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Original Research

Defining a Theory-Driven Ultrasound Curriculum for Prehospital Providers

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ABSTRACT

Advances in point-of-care ultrasound technology have allowed for the extension of emergency medicine ultrasound beyond the walls of the emergency department. Emergency medical system providers may benefit from the use of ultrasound. It has previously been shown that with a brief introductory course, novices can obtain and correctly interpret focused ultrasound examinations. The purpose of this study was to design a theory-driven point-of-care ultrasound curriculum to assess and develop ultrasound skill in prehospital providers. The resultant curriculum outlined in this paper encompasses a large array of skills that may be useful for different prehospital services to use to develop curriculum for their own needs.

Point-of-care ultrasound (POCUS) is increasingly integral to the practice of emergency medicine.[1] Advances in portable ultrasound technology allow for an extension of the practice of emergency medicine beyond the walls of the hospital. Multiple studies suggest that emergency ultrasound performed by physicians in the prehospital setting can affect clinical decision making and patient care.[2-4] However, only a small fraction of emergency medical systems (EMS) in North America use ultrasound in the prehospital setting.[5]

After a brief introductory course, novices can obtain and correctly interpret focused ultrasound examinations.[7-10] Continuing education opportunities in the form of didactics and hands-on practice in the emergency department can supplement and reinforce fundamental knowledge and skills. When used by trained prehospital providers, ultrasound can improve diagnosis, management, and hospital referral.[6-8] A review of the literature produces a need for a theory-driven POCUS curriculum to facilitate improvement in clinical care.

The goal of this study was to design a theory-driven POCUS curriculum to assess and develop ultrasound skill in prehospital providers. This curriculum is meant to encompass a large array of skills but not necessarily define in entirety what each prehospital service provider should know. As such, different prehospital services may find parts of this curriculum useful for their own needs.

Methods

An expert panel was assembled via a convenience sample of multi-institutional emergency medicine physicians with either advanced ultrasound or EMS training, which included 4 attending physicians with advanced ultrasound training, 1 EMS faculty member, 1 EM resident with advanced training in ultrasound, and 1 EM resident with advanced experience in EMS. This group performed a literature review and assembled a list of specific ultrasound modalities, as well as competencies encompassing ultrasound-based diagnoses and specific technical skills and ultrasound knowledge.[1,11-13] We then used a modified Delphi technique to build consensus on core POCUS scans for prehospital providers.

The Delphi technique is a well-established theory-driven educational method that uses expert opinion to build agreement.[13,14] A questionnaire with the full list of ultrasound modalities and competencies was designed by the research team and was sent out to the expert panel via the Qualtrics online survey platform Provo, Utah. This platform is able to receive information from respondents and confidentially collect data.

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In the first round of the modified Delphi, participants were presented with each of the ultrasound modalities and competencies and rated them on a scale of how important knowledge of this skill or topic would be for prehospital providers. These were rated on a 5-point scale (1 = absolutely do not include/not important, 2 = not very important, 3= kind of important, 4 = important, and 5 = definitely include or very important). There was a comment box available after each prompt where participants could provide feedback to suggest improvements for clarity/accuracy. Participants were also asked to contribute additional prompts that they felt were important that were not included on the original list.

After the initial round, the research team pulled the results from Qualtrics and generated a detailed report that included both the score of the participant and the mean score of the group for that particular item. The mean score, mode, standard deviation, and level of agreement were generated and made available to participants. Levels of agreement were assessed for each item based on a method described by de Loe[15] that is commonly used to analyze modified Delphi results.[14,16,17] When using this methodology, a high level of agreement occurred when > 80% of the responses fell on 2 contiguous points on the 5-point scale, a medium level of agreement occurred when this was true for 70% to 80% of the responses, and a low level of agreement occurred when this was true for 70% or less of the responses. We rated items as high agreement when > 80% of responses were either a 4 or 5 and all other items as not high agreement.

The Delphi group then met to discuss the results of the first round. Members of the panel were allowed to ask questions of other members to explain their scores. Additionally, the panel proposed changes to the questionnaire, which included adding additional ultrasound competencies for consideration or alterations/clarifications in the language of existing items.

The research team made these changes and then sent the questionnaire out to the expert panel for the second round of the modified Delphi process. The expert panel filled out the revised questionnaire via Qualtrics. The research team then analyzed the data described previously and provided the results to the Delphi panel during a second meeting. All topics that had a score of at least 4.0 and a high level of agreement after the second round were included in the final curriculum. The panel then voted to include or remove items that did not achieve high agreement. All topics with > 80% votes to remove were dropped from the assessment. The items that did not achieve consensus to include nor consensus to remove after the first 2 rounds proceeded to a third round of the Delphi process.

Results

The ultrasound modalities, diagnoses, and technical skills necessary for prehospital providers as determined by the Delphi panel are presented in Supplemental Table S1. There were a total of 5 initial ultrasound modalities (cardiac, thoracic, focused assessment with sonography for trauma [FAST], aorta, and procedures) with 32 measured competencies and a total of 274 subcompetencies. After the first round, consensus with high agreement was achieved on 91 of the 274 subcompetencies, and 183 were medium or low agreement. After the second round, of the 91 items that had initially achieved high agreement in round 1, 57 achieved high agreement after round 2. The remaining 34 items were revised or went to round 3 after discussion, and 15 achieved consensus with high agreement (Fig. 1). A total of 72 subcompetencies achieved consensus with high agreement after the final 3 rounds (Table 1).

Limitations

A limitation associated with use of the Delphi method is the potential for bias. We acknowledge we were limited by the convenience sample method of choosing our expert panel. We addressed this with the size, level of training, and varied expert background of the panel to promote diverse opinions. We included participants from more than 1 institution; however, numbers were skewed toward a single provider group. In addition, we maintained a 100% response rate and provided the panel the results of the prior round to reflect on before responding for subsequent rounds.

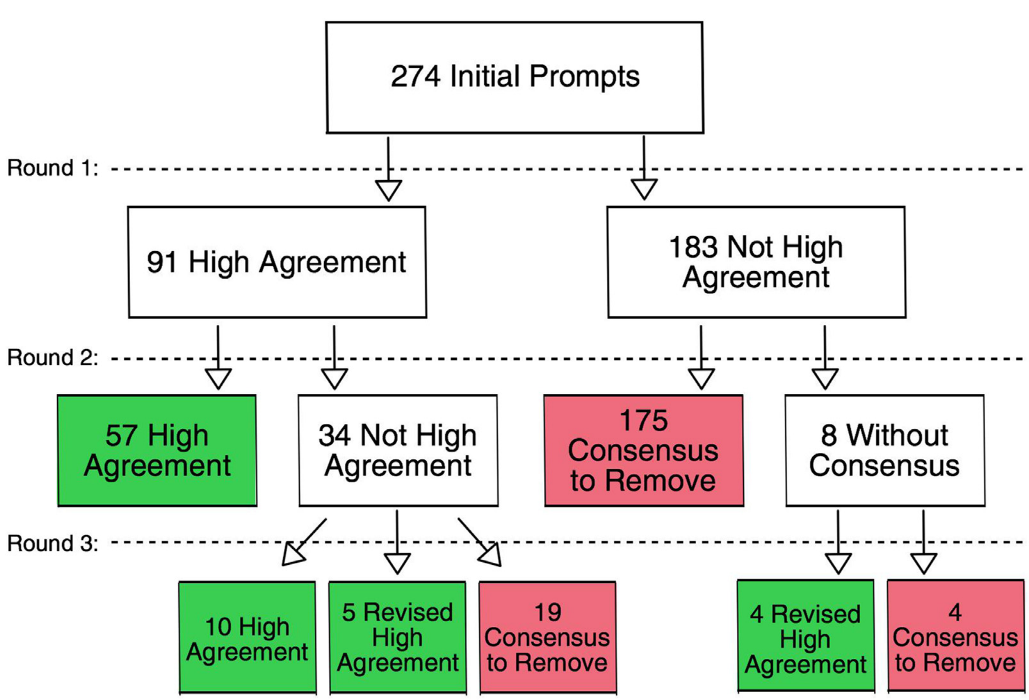

Figure 1.

Table 1
Consensus Elements for Ultrasound Curriculum

Normal anatomy subxiphoid view
Identify left ventricle (LV)
Identify right ventricle (RV)
Identify pericardium
Demonstrate parasternal long axis
Normal anatomy parasternal long axis
Identify LV
Identify RV
Normal anatomy parasternal short axis
Identify LV
Identify RV
Normal anatomy apical 4 chamber
Identify LV
Identify RV
Cardiac arrest
Describe sonographic appearance of cardiac standstill
Evaluation of gross global cardiac function
Cardiac tamponade
Demonstrate where pericardial fluid would accumulate
Describe US findings of cardiac tamponade
Right ventricular collapse
Plethoric IVC
Cannot measure proximal to hepatic veins
Describe normal IVC collapsibility
Interpret volume responsiveness in the setting of increased IVC collapsibility
Interpret volume responsive in the setting of decreased IVC collapsibility
Normal anatomy: right upper quadrant
Identify liver
Identify kidney
Identify diaphragm
Identify pouch of Morison
Normal anatomy: left upper quadrant
Uses appropriate gain
Sets depth appropriately to visualize all necessary structures
Identify spleen
Identify kidney
Identify diaphragm
Identify splenodiaphragmatic space
Identify splenorenal space
Normal anatomy pelvis
Identify bladder in the transverse plane
Identify bladder in the sagittal plane
Intra-abdominal hemorrhage
Know the potential spaces where intra-abdominal blood can accumulate
Pouch of Morison
Splenodiaphragmatic space
Splenorenal space
Pouch of Douglas in a female patient
Rectovesicular pouch in a male patient
Normal anatomy chest
Identify ribs
Identify lung pleura
Hemothorax
Demonstrate where hemothorax would accumulate
Pneumothorax
Describe appearance of pneumothorax
Loss of lung sliding
Identify anterior chest as most sensitive location for PTX evaluation
Interstitial pulmonary fluid
Describe B lines appearance
Describe B lines physiologic significance
Describe appearance of pulmonary edema on ultrasound examination
Diffuse B lines
Describe conditions that can mimic pulmonary edema
Line placement
Describe appearance of artery under US
Noncompressible
Pulsatile
Describe appearance of vein under US
Compressible
Nonpulsatile
Identify needle in short axis
Visualize needle tip entering vein

IVC = inferior vena cava; PTX = pneumothorax; US = ultrasound.

Discussion

The study started with a pool of 274 ultrasound subcompetencies, which included important ultrasound diagnoses, specific technical skills, and ultrasound knowledge prompts. The discussions during each of the rounds of the Delphi process centered on the value of achieving ultrasound skill to impact and change prehospital patient care. This included both modalities and techniques that would assist with diagnosis and management (eg, cardiac and pulmonary ultrasound for the identification of heart failure and pulmonary edema, inferior vena cava evaluation for responsiveness to fluids, and insertion of ultrasound-guided peripheral intravenous access) or would assist in-hospital preparation for the inbound patient (eg, a positive FAST examination allowing earlier mobilization of trauma team operative resources).

Several common emergency medicine ultrasound modalities were not included in the curriculum because of their failure to reliably impact and change prehospital patient care. In addition, several items that had achieved high agreement in round 1 were removed after round 2 in the context of carefully examining the role of the prehospital provider. These included items such as procedural competency in placing ultrasound-guided central lines. Ultimately, our study found consensus expert support for 72 subcompetencies to be used for the development of an ultrasound curriculum by prehospital providers. We have included a full list of the consensus elements of the prehospital POCUS curriculum.

The curriculum identified involves multiple modalities, each of which require knowledge of image acquisition, image interpretation, and troubleshooting. This is a significant amount of information and may be ambitious for many EMS in their current state given the resources and time investment required.

As stated previously, this curriculum is meant to encompass a large array of skills. Importantly, it does not define what each prehospital service provider should know in entirety. Different prehospital services may find parts of this curriculum useful for their own individual settings. For example, in urban centers with a larger relative proportion of trauma, the FAST examination to identify free fluid in the peritoneum may be more useful, whereas line placement may be less useful.

Conclusion

Our study found expert consensus for an ultrasound curriculum for POCUS use by prehospital providers. The results of the Delphi could be used to design a suitable objective structured clinical examination to evaluate providers in core ultrasound principles. Additionally, parts of this curriculum could be used to target specific areas of development for different prehospital settings depending on their interests and needs.

Supplementary materials

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.amj.2019.03.018.

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