

Performance Accuracy of Hand-on-needle versus Hand-on-syringe Technique for Ultrasound-guided Regional Anesthesia Simulation for Emergency Medicine Residents

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Introduction: Ultrasound-guided nerve blocks (UGNB) are increasingly used in emergency care. The hand-on-syringe (HS) needle technique is ideally suited to the emergency department setting because it allows a single operator to perform the block without assistance. The HS technique is assumed to provide less exact needle control than the alternative two-operator hand-on-needle (HN) technique; however this assumption has never been directly tested. The primary objective of this study was to compare accuracy of needle targeting under ultrasound guidance by emergency medicine (EM) residents using HN and HS techniques on a standardized gelatinous simulation model.

Methods: This prospective, randomized study evaluated task performance. We compared needle targeting accuracy using the HN and HS techniques. Each participant performed a set of structured needling maneuvers (both simple and difficult) on a standardized partial-task simulator. We evaluated time to task completion, needle visualization during advancement, and accuracy of needle tip at targeting. Resident technique preference was assessed using a post-task survey.

Results: We evaluated 60 tasks performed by 10 EM residents. There was no significant difference in time to complete the simple model (HN vs. HS, 18 seconds vs. 18 seconds, $p=0.93$), time to complete the difficult model (HN vs. HS, 56 seconds vs. 50 seconds, $p=0.63$), needle visualization, or needle tip targeting accuracy. Most residents (60%) preferred the HS technique.

Conclusion: For EM residents learning UGNBs, the HN technique was not associated with superior needle control. Our results suggest that the single-operator HS technique provides equivalent needle control when compared to the two-operator HN technique. [West J Emerg Med. 2014;15(6):641–646]

INTRODUCTION

Pain is a frequent complaint in the emergency department (ED).^{1,2} Ultrasound-guided nerve blocks (UGNB) are a potentially effective means to improve pain management in the ED.³⁻⁶ There is increasing interest in the use of UGNBs for a wide variety of ED conditions including pain control for common injuries such as hip fractures and anesthesia for invasive procedures such as shoulder reductions and abscess incision and drainage. The

bulk of existing literature on education and technique for UGNBs has been conducted by anesthesiologists and refers to peri-operative applications.⁷⁻¹¹ However, the application of UGNBs in emergency medicine (EM) requires a distinct skill set that has to date not been extensively studied.

Two alternate needle guidance techniques are used for UGNBs – the hand-on-syringe (HS) technique and the hand-on-needle (HN) technique (Figure 1). The HN technique has traditionally been assumed to be more accurate. However,

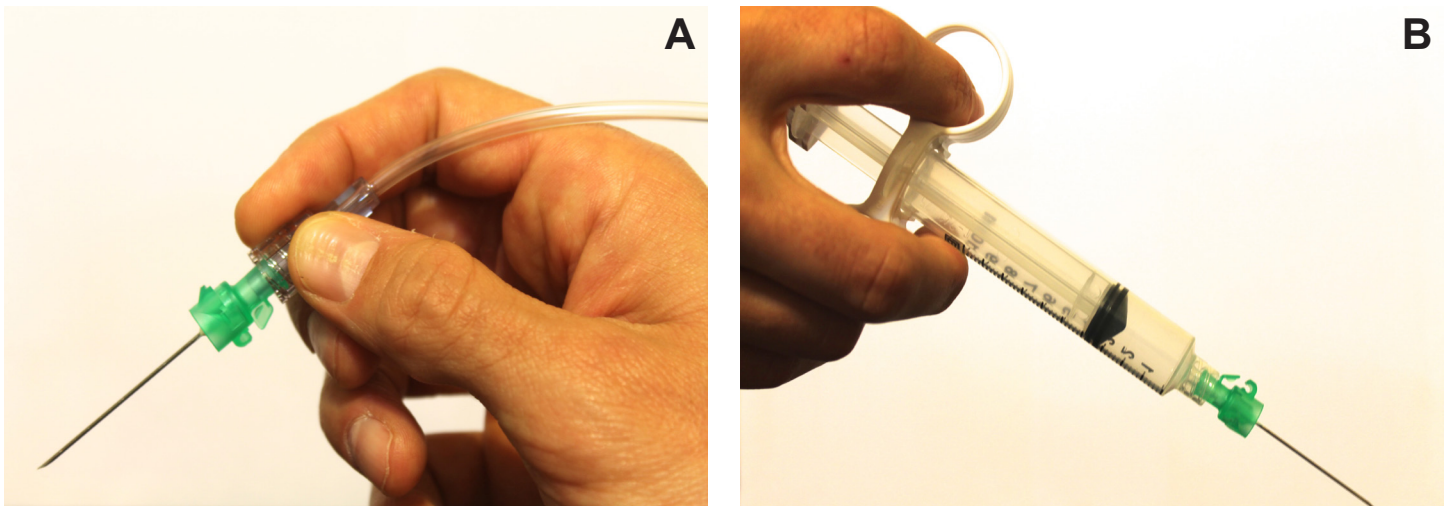


Figure 1. A, Hand-on-needle technique has the provider holding the needle hub in a pencil-like fashion while resting their hand on the body surface. B, Hand-on-syringe technique has the operator hold the syringe rather than the needle, enabling them to aspirate and inject local anesthetic without the use of an assistant.

this technique requires a second operator to inject the anesthetic and also results in the primary operator losing the tactile feedback of resistance to injection. Loss of tactile feedback could potentially make it more difficult to identify a possible intraneural needle tip placement and high-pressure injection with a subsequent increased risk of peripheral nerve injury.^{12,13} In contrast, the HS technique requires only a single operator to maneuver the needle while also injecting the anesthetic, obviating the need for additional personnel and allowing the operator to maintain tactile feedback throughout the procedure. The single-operator method and ability to maintain tactile feedback make the HS technique advantageous in the ED setting. Additionally, the assumption that a two-operator HN technique confers more accuracy has, to our knowledge, never been investigated.

Our goal was to compare the HS and HN needle technique using a low fidelity, low cost partial-task simulator. Our hypothesis was that among EM residents, there would be no difference in performance between the two ultrasound (US) guided needle techniques.

METHODS

Study Design

This was a prospective, randomized trial evaluating task performance on a simulated UGNB model comparing HN and HS techniques. The local institutional review committee reviewed and approved the study.

Study Setting and Population

EM residents in their first to fourth years of clinical training were enrolled in the needle task study after providing written consent.

Study Protocol

Study participants performed a set of structured needling

tasks on a standardized UGNB partial-task simulator that has been described in previous research.¹⁴ Extra-firm tofu (10 by 8 by 4 cm) provided appropriate US visualization and firmness for minimal translational movement on needle advancement. Wooden dowels were inserted through the tofu to correspond with a modeled nerve and a modeled vessel. Residents used a linear 12-5MHz transducer (Philips HD11XE, Andover, MA) with appropriate gain and depth set by one of the study authors. Each resident used a 21-gauge needle for the HN technique and a 21-gauge needle attached to a 10 cc control syringe for the HS technique. When the participant reported having reached the appropriate target, the needle task was defined as completed. These maneuvers were designed to replicate clinical scenarios relevant to ED application of UGNBs.

A study author enrolled each resident. After a brief tutorial that included description of both HN and HS techniques, each participant was allowed to practice both needle techniques on the simple model without instruction for five minutes. Each resident was randomized to begin task performance using either the HN or HS technique again on the simple model based on odd and even enrollment. After completion of the simple model, residents in each arm crossed over and completed the difficult model task.

Each resident performed a total of six needling tasks using two UGNB models described as 1) simple and 2) difficult. The simple model simulated a technically simple UGNB in which the modeled nerve was superficial (approximately 2 cm below the surface) and distant from the modeled vascular structure (approximately 2 cm) (Figure 2). The wooden dowels that represented nerve and vessel were placed in parallel orientation. The difficult model simulated a more technically challenging UGNB in which the modeled nerve was deeper (approximately 4 cm below the surface) (Figure 3). The modeled vessel was

Table 1. Demographics and self-reported ultrasound proficiency of enrolled emergency medicine residents.

Variable	Frequency	
	n	%
Postgraduate year		
One	6	60
Two	2	20
Three	1	10
Four	1	10
Sex		
Female	3	30
Age		
Mean	29	
Number of UGRA procedures performed*		
None	1	10
< 10	4	40
10 to 20	2	20
21 to 30	2	20
31 to 40	1	10
Number of ultrasound-guided procedures performed†		
< 10	1	10
11 to 50	6	60
51 to 100	1	10
> 100	2	20
Confidence in ultrasound‡		
Very confident	2	20
Somewhat confident	8	80
Somewhat not confident	0	0
Not confident	0	0
Confidence in UGRA‡		
Very confident	0	0
Somewhat confident	7	70
Somewhat not confident	3	30
Not confident	0	0

UGRA, ultrasound-guided regional anesthesia

* Self-reported estimate of the number of ultrasound-guided regional anesthesia procedures carried out on patients in the peri-operative or emergency department setting

† Self-reported estimate of the number of ultrasound-guided procedures performed by the subject including central and peripheral intravenous lines, thoracentesis, paracentesis, pericardiocentesis, lumbar puncture and arthrocentesis

‡ Self-report of confidence based on five point Likert scale

placed directly below the modeled nerve with a perpendicular orientation. Each resident performed the UGNB on each model with both the HN technique and HS technique.

Measures

Before completion of the study, we collected the following demographics: post-graduate year, gender, age, number of UGNBs performed, number of US-guided procedures performed, confidence in US, and confidence in UGNBs. A study author recorded parameters of task performance and needle control at the time of each task; these included missed appropriate modeled vessel, reached close proximity to appropriate modeled nerve (<5mm), advanced needle only when visualized, and time-to-task completion. Residents completed a post-task survey that included needle technique preference, confidence in UGNBs, and skills learned from tutorial.

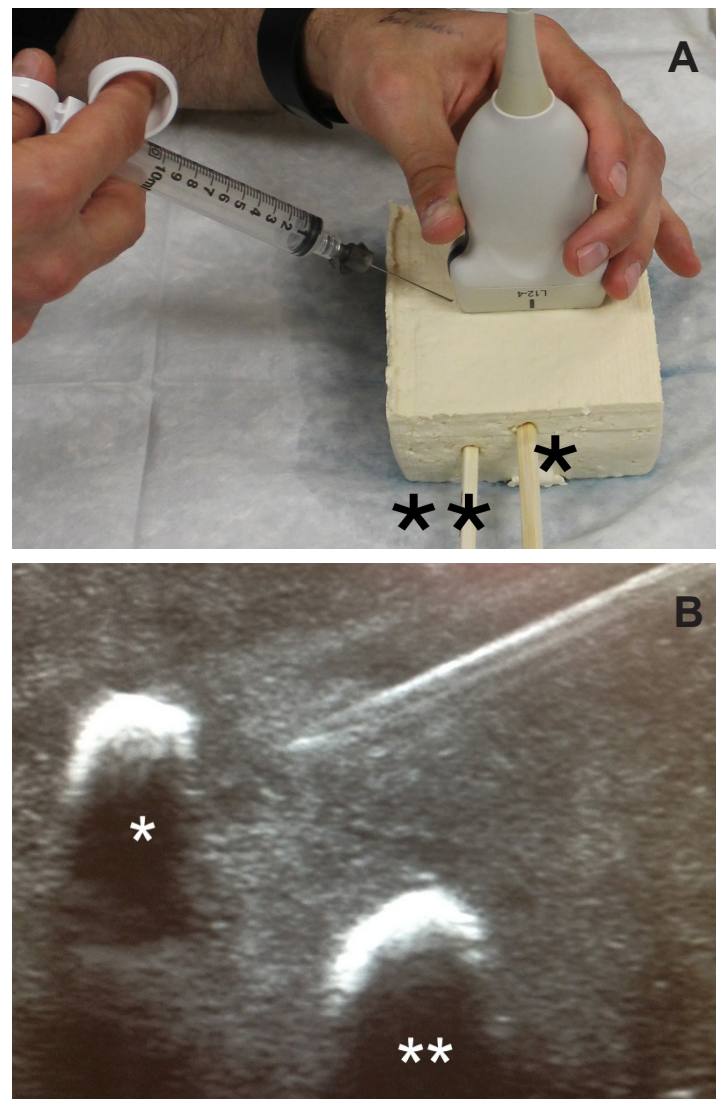


Figure 2. A, Simple phantom model made of extra-firm tofu (10 by 8 by 4cm) with two wooden dowels inserted in parallel fashion to simulate nerve (*) and adjacent vessel (**). B, Ultrasound image of simple model with modeled nerve (*) and vessel (**) with inplane needle view using a linear 12-5MHz transducer with appropriate gain and depth set by one of the study authors.

Table 2. Performance accuracy using hand-on-needle versus hand-on-syringe technique* for ultrasound-guided regional anesthesia on a simulation model.†

Variable	Simple model		p-value‡	Difficult model		p-value‡
	Hand-on-syringe	Hand-on-needle		Hand-on-syringe	Hand-on-needle	
	n (%)	n (%)		n (%)	n (%)	
Avoided appropriate vessel						
Yes	10 (100)	9 (90)	1	10 (100)	8 (80)	0.2
No	0 (0)	1 (10)		0 (0)	2 (20)	
Successfully targeted nerve						
Yes	10 (100)	10 (100)	1	10 (100)	10 (100)	1
No	0 (0)	0 (0)		0 (0)	0 (0)	
Advanced needle only when visualized						
Yes	9 (90)	7 (70)	0.6	8 (80)	8 (80)	1
No	1 (10)	3 (30)		2 (20)	2 (20)	
Time						
Mean	18.2	17.9	0.9	49.9	56.1	0.6
Minimum, maximum	10, 34	7, 28		18, 131	34, 100	

* The hand-on-needle technique has the operator holding the needle hub in a pencil-like fashion while resting their hand on the body surface. The hand-on-syringe technique has the operator hold the syringe rather than the needle, enabling them to aspirate and inject local anesthetic without the use of an assistant.

† Residents performed needling tasks on two simulated phantom models representing a simple and difficult ultrasound-guided regional anesthesia scenario. Residents were randomized on which needle technique to perform first and then second on the simple model. The needle technique order was then reversed for the difficult model.

‡ Categorical variables: Chi square and Fisher exact test for expected cell counts less than 5. Continuous variables: pooled variance independent t-test

Data Analysis

We stratified primary outcomes by HN technique and HS technique in both the simple and difficult model. Variables were not recorded during the initial practice period with the simple model. For categorical variables, we calculated p-values by chi square analysis and Fisher exact test if expected cell counts were less than five. For continuous variables, p-values were calculated using the pooled variance t-test. We completed analyses using Statistical Analysis Software version 9.2 (Cary, North Carolina) and Microsoft Excel (Redmond, WA).

RESULTS

Ten residents performed a total of 60 US-guided tasks. The majority were first-year residents (6/10) and male (7/10) (Table 1). Half of participants had performed less than 10 UGNBs while the majority had performed more than 10 total US-guided procedures (9/10). All participants were “very” or “somewhat” confident in US (2/10 and 8/10 respectively); however three out of 10 participants were “somewhat not confident” in UGNBs.

The HN technique did not demonstrate superior control compared to the HS technique. In both the simple model and the difficult model, no measured parameter was statistically different between the HN technique and the HS technique (Table 2). There was no difference in time to complete

the simple model (HN vs. HS, 18 seconds vs. 18 seconds, $p=0.93$). There was no difference in time to complete the difficult model (HN vs. HS, 56 seconds vs. 50 seconds, $p=0.63$). Most participants were able to successfully meet each parameter. Most residents preferred the HS technique (60%, 6/10), 30% preferred the HN technique (3/10) and 10% had no preference (1/10). The majority of residents (9/10) endorsed increased confidence and knowledge of UGNBs after completion of the study.

DISCUSSION

Our results suggest that the single-operator HS technique provides equivalent needle control when compared to the two-operator HN technique among EM residents. The HS technique has two advantages in the busy ED setting. First, one provider can complete the HS technique while the HN technique requires two providers (one to control the needle, the other to inject anesthesia). Second, delegating aspiration and injection to an assistant removes the immediate tactile feedback on injection pressures that a single-operator technique affords. This is a known concern in the anesthesiology literature, and in fact there are reports of novel hand and syringe positions that would permit a single-operator technique with a standard HN apparatus.¹⁵ These hand positions seem somewhat complex for novice practitioners.

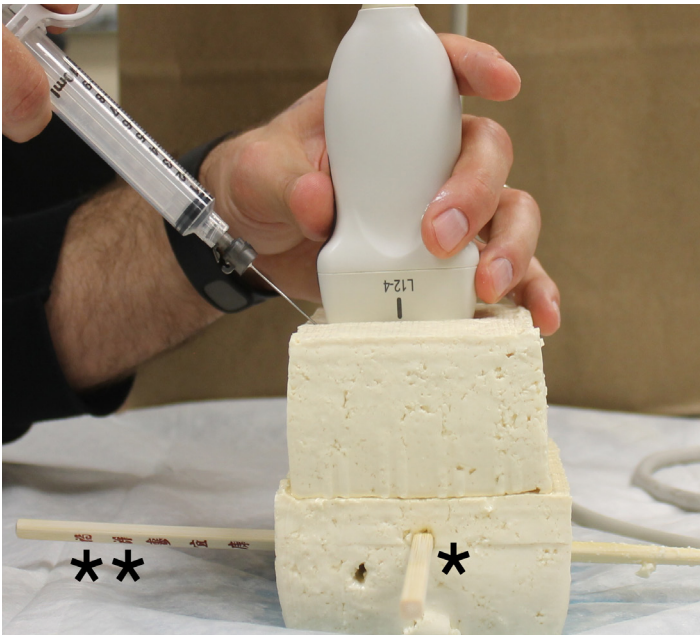


Figure 3. Difficult phantom model with hand-on-syringe approach. The simulated phantom model employed two sections of extra-firm tofu (10 by 8 by 4cm). Two wooden dowels were inserted through the tofu in perpendicular orientation to reflect a modeled nerve (*) and vessel (**). The modeled vessel was deeper and adjacent to the modeled nerve.

The HS technique would be much more appealing in the ED environment, using a commonly available control syringe to retain tactile feedback.

Our low cost, low fidelity model could be used in most domestic or international ED settings with success. Any EM provider wishing to simulate UGNB would only require a physician knowledgeable in UGNBs, an appropriate US, tofu, and wooden dowels. Partial-task simulators such as the one described in our study have been described extensively in the anesthesia literature.^{7,8,10,11,16} Our study is the first to extend such simulation methods to the ED setting. UGNB needle skills are potentially transferrable to other US-guided procedures, such as central and peripheral intravenous lines, arthrocentesis and pericardiocentesis. As UGNBs become common practice in the ED setting, an UGNB curriculum will be essential to any EM residency program. We hope our study can foster additional innovative models and training curriculum to improve needle performance.

LIMITATIONS

Our study has several limitations. The phantom model used has both a flat surface that was easily positioned for an optimal needle approach and remained immobile. In actual practice, the challenges of irregular body contours and patient movements could create circumstances that we were not able to simulate in our model. Nevertheless, the partial-task phantom model simulators such as the one described in our study have been described extensively in the anesthesiology literature and likely allowed us to evaluate

performance akin to best-case scenario actual practice where the patient is adequately sedated and well positioned.^{8,10,11,16} Ours was a pilot study to investigate a novel question that has not been investigated previously. While statistical analysis was performed on our results including p-values, our study was not meant to detect small differences. While needle tasks were randomized, subject preference could have been dictated by order as one might expect increasing preference with increasing experience with the task. We opened study enrollment to all interested residents and there was likely some self-selection bias. However it is not directly clear how this bias would alter the generalizability of our results. Finally, the EM residents at our institution use ultrasound extensively in their training. Their comfort with US might not reflect other training sites where it is used less frequently.

CONCLUSION

For EM residents learning UGNBs, we found the HN technique was similar to the HS technique for superior needle control. The HS technique may represent an attractive alternative in emergency settings. Using a brief tutorial and a low fidelity, low cost, partial-task simulator, EM residents were able to complete both simple and difficult simulated UGNBs.

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