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Original Contribution

Teaching sonoanatomy to anesthesia faculty and residents: utility of hands-on gel phantom and instructional video training models☆,☆☆

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Abstract
Study objective: Thousands of patients worldwide annually receive neuraxial anesthesia and analgesia. Obesity, pregnancy, and abnormal spinal anatomy pose challenges for accurate landmark palpation. Further, spinal sonoanatomy is not uniformly taught in residency education, even though its use has previously been shown to improve identification of relevant structures and decrease procedural complications and failure rates. The aim of this study was to evaluate the use of hands-on gel phantom and instructional video training for teaching spinal sonoanatomy among anesthesiology faculty and residents.
Design: Twenty-three residents and 27 anesthesiologists were randomized to gel phantom, video teaching, and control groups.
Setting: Academic Hospital.
Measurements: Successful identification of spinal sonoanatomy was attempted on a human volunteer before and immediately after the respective intervention and 3 weeks later. Perceived knowledge and training modality satisfaction were assessed using modified Likert scales.
Interventions: Gel phantom and video teaching groups compared with control (no intervention).
Main results: Both interventions significantly improved spine sonoanatomy identification accuracy. Logistic regression analysis demonstrated both interventions improved the odds of transverse process (gel 12.61, $P = .013$; video 7.93, $P = .030$) and lamina (gel 65.12, $P = .003$; video 8.97, $P = .031$) identification. Perceived knowledge of basic spinal anatomy and spinal sonoanatomy improved in the intervention versus

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control groups. Mean (SD) modified Likert scale scores for learning satisfaction (1 = unsatisfied, 10= very satisfied) were 8.1 (1.5) and 8.0 (1.7) for hands-on gel phantom and instructional video training participants, respectively.

Conclusion: Use of hands-on gel phantom or instructional video training can improve anesthesia staff and resident knowledge of lumbar spine sonoanatomy.

1. Introduction

Neuraxial anesthesia is performed annually for thousands of patients [1,2], most commonly for childbirth, orthopedic surgeries, and postoperative and chronic pain management. These procedures are facilitated by the clinician's ability to identify the patient's midline to direct needle placement into the epidural or intrathecal space. This localization process may be problematic when patients are obese, pregnant, or have spinal abnormalities, including misalignment or degenerative changes [3–7]. Ultrasound can be used to gain a more accurate understanding of a patient's spinal anatomy, leading to fewer needle insertion attempts and spinal needle manipulations, and improve patient satisfaction [3,5,6,8–18]. Further, a decrease in the number of needle insertion attempts has been shown to correlate with a decreased incidence of postdural puncture headache [19], new-onset persistent low-back pain [20], and puncture site bleeding [21]. Seizures or cardiac arrest may result from delivery of anesthetic agents into an inappropriate anatomical space or vasculature [22]. Although additional time is required to establish landmarks using ultrasound guidance, fewer needle insertion attempts are required for successful anesthetic placement [5,21].

Previous studies have demonstrated that gel phantom models accurately reflect the echogenicity of osseous and tissue structures [23–25] and serve as a low-cost teaching modality [25–28]. In addition, educators increasingly rely on the use of multimedia teaching tools (eg, instructional videos) due to accessibility and convenience. However, the literature evaluating the effectiveness of these teaching tools for improving ultrasound use and spinal sonoanatomy knowledge remains limited [23,26]. The purpose of this study was to evaluate the use of a hands-on gel phantom model and instructional training video on ultrasound identification of spine landmarks and perceived knowledge of basic spine anatomy, spinal sonoanatomy, and risks associated with neuraxial interventions on a human model among staff and resident anesthesiologists.

2. Materials and methods

After approval from the University of Wisconsin Health Sciences Minimal Risk Institutional Review Board, anesthesiology faculty and residents were recruited via e-mail invitation in the research study regardless of ultrasound experience, area of expertise, or years of clinical experience. Faculty and residents were grouped together for purposes of randomization. The order of gel phantom, video teaching, and control group designations were created using an on-line randomizer (www.randomizer.org). Volunteers were then paired with an intervention based on the order they participated. Data regarding years of training were collected after randomization.

The study progressed in 3 distinct phases. In phase 1, those randomized to the intervention groups were exposed to the assigned instructional intervention (ie, hands-on gel phantom teaching or instructional video teaching), as described below, or no intervention (control group). After phase 1, participants were asked to identify specific sonoanatomical lumbar spine features (spinous and transverse processes and vertebral lamina) on a human subject and complete a survey aimed to quantify perceived learning (phase two). Three weeks later, during phase 3, the participant's ability to identify specific sonoanatomical features on the same human subject was reassessed. Participants were asked to rate their satisfaction of the study on a Likert scale (1 = unsatisfied, 10 = very satisfied) upon completion.

3. Phase 1—instructional interventions

3.1. Hands-on gel phantom training

A gel phantom spine model, which yields ultrasound images similar to those obtained on a human subject (Figure), was created by submerging a commercially available, L2-L5 lumbar spine model (CHLS4, Anatomical Chart Company, Windham, NH) in a mixture of sugar-free psyllium hydrophilic mucilloid fiber (240 g), gelatin (480 g), and water, and allowing it to cure under refrigeration [23]. As previously described, chlorhexidine gluconate 2% solution (Scrub Care, CareFusion Inc, Leawood, KS) was added to the mixture to retard microbial growth and extend shelf life [25]. Participants assigned to the hands-on gel phantom training group were individually taught spinal sonoanatomy by study staff using a semistructured teaching script and were allowed time to practice the ultrasound identification of basic spine structures. The semistructured teaching script included background information on the use of ultrasound technology, complications of spinal interventions, and basic spinal anatomy. Time allotted for hands-on gel phantom training was not standardized, but generally did not exceed 10