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...
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 phan-
tom 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 pro-
gresses 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, Dun-
dee, 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 sa-
line (5 mL); (11) a microwave; (12) a spoon; (13) blue food
color (Dr. Oetker, Leeds, England, UK); (14) Dettol anti-
septic 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 (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.

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 pres-
ence 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

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.
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
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.

References


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.