TEACHING ULTRASOUND PROCEDURAL SKILLS-LOW COST PHANTOMS AND ANIMAL MODELS

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Abstract

Acquiring the necessary cognitive and psychomotor skills to perform ultrasound guided procedures may require initial training. Growing evidence shows that simulation can help in the acquisition of procedural skills. Commercially available phantoms are expensive, have non-tissue like haptics, are preformed with fixed targets and do not allow for additional targets to be imbedded.

In this study we have described several new phantoms and animal models that are inexpensive, easy to assemble and allow a rapid change of targets. Such phantoms can provide an ideal initial learning opportunity in a zero-risk environment.

Key words: ultrasound phantoms, ultrasound-guided procedural skills.

Introduction

Ultrasound (US) guided nerve blocks, cricothyroid punctures and vascular cannulations require, for safety reasons, initial training in animal models or phantoms. In-vitro models can facilitate learning of scanning techniques and hand-eye coordination skills. The elastomeric phantoms that are usually used for training lack tissue feedback, are expensive, rapidly deteriorate and become unusable due to needle tracks. In this study we describe new, improved animal models and phantoms that can be used in teaching ultrasound guided procedural skills.

Methods

We have prepared and evaluated low-cost phantoms (gelatin/agar or tofu bars with immersed tubular structures or plastic spine models), animal models (intact porcine heads, infrahyoid airway) and hybrid models (animal tissues immersed in gelatin or tofu, human hand placed on the foam to model lung with rib cage).

US scanning was performed using BK Medical Flex Focus 400 and Sonosite S-Series systems.

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Results

Retrobulbar blocks are usually placed blindly in awake patients without US guidance\textsuperscript{1}. Severe complications of this blind technique have been reported. Real-time US guidance provides visualization of the eye and the optic nerve before and during insertion of the needle which can improve the quality and safety of the block. Intact porcine head models (Fig. 1) obtained in the slaughterhouse allow for supervised training to avoid ocular perforation and injection of local anesthetic into the optic nerve or sheath.

Cricothyroid membrane punctures were performed in the porcine infrahyoid airway embedded in gelatin (Fig. 2 and 3) which allowed visualization of the posterior wall of the airway.

Vascular cannulations\textsuperscript{2} were performed in tofu models. Thin polyethylene tubings filled with saline were inserted into tofu bars (Fig. 4). Thin walls allowed easy penetration of the needle and confirmation of the successful cannulation.

Ultrasound-guided placement of the spinal needle was performed in plastic lumbar and sacral spine models\textsuperscript{3} immersed in gelatin or water bath (Fig. 5).

\textbf{Fig. 1}

\begin{itemize}
  \item A - pig eye axial sonogram (12 MHz linear probe). The lens (L) is intact and the retrobulbar area well visualized.
  \item B - injection of 5 ml of saline through the needle (N) fills the orbital canal.
  \item Sclera and the needle tip are well visualized.
\end{itemize}

\textbf{Fig. 2}

\begin{itemize}
  \item A - cross section of a pig trachea (T) and esophagus (E) embedded in gelatin.
  \item B - transverse ultrasound scan of the same specimen (18 MHz linear probe).
  \item C - longitudinal scan of the specimen.
  \item The anterior and posterior walls of the trachea (T) are visualized. The needle was inserted through the crico-thyroid membrane.
\end{itemize}
Fig. 3
Upper panels - transverse ultrasound scans of the porcine thyroid cartilage immersed in gelatin (left); porcine cricothyroid membrane puncture (right) with needle reverberation artifact. Lower panels – transverse (left) and longitudinal (right) scans of the trachea immersed in gelatin. Needle visible in the trachea.

Fig. 4
Vascular puncture performed in tofu models. Polyethylene tubings filled with saline were inserted into tofu bars to mimic blood vessels.
Ultrasound-guided thoracentesis was performed in the model consisting of the experimenter’s hand placed on top of the water-filled container with a wet foam. Metacarpal bones of the human hand simulated a rib cage and a wet foam simulated a diseased lung immersed in the pleural fluid (Fig. 6).

Discussion

Ultrasound guidance improves safety, success rate and efficacy of various procedures provided that the tip of the needle is visualized at all times. This skill can be taught in animal models and phantoms. The image of the needle with ultrasound beam alignment and reaching a target inside the phantom or the animal model may require a considerable number of attempts. The cumulative sum (cusum) charts revealed that novice operators acquire such abilities at variable rate. Appropriately designed models may allow for controlled, supervised learning, including a formative feedback between trials and construction of individual learning curves. An important benefit of using animal models is that it also allows teaching of the ultrasound anatomy. Imbedding the animal tissue in gelatin or gelatin/agar mixture for improved durability of the phantom enhances the quality of the ultrasound image while preserving tissue feedback.
The role of ultrasound in central neuraxial blockade has been underappreciated due to the perceived difficulty in imaging through the narrow acoustic window produced by the vertebra. However, the interlaminar window permits passage of sound waves. The intervertebral level can be identified and the depth to the epidural and intrathecal spaces can be estimated.

Practicing on cadavers allows participants to study the sonographic anatomy and practice sonographically guided blocks with realistic tactile feedback, but they are often limited by the quality of sonograms and have to be conducted in credentialed facilities.

In-vitro models as described in this study allow visualization of the osseous and soft tissue anatomy and can facilitate the teaching of scanning techniques and hand-eye coordination skills that are required for real-time sonographically guided blocks.

Procedural skills in the field of anesthesiology are assessed poorly compared with other domains of learning as they are often given less importance than the assessment of knowledge and judgement-based skills. This is partly because there has been no universally accepted and comprehensive way to assess procedural skills. It is our goal to further develop and optimize our in-vitro models to enable an objective assessment of procedural skills by our anesthesia trainees.

**Conflict Of Interest**

None.
References

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Lock-up

Postoperative Pain

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- **Initial bolus**
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    - Infusion rate 12-24 mg Tramal® (16-20 drops/min or 30-60 ml/h)
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    - If needed further doses of Tramal® up to a total of 200 mg (excluding the initial bolus) within the first 60 min.
  - **PCA**
  - **Injection**

**STEP III**

- **Follow-up**
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References


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