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A LOW-FIDELITY, HIGH-FUNCTIONALITY ULTRASOUND-GUIDED SERRATUS PLANE BLOCK MODEL

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☐ **Abstract—Background: Thoracic injuries present many challenges for management in the acute and inpatient settings, including achieving appropriate pain control. Traditional modalities, such as opioids and spinal epidural anesthesia, are associated with multiple complications. Ultrasound-guided regional nerve blocks are becoming more prevalent, and they have been shown to be an effective modality of pain control for other traumatic injuries. Models comprised of animal tissue to simulate human anatomy are widely utilized to facilitate training of needle-guided procedures, but no such model for the serratus anterior plane block has yet been defined in the literature. Objectives: Our goal was to produce a high-functionality serratus anterior plane block model with reasonable anatomic fidelity from low-cost materials. Discussion: We describe the creation of an inexpensive high-functionality serratus anterior plane block model from common materials, including pork ribs and chicken breasts, to realistically simulate human anatomy, including multiple muscle and fascial planes, as well as to allow hydrodissection. Conclusions: This model will facilitate training and can improve success when caring for patients with thoracic trauma. © 2019 Elsevier Inc. All rights reserved.**

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☐ **Keywords—ultrasound; nerve block; regional anesthesia; simulation; education**

INTRODUCTION

Traumatic injuries to the thorax impose many challenges for management, increasing risk for pneumonia and respiratory failure, conveying significant morbidity and mortality (1–4). In addition, iatrogenic injuries such as a thoracotomy can increase the risk of developing pneumonia and respiratory failure. Achieving appropriate pain control using parenteral narcotics or thoracic epidural anesthesia can be difficult and associated with serious complications, such as respiratory depression, delirium, and hypotension (5,6). Ultrasound-guided regional nerve blocks can provide improved pain control, are relatively simple to perform, can be done at bedside, and are within the scope of practice of emergency medicine providers (7–9). Ultrasound-guided regional nerve blocks have proven to be an effective modality for pain control for a variety of traumatic injuries (10,11). When compared with landmark-based approaches, ultrasound guidance has the advantage of being able to directly visualize the target nerve prior to and during anesthetic injection as well as avoid vascular structures (12–17). Traditionally, ultrasound-guided nerve blocks such as the femoral nerve block have involved local anesthetic deposition directly

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adjacent to the targeted nerve; however, this entails the risk of neurovascular injury due to the proximity of the needle to the nerve and accompanying vasculature. Most nerves reside on fascial planes, and more recently, fascial blocks, such as the fascia iliaca block, have been developed; these involve local anesthetic deposition on the fascial plane remote to the targeted nerve, reducing the risk of neurovascular injury, with the local anesthetic diffusing along the fascial plane to anesthetize the nerve (18).

The anterolateral thorax is primarily innervated by the lateral cutaneous branches of the thoracic intercostal nerves. These nerves penetrate through the muscular layers of the thorax, including the intercostal and serratus anterior muscles. The serratus anterior plane block (SAPB) was first described in 2013 and provides anesthesia to these nerves and therefore, the anterolateral chest wall, by anesthetizing them in either the fascial plane just deep to the serratus anterior muscle or just superficial to it (19). Although large population comparisons are lacking, current evidence suggests that both approaches achieve similar pain control, with the superficial approach ensuring that the needle is kept further from the pleura, reducing the risk of pneumothorax (20). Although initially utilized for periprocedural pain control with breast surgeries, it has seen increasing use in thoracic wall trauma; particularly, it has been shown to decrease pain associated with rib fractures and assist with extubation after thoracotomy while avoiding the hypotension that can be associated with thoracic epidural anesthesia (19–22).

To perform the SABP, a high-frequency linear ultrasound transducer is placed transversely over the midaxillary line at the level of the fifth rib. The latissimus dorsi, serratus anterior, and intercostal muscles are visualized, as are the ribs and the pleura. The needle tip is advanced into the plane just superficial to the serratus anterior muscle, with small-volume injections of local anesthetic used to hydrodissect the fascial planes and ensure proper needle tip placement. Approximately 30 mL of local anesthetic is then deposited, providing anesthesia to the lateral cutaneous branches of the thoracic intercostal nerves (19).

Our objective was to create a model that would accurately reproduce the human anatomy of the superficial thorax to train emergency physicians to perform SAPBs. This model is inexpensive, easy to produce, and provides a realistic simulation of human anatomy and needle-guided procedures. The use of animal tissue to simulate human anatomy has been described in several regional nerve block models, but a model recreating the SAPB has yet to be defined in the literature (23–25).

DISCUSSION

The model was primarily constructed of chicken breasts and pork ribs, with paper towels to simulate fascial planes. As described in previous nerve block models, the chicken breasts and pork ribs were soaked in an alcohol-based hand sanitizer for 12 hours to improve longevity of the model, and then rinsed and patted dry (24). After this, the model was constructed in layers. The meat used in this model included a rack of pork ribs, three chicken breasts, and two paper towels that were dampened with water, as shown in Figure 1. To construct the model, a rack of pork ribs comprised the first layer, representing the rib cage. Over this was placed a chicken breast (flattened to approximately ½ inch thickness) with muscle fibers oriented perpendicular to the pork ribs, representing the serratus anterior muscle. A damp paper towel was positioned on top of the flattened chicken breast, representing the fascia overlying the serratus anterior. A third chicken breast was then cut into thirds and the pointed third of the breast was placed over the lower half of the model to represent the teres major muscle. Next, another damp paper towel was placed over this chicken layer to simulate the overlying fascia. Finally, a third chicken breast (pounded to approximately ½ inch thickness) with muscle fibers parallel to the pork

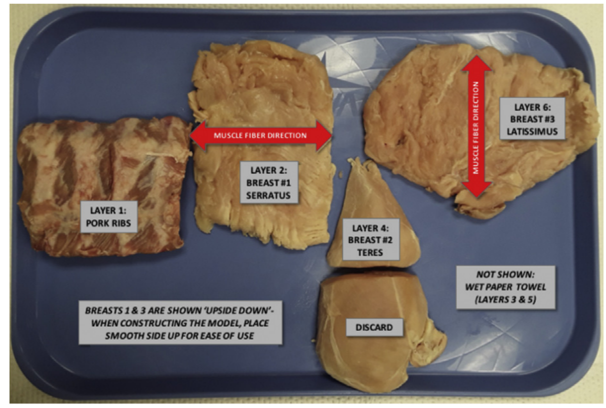

Figure 1. Disassembled pork rib and chicken breast components required. These include rack of pork ribs, two chicken breasts pounded to approximately ½-inch thickness, and the pointed third of another chicken breast.

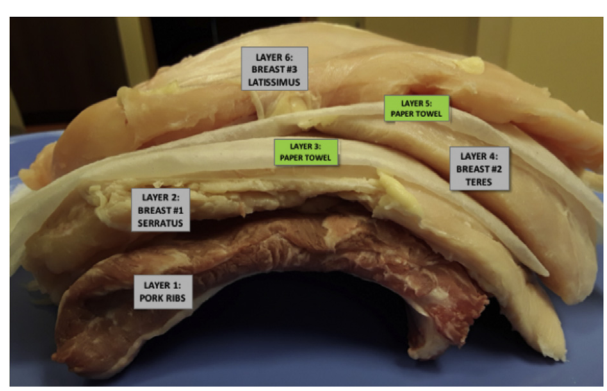

Figure 2. Assembled model with layers annotated.

Figure 3. Supplies required in addition to pork ribs and chicken breasts include two paper towels, a dissection tray or other suitable base, ultrasound gel, syringes (10 mL, 20 mL, and 60 mL), 18-gauge needles, 21-gauge nerve block needle, dissection pins to adhere the model to the dissection tray, and vegetable oil for injection.

ribs was placed, representing the latissimus dorsi muscle. Dissection pins were then placed at the edges of the model to maintain stability. The final assembled model is shown in Figure 2. To perform the needle-guided procedure and hydrodissection, the materials used can be seen in Figure 3. Note that multiple types of needles are shown and can be used, including an 18-gauge needle, an 18-gauge spinal needle, or a 21-gauge nerve block needle.

By using pork ribs, chicken breasts, and damp paper towels, we established that an anatomically accurate model of the SAPB could be recreated in an inexpensive and efficient manner (Figures 4, 5). Our model accurately reproduced the muscle and fascial planes and allowed for a provider to perform long-axis needle guidance and hydrodissection (Figure 6; Video 1, available online). It is able to accommodate multiple injections prior to losing anatomic fidelity. By preserving the tissue with alcohol-

Figure 4. Ultrasound image of the human serratus anterior. Latissimus dorsi (LD), teres major (TM), Serratus anterior (SA), Rib (R), intercostal muscle (IC).

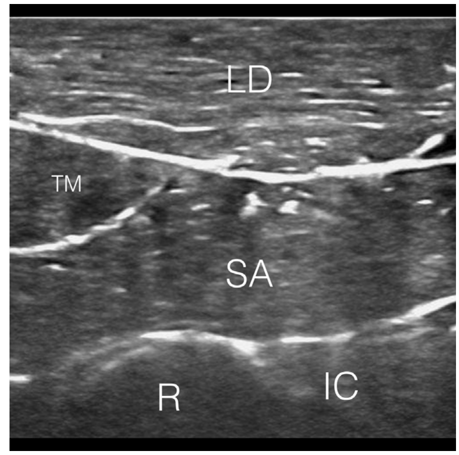

Figure 5. Ultrasound image of the serratus anterior model. Latissimuss dorsi (LD), teres major (TM), serratus anterior (SA), rib (R), intercostal muscle (IC).

based hand sanitizer, it can be maintained in a refrigerated environment for several weeks. The total cost of our model is approximately $15 (USD).

There are several limitations to our model, including the amount of time used to manufacture each model. Although the technique to produce these models is simple, large-scale production may be time consuming, with each model taking 30 minutes to construct. Additionally, hydrodissection may be dependent on injectate material and needle gauge used. When performing the SAPB on human subjects, an anesthesia needle 21-gauge or smaller is often used. However, we found that for our model, a mixture of equal parts ultrasound gel and saline utilizing an 18-gauge needle provided the most consistent hydrodissection results. Although saline alone is very fluid and does not allow for accurate hydrodissection visualization by ultrasound in our model, ultrasound gel is too viscous and difficult to inject, despite utilizing a

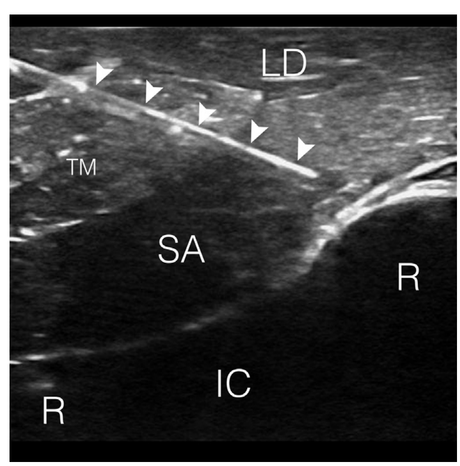

Figure 6. Ultrasound image of the serratus anterior model with needle in long axis. Latissimus dorsi (LD), teres major (TM), serratus anterior (SA), rib (R), intercostal muscle (IC) needle (arrows).

larger-bore needle; the mixture of both provides an ideal balance of fluidity with a measure of viscosity.

Although this model has the potential to improve the training of emergency medicine providers to perform the SABP, this has yet to be demonstrated in practice. To this end, possible next steps involve incorporating this model into the training curriculum at our residency program and evaluating its efficacy by conducting pre- and post-implementation surveys of trainees and their comfort performing the SABP.

CONCLUSIONS

Our model provides a high-fidelity simulation for ultrasound-guided SAPB training. Providers undergoing training to perform ultrasound-guided SAPB using our simulation model will be more familiar with the ultrasound anatomy of the chest wall musculature and facial planes, as well as more practiced using the long-axis approach for needle visualization. Our model offers an excellent tool for emergency medicine providers looking to expand their armamentarium when treating patients with acute thoracic trauma with ultrasound-guided regional anesthesia.

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SUPPLEMENTARY DATA

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jemermed.2019.09.004.

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