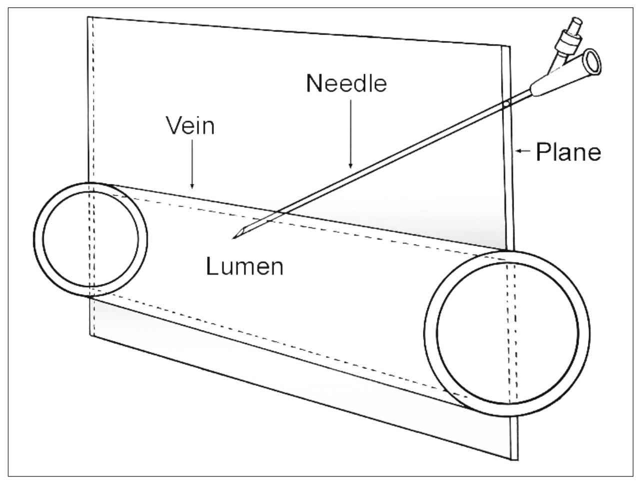

Figure 2: Schematic diagram showing longitudinal scan with full visualization of needle and vessel in ultrasonic plane

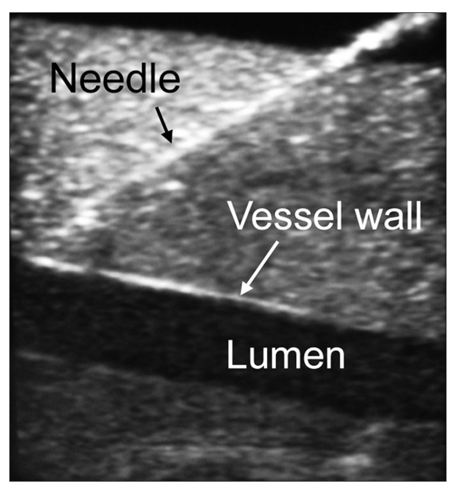

Figure 3: Real time imaging of needle and vein in longitudinal ultrasonic plane in the training model

et al.[10] We have increased the echogenecity and opacity and provided some tactile feel with the use of coarse finger millet flour. This model is robust and can withstand multiple punctures, and persistence of needle tracks has not proven to be an issue and the model quickly comes to its native state with heating and resetting.

In US-guided CVC insertion at subclavian sites the probe has to be held away from the clavicle and angulated to visualize the vessels. The addition of a plastic rod to mimic the clavicle in our model allows the trainees to learn how to angulate the probe and learn appropriate eye-hand co-ordination. The subsequent identification of the longitudinal ultrasonic plane and complete needle visualization will minimize mechanical complications which can be hazardous in these approaches. The use of plastic tubing provides a false feeling of localization of vessel as it is much more rigid than a vessel *in vivo*. Latex catheters or thin rubber sheaths are more realistic but are not as durable and the models are not easily reusable. The tactile feel of this model does not mimic human tissue but the use of animal tissue models has its own disadvantages. The application of a firmer clear gelatin as a second layer improves initial needle visibility and can help the trainees to acquire the necessary eye-hand co-ordination. The use of cling film and reheating in a microwave makes for a robust and reusable model.

Conclusions

This simple training model has the advantages of easy construction, reusability and low cost. The training provided by this model, improves eye-hand co-ordination, increases confidence and safety.

References

1. Kumar A, Chuan A. Ultrasound guided vascular access: efficacy and safety. Best Pract Res Clin Anaesthesiol 2009;23:299-311.
2. Barsuk JH, McGaghie WC, Cohen ER, Balachandran JS, Wayne DB. Use of simulation-based mastery learning to improve the quality of central venous catheter placement in a medical intensive care unit. J Hosp Med 2009;4:397-403.
3. Nagashima G, Kikuchi T, Tsuyuzaki H, Kawano R, Tanaka H, Nemoto H, *et al*. To reduce catheter-related bloodstream infections: Is the subclavian route better than the jugular route for central venous catheterization? J Infect Chemother 2006;12:363-5.
4. Eisen LA, Narasimhan M, Berger JS, Mayo PH, Rosen MJ, Schneider RF. Mechanical complications of central venous catheters. J Intensive Care Med 2006;21:40-6.
5. Cavanna L, Civardi G, Vallisa D, Di Nunzio C, Cappucciati L, Bertè R, *et al*. Ultrasound-guided central venous catheterization in cancer patients improves the success rate of cannulation and reduces mechanical complications: A prospective observational study of 1,978 consecutive catheterizations. World J Surg Oncol 2010;8:91.
6. D'souza N, Gupta B, Sawhney C, Chaturvedi A. Misdirected central venous catheter. J Emerg Trauma Shock 2010;3:209-10.
7. Blue Phantom, Branched 4-vessel ultrasound training model. Available from: http://www.bluephantom.com/details.aspx?pid=64andcid=524,Accessed Feb 9 2011.
8. Sisney GA, Hunt KA. A low-cost gelatin phantom for learning sonographically guided interventional breast radiology techniques. AJR Am J Roentgenol 1998;171:65-6.
9. Burlew MM, Madsen EL, Zagzebski JA, Banjavic RA, Sum SW. A new ultrasound tissue-equivalent material. Radiology 1980;134:517-20.
10. Hocking G, Hebard S, Mitchell CH. A review of the benefits and pitfalls of phantoms in ultrasound- guided regional anesthesia. Reg Anesth Pain Med 2011;36:162-70.

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