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BRIEF COMMUNICATION

A Novel Phantom for Teaching and Learning Ultrasound-guided Needle Manipulation

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Training in ultrasound-guided regional anesthesia can be acquired by attending peripheral nerve block courses. The most common novice error is "advancement of needle when tip was not visualized." The use of simulation has shown improvement in the skill and success of ultrasound-guided procedures. Phantoms provide a simple tool that aid in the improvement of such skills. We describe a gelatin-based phantom that can be easily constructed and used to identify novice errors and facilitate in learning relevant skills. The phantom can be transilluminated to identify the target and is helpful in providing real-time, immediate feedback to novices as they practice probe—needle—target orientation.

Introduction

It is recommended that training in ultrasound-guided regional anesthesia should address the following four skill sets: (1) understanding ultrasound image generation and device operation, (2) image optimization, (3) image interpretation, and (4) needle insertion and injection [1]. These skills can be acquired by attending peripheral nerve block courses, practicing ultrasound-scanning techniques, and learning sonoanatomy by imaging oneself and colleagues, and practicing needle manipulation using simulators and phantoms [1]. Sites et al have identified errors characteristic of novice learning of ultrasound-guided peripheral nerve blockade; the most common of these is "advancement of needle when the tip was not visualized" [2].

Simulation is an integral part of training, assessment, and research in the fields of aviation, nuclear power, and the military [3], and is likely to become a mandatory component of training of health professionals [4]. Simulation has a key role to play in enabling development of medical skills from novice to expert [4]. The use of simulation models has been shown to improve skills and success with ultrasound-guided procedures [5]. A phantom may be described as any medium other than live human tissue that can be used for research or training. Phantoms generally provide a simple

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tool that can be used to learn the skills of ultrasound-guided needle placement, before clinical use, with the aim of decreasing the incidence of complications [6].

In this article, we describe a gelatin-based phantom that can be used to identify most of the common novice errors and to facilitate learning of the relevant skills. This phantom can be constructed from low cost, readily available items, and is reusable. It can also be modified to present a learner with greater degrees of difficulty as he/she progresses in training with no additional cost.

Methods

Phantom construction

The equipment required to construct the phantom are: (1) one microwave-safe bowl of >500-mL capacity; (2) cling film (e.g., TESCO cling film microwave safe, TESCO, Dundee, UK), 35 cm wide or greater; (3) a jug (microwave safe), approximately 1-L capacity for measuring and mixing; (4) hot water (boiling to tepid) 500 mL; (5) gelatin (such as Dr. Oetker Gelatine, Dr. Oetker Ireland Ltd, Dublin, Ireland); (6) sachets (70 g); (7) mangetout pea pods; (8) 5-mL syringe; (9) 24-G needle (orange); (10) 0.9% normal saline (5 mL); (11) a microwave; (12) a spoon; (13) blue food color (Dr. Oetker, Leeds, England, UK); (14) Dettol antiseptic liquid (Reckitt Benckiser Healthcare Ltd., Hull, North Humberside, UK). The flowchart shows the steps involved in constructing the phantom.

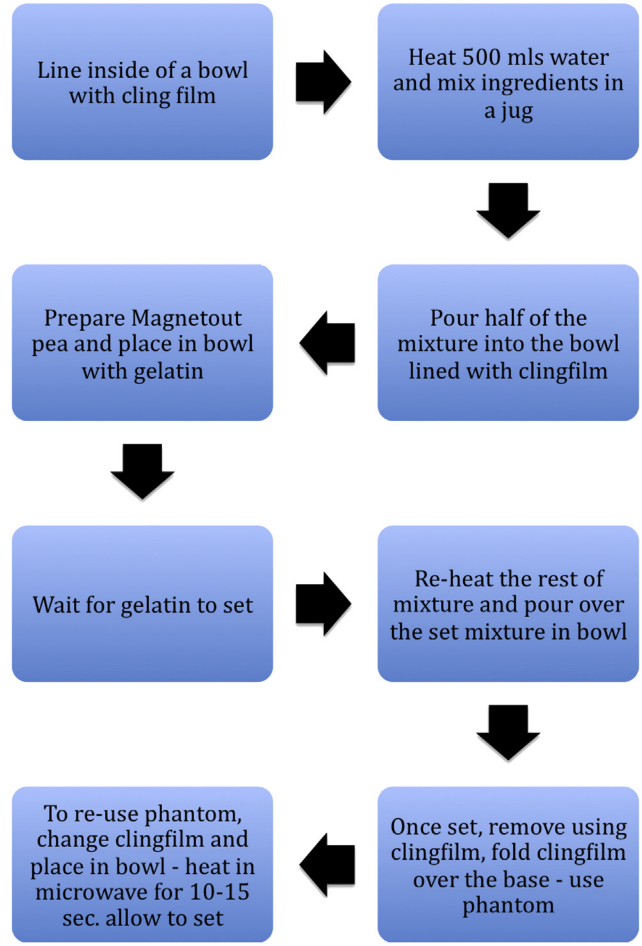
First, spread the cling film (approximately 30 cm) on a clean table, and fold it to create a double layer. Press firmly to remove all air bubbles. Line the inside of the bowl such that all sides are covered with the cling film. Pour 500 mL of water into the measuring jug, and then add the gelatin into the jug. Mix with a spoon until the gelatin dissolves. Add one spoonful (5 mL) blue food color and 1 mL Dettol to this mixture. Pour 300 mL of this mixture into the cling film-lined bowl.

Select an undamaged mangetout pea pod. Use the 5-mL syringe (filled with 0.9% normal saline) and needle to pierce one end of the mangetout pea pod. Inject approximately 1 mL of 0.9% normal saline into the pea pod to expand and separate its internal walls. Withdraw the needle and place the prepared pea pod in the bowl with the gelatin. Wait for the gelatin to set with the mangetout pea pod *in situ*.

Once the gelatin in the bowl has set, place the measuring jug in a microwave and heat until the remainder of gelatin liquefies (depending on settings, 600—800 W is standard, usually 30 seconds to 1 minute will suffice). Pour the remainder of the gelatin into the bowl with the set gelatin to form another layer, so as to incorporate the prepared pod completely in the center of the completed phantom. Set the preparation aside until the gelatin has hardened (refrigeration can also be used). Once the gelatin has hardened, lift the phantom from the bowl using the cling film and fold the cling film over the top. Turn the model upside down (Fig. 1A) to use for scanning and needle manipulation.

Reusing the model

Once a needle has been placed in the phantom, it retains the deformation (memory) caused by the needle's advancement. Line the inside of the bowl with cling film as described earlier; remove the model from the used cling film and place it in a bowl. Place the bowl (with a new layer of cling film) in a microwave and heat (on high setting) for 10—15 seconds, longer for lower settings. This reheating process liquefies the gelatin enough for the needle track to disappear. Set the bowl aside until the gelatin hardens and the phantom is ready to be used again.



Flowchart

Discussion

The shape and size of the model can easily be modified during its preparation. Once set, it is quite robust and easy to transport between teaching locations.

The double layer of cling film on the phantom provides the user with reasonably realistic feel of a needle piercing the skin. The gelatin provides an anechoic background, which enhances needle visibility. The most common error by novices is loss of needle visualization; we believe that, in clinical practice, this may be due to the distracting presence of other echoic structures. For novices to learn this critical skill, it may be advantageous to remove such distractions.

As we have described its preparation, the phantom is opaque due to inclusion of the blue coloring. If the coloring

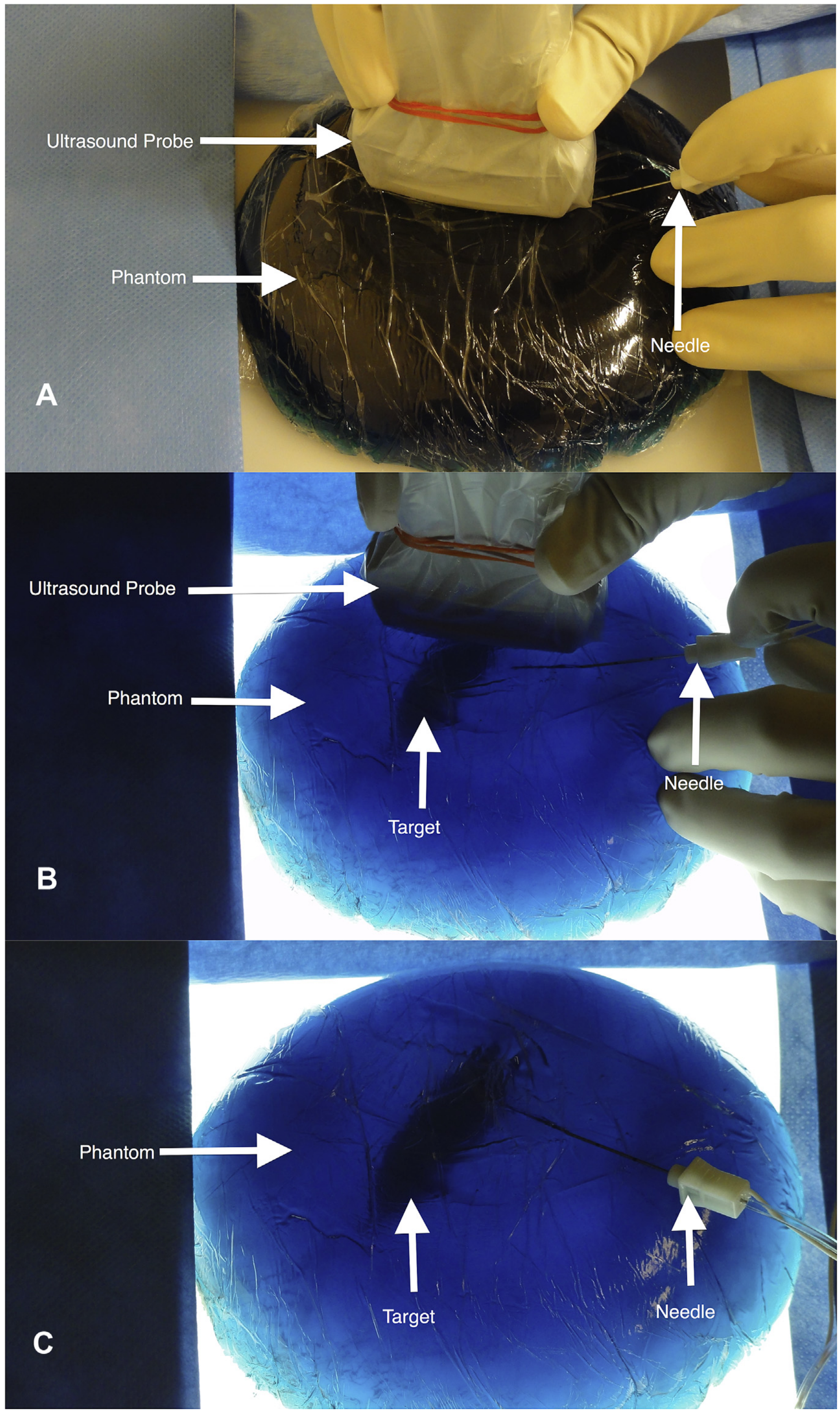


Fig. 1 (A) The ultrasound probe (M-Turbo Ultrasound System with a linear probe 6—13 MHz; SonoSite Inc, Bothell, WA, USA), phantom, and needle; (B) ultrasound probe, phantom, needle, and the target structure (by transillumination); (C) phantom, needle, and the target structure without the ultrasound probe; the visible target structure may readily be identified by the novice trainee.

is omitted, the target can be seen in daylight and be clearly identified. When the phantom, as described, is trans-illuminated (using a light source underneath), the target can be identified as well. We have found this to be a very useful means of providing real-time, immediate, or early feedback while a novice practices probe—needle—target orientation (Fig. 1B and C).

The target structure (mangetout pea) inside the pod is reasonably similar in appearance to a target nerve; the pea-pod wall offers resistance to needle advancement (a

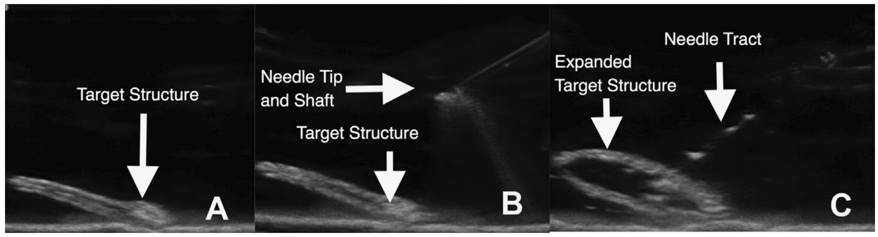


Fig. 2 Images from the ultrasound machine (M-Turbo Ultrasound System with a linear probe 6—13 MHz; SonoSite Inc, Bothell, WA, USA) (A) target; (B) needle tip and shaft approaching the target structure; (C) expansion of the target structure with fluid; the needle tract memory in the phantom is also seen.

pop) similar to that of a fascial layer and allows aspiration and injection of fluid into the pod. Hence, the performer can see the injectate spreading around the target structure (Fig. 2). This quality of this phantom differentiates it from the other available nonanimal tissue phantoms, in that one can visualize injection and spread of injectate relative to a target structure. This is so because the pea pod limits the unrestricted dissipation of injectate while retaining it within expansible walls (Fig. 2C). Although this is an advantage, it is also one of the limitations of the phantom. It is possible for a novice to identify correct placement of the needle tip (by feeling the pop) despite having lost visualization of the needle tip.

The needle track (memory) is removed by reheating the phantom as described earlier. This makes this phantom ideal for research purposes, as a standardized phantom can be reused with no changes in the structure or position of the target or the phantom.

The phantom can be modified to present the learner with tasks of greater levels of difficulty. This is achieved using either strips of cling film placed in the phantom to represent fascial planes or by adding flour or husk to the preparation to increase the echogenicity of the phantom or both. A blood vessel can be represented by incorporating a length of intravenous tubing in the phantom and attaching it to a roller infusion pump. The roller mechanism of the pump replicates pulsatile flow and can be identified using a color Doppler.

Conclusion

Based on our routine use of this phantom, we believe it to be an inexpensive and effective tool to facilitate the learning of ultrasound-guided peripheral nerve blockade by novices. Many of the errors characteristic of novice learning can be reproduced using the phantom and therefore a novice can learn or be taught to avoid them. Such a model may be useful for those providing training or courses in ultrasound-guided peripheral nerve block. We believe that it will be worthwhile to formally examine the educational value of using this phantom in a training program for novices.

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