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Research article

Brief training increases nurses' comfort using tele-ultrasound: A feasibility study

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A R T I C L E I N F O

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A B S T R A C T

Background: Nurses and other non-physician providers have demonstrated proficiency at obtaining images in the tele-ultrasound system. However, use of this skill requires comfort with the procedure and willingness to incorporate it into practice.
Objectives: To assess 1) level of comfort of non-physician providers performing tele-ultrasound before and after brief training and 2) feasibility of implementing an educational programme that improves level of comfort.
Methods: Feasibility study including a brief training session followed by hands-on tele-ultrasound. The pilot cohort performed tele-ultrasound on a healthy volunteer. The clinical cohort performed tele-ultrasound on criticalli ill patients with shock or respiratory failure. Remote intensivists provided real-time guidance via tele-medicine technology. Each participant completed a survey assessing training experience and level of comfort before and after training.
Results: Sixteen non-physician providers participated. All participants agreed that the training session prepared them for image acquisition and that the training experience was positive. The number of participants comfortable with ultrasound improved significantly (before vs. after training: 5/16 [31%] vs. 16/16 [100%], mean Likert score 2.7 vs. 4.8, $p = 0.001$).
Conclusions: After brief training, participants could comfortably perform tele-ultrasound and were more willing to incorporate it into tele-ICU-directed care. Results support conducting a larger-scale trial of tele-US to assess clinical utility.

Implications for clinical practice

- A brief training session can improve the comfort level of ultrasound-inexperienced nurses and other non-physician providers with performing point-of-care ultrasound within a tele-ICU construct.
- It is feasible that ICU nurses and other non-physician providers can perform tele-US on patients in an actual clinical setting
- Widespread incorporation of tele-US into tele-ICU-directed care can be facilitated by augmenting the comfort level of frontline providers

Introduction

The utilisation of critical care ultrasound, a type of point-of-care ultrasound (POCUS) used in the ICU, has increased in the last

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decade (Lichtenstein, 2015). It is a noninvasive, radiation-free, portable tool able to rapidly diagnose or rule out life-threatening conditions (Breitkreutz et al., 2007; Lichtenstein and Mezière, 2008; Seif et al., 2012), guide invasive procedures and assess the effects of various therapies (Kumar and Chuan, 2009). Meanwhile, because of the increasing critical care demands of an ageing population and the reduced supply of intensivists, tele-ICU programmes now support 13% of adults admitted to non-federal ICU beds, defined as beds within a hospital run by state or local government in the United States (Hawkins et al., 2016; Lilly et al., 2014). Integrating telemedicine with ultrasound enables relatively ultrasound-naïve individuals to obtain and transmit ultrasound images to remotely located experts for interpretation (Biegler et al., 2013; Boniface et al., 2011; Ferreira et al., 2015; McBeth et al., 2013; Sargsyan et al., 2005). Tele-ultrasonography (tele-US), the union of these two important technologies, may greatly enhance the ability of tele-intensivists to assist bedside providers with the care of critically ill patients.

Prior studies have shown that nurses and other non-physician providers with minimal ultrasound experience can obtain and transmit high-quality ultrasound images via tele-ICU cameras to remotely located intensivists (Levine et al., 2015; Olivieri et al., 2018). Moreover, images obtained via commercially available smartphone technology are of equal quality to those obtained via tele-ICU cameras (Levine et al., 2016a); this leaves the security of protected health information (PHI) and the cost of employing a tele-ICU model as the last barriers to be addressed before resource limited hospitals can benefit from tele-US.

Bedside nurses and other non-physician providers are a constant presence in critical care settings and are highly invested in the care of their patients, making them well suited to perform tele-US. However, successful adoption of any new technology in nursing care depends on perceptions about the relevance and ease of use of such technologies, as well as the availability of adequate training and support (de Veer et al., 2011). While the ability of these non-physician providers, including bedside nurses and other non-physician providers such as respiratory therapists, to perform POCUS has been demonstrated in prior studies (Biegler et al., 2013; Boniface et al., 2011; Levine et al., 2015; McBeth et al., 2013; Olivieri et al., 2018; Sargsyan et al., 2005), the requisite level of comfort with the procedure needed to accept it as worthwhile and incorporate it into practice has not been previously documented. This "buy-in" of frontline staff, seen as a manifestation of their comfort with tele-US, is a critical factor in determining the success of telemedicine implementation (Biegler et al., 2013; Brewster et al., 2014). Therefore, we performed a study to assess: 1) level of comfort of nurses' and other non-physician providers performing tele-ultrasound before and after brief training and 2) feasibility of implementing an educational programme that improves participants' level of comfort.

Methods

We performed an educational feasibility study with two separate cohorts of nurses and other non-physician providers. The first cohort of providers, the pilot cohort, performed tele-US on a healthy volunteer and evaluated the neck veins, lungs, heart, and bladder. The second cohort of providers, the clinical cohort, performed tele-US on real patients admitted to an ICU with shock or respiratory failure and evaluated the heart and lungs.

Objectives

Our objectives were to: 1) to assess the comfort level of nurses' and other non-physician providers performing tele-ultrasound (tele-US) before and after brief training and 2) determine the feasibility of implementing and further investigating an educational programme that improves participants' level of comfort.

Setting

The facilities and equipment of the sponsoring institution's preexisting tele-ICU programme were utilised in conducting the pilot cohort study. The clinical cohort study was performed in an 18 bed community ICU within the hospital system of the sponsoring institution. As with the pilot cohort, the facilities and equipment of the same sponsoring institution's preexisting tele-ICU programme were used for the clinical cohort study.

Ethical approval

The pilot cohort study was determined to be exempt by the Institutional Review Board (IRB) of the sponsoring institution (HP-00059371). The study protocol for the clinical cohort was approved by the IRB of the Human Research Protections Office of the sponsoring institution (HP-00070767).

Inclusion/exclusion criteria

Participants in both cohorts were recruited by word of mouth from among the staff. The only inclusion criteria was that they were a non-physician provider in an ICU setting. No specific exclusion criteria were employed for either cohort.

Pilot cohort

Participants were recruited to participate by word of mouth from among the staff of the sponsoring institution. The volunteers underwent a 20-minute didactic training session on ultrasound. The training was delivered by an internal medicine resident and included a PowerPoint slide presentation designed to address fundamental ultrasound principles such as probe handling and "knobology." Publicly available SonoSite (FUJIFILM SonoSite, Inc., Bothell, WA, USA) eLearning videos were used to augment the PowerPoint presentation and demonstrate the proper technique for acquisition of ultrasound images at the following anatomic locations: internal jugular vein, lung apices and bases, cardiac subxiphoid view, and urinary bladder. A SonoSite S-ICU™ ultrasound was used to accomplish all training and image acquisition. We constructed a remotely mentored tele-ultrasound (RTMUS) system using a simulated patient room with a mounted tele-ICU camera to visualise both the ultrasound machine and the participant. Images were viewed in real time by an intensivist monitoring the simulated patient room from a remote site using Philips monitoring software. A Philips audio-visual communication link, embedded in their ICU software system, was used to connect the remotely located intensivist with the "patient." The patient was a healthy male volunteer with a body mass index of 25 kg/m^2. The remotely located physician provided the participants with real-time guidance via the Philips two-way camera as they acquired ultrasound images at the anatomic sites reviewed during the didactic session. Both the training and data collection took place on two separate days over a two week period in October 2013.

Clinical cohort

The participants were recruited to participate by word of mouth from among the nursing staff of a community ICU associated with the sponsoring institution, and underwent a 60-minute didactic training session on ultrasound. Training occurred on three separate days over a two week period in April 2017. The training was delivered by a pulmonary and critical care medicine fellow and included a PowerPoint slide presentation designed to address fundamental ultrasound principles such as probe handling and "knobology" as well as the proper technique for acquisition of ultrasound images at the following anatomic locations: parasternal long, parasternal short, and subxiphoid for cardiac ultrasound, and the "blue points" and "posterolateral alveolar and/or pleural syndrome (PLAPS) points" for lung ultrasound as described by Lichtenstein (2015). A SonoSite X-Porte™ ultrasound was used to accomplish all training and image acquisition. The same telemedicine technology (Philips audio-visual communication link and Philips monitoring software) used for the pilot cohort was used for the clinical cohort; however, in this case, evaluation took place in an active ICU where patients are routinely monitored by a tele-ICU programme. Tele-US was performed on patients admitted to this ICU with shock or respiratory failure. Data were collected over five separate days over a six week period between June and July 2017 based on clinical availability of participants and enrolled patients. A remotely located clinical instructor, trained in pulmonary and critical care medicine, provided the participants real-time guidance via a two-way camera as they acquired ultrasound images of the heart and lungs.

Data collection

Participants in both cohorts completed an anonymous demographic form consisting of eight questions and a five-point Likert scale survey consisting of five questions describing their perception of the training experience and their comfort level obtaining POCUS images post-training (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree) (Watson, 1994). All providers in both cohorts completed this survey after performing one tele-US examination, both to standardise the experiment and to keep the burden of this study appropriate to its size.

Table 1
Demographic characteristics of participants.

Participants	Pilot Cohort N (%) = 11	Clinical Cohort N (%) = 5
Female	10 (91)	4 (80)
Training level		
RN	2 (18)	2 (40)
BSN	5 (45)	3 (60)
Nursing student	2 (18)	0
Respiratory therapist	1 (9)	0
Other	1 (9)	0
Employment location		
Medical intensive care unit	9 (82)	5 (100)
Step-down unit	1 (9)	0
Trauma intensive care unit	1 (9)	0
CCRN certification	5 (45)	4 (80)
Previous experience with US	3 (27)	1 (20)
Years of prior US experience	0.6 ± 1.5	1 ± 0.4
Years of prior nursing experience	6.7 ± 7.7	18.8 ± 4.6

Data analysis

Normally distributed data were analysed using mean and standard deviation (±) in accordance with Sullivan and Artino (2013). Categorical data were analysed using count and percentages. Student t-tests were used to calculate statistical significance between the two cohorts. The Fisher's exact test (FET) was used to calculate statistical significance between participants' Likert Scale mean scores and percentages before and after training.

Results

Eleven non-physician providers volunteered to participate in the pilot cohort of the study. The participants were overwhelmingly nurses or nursing students of various training levels, with one respiratory therapist in the pilot cohort. Additional participant demographics are represented in Table 1. All participants agreed (further defined as agreed or strongly agreed) that the training prepared them to acquire ultrasound images. All participants agreed that their experience learning basic sonography and performing ultrasound was positive. Only 27% (3/11) of participants felt comfortable with ultrasound prior to this experience, but 100% of participants (11/11) were comfortable performing bedside ultrasound, including utilising the tele-ICU infrastructure, after training (FET $p = 0.001$, Table 2).

Five ICU nurses volunteered to participate in the clinical cohort of the study. Recruitment was limited by nursing schedules and availability of training staff. All participants agreed that the training prepared them to acquire ultrasound images. All participants agreed that their experience learning basic ultrasonography and performing ultrasound was positive. Only 40% (2/5) of participants felt comfortable with ultrasound prior to this experience, but 100% of participants (5/5) were comfortable performing bedside ultrasound, including utilising the tele-ICU infrastructure, after training (FET $p = 0.17$, Table 2).

To report all nurses overall experience with using ultrasound in general, all participants agreed that the training prepared them to acquire ultrasound images. All participants agreed that their experience learning basic ultrasonography and performing ultrasound was positive. Only 31% (5/16) of participants felt comfortable with ultrasound prior to this experience, but 100% of participants (16/16) were comfortable performing bedside ultrasound, including utilising the tele-ICU infrastructure, after training (FET $p = 0.001$).

Discussion

This study demonstrated the use of RTMUS system is feasible at the bedside in an actual ICU after a brief educational programme. Additionally, basic ultrasonography training of nurses and other non-physician providers improves their comfort with using ultrasound within the tele-ICU model. Prior work employed a similar experimental model that trained ultrasound-naive individuals to acquire high-quality images in the context of tele-US (Levine et al., 2015, 2016a; Olivieri et al., 2018). These previous studies

Table 2
Participant ultrasound experience.

Question	Pilot Cohort		Clinical Cohort	
	N (%) = 11	Mean Likert Score ± SD	N (%) = 5	Mean Likert Score ± SD
Prepared to perform ultrasound given training received	11 (100%)	4.5 ± 0.5	5 (100%)	4.4 ± 0.5
Ultrasound experience considered positive	11 (100%)	5 ± 0	5 (100%)	4.8 ± 0.4
Comfortable using ultrasound prior to training	3 (27%)*	2.6 ± 1.3	2 (40%)	2.8 ± 1.8
Comfortable using bedside ultrasound after training	11 (100%)*	5 ± 0	5 (100%)	4.4 ± 0.5

* $p = 0.001$ when comparing prior to and after training.

addressed the determination of individual image quality as well as overall clinical utility of the images obtained. Importantly, however, successful evaluation and subsequent implementation of such telemedicine technologies requires the support of frontline staff, including bedside nurses and other non-physician providers (Brewster et al., 2014). Therefore, the perceptions of these providers regarding the relevance of tele-US, the ease of performing bedside ultrasonography, and the interaction with the remotely located intensivist together likely determine whether this tele-US model could be effectively tested in a real-world ICU setting (Brewster et al., 2014; Taylor et al., 2015; de Veer et al., 2011).

The present study demonstrates that a brief training session significantly improves ultrasound-inexperienced participants' level of comfort with performing tele-US. Additionally, our results support the feasibility of RTMUS image acquisition by nurses in a real-world ICU setting after implementation of an educational programme to improve their level of comfort. This study also demonstrates that while it is feasible to employ such an educational model as demonstrated in the pilot cohort, changes to that model may be required in order to fit the needs and requirements of each particular tele-ICU environment (i.e. the clinical cohort). All of the providers involved had a positive experience, felt prepared to perform ultrasound based on the training they had received, and felt comfortable using tele-US after the training. These encouraging results suggest that a larger-scale trial evaluating brief training sessions could demonstrate a positive impact on providers' level of comfort and perceptions surrounding tele-US, which may increase the likelihood that this technology, which has so much potential to improve the care of critically ill patients, is accepted and adopted. More widespread adoption of critical care ultrasound may improve patient safety by reducing the need to transport critically ill patients out of the ICU for radiologic studies, decreasing patient exposure to radiation, and improving the safety of invasive procedures. Additionally, critical care ultrasound further reduces resource utilisation and cost by replacing radiologic studies, such as routine chest X-rays (Brogi et al., 2017; Ioos et al., 2011; Zieleskiewicz et al., 2015).

In addition to its potential benefits to patient care, tele-US may improve the satisfaction and collaboration of involved providers. Participation of nurses and other non-physician providers in a collaborative tele-US model increases their involvement in clinical decision-making within the larger tele-ICU system, as well as enhance nurse-physician communication, all of which can increase job satisfaction (Iliopoulou and While, 2010; Manojlovich, 2005). Additionally, the application of non-physician provider-performed tele-US to resource-limited settings (i.e. with no 24 hour intensivist coverage) where tele-ICU is most beneficial could transform the intensive care given in these locations (Levine et al., 2016b; Robertson et al., 2017).

Limitations

This study's major limitations are its small sample size and limited participant variability. Although the participants may not have used ultrasound prior to this study, they may have been more comfortable with POCUS as a result of frequent exposure to critical care house staff routinely performing bedside ultrasound. Also, the potential for bias is present since these ICU nurses may have already believed that POCUS was an important skill that they wanted to master. Additionally, the tele-intensivist and nurse volunteers, having worked in the same ICU, were acquainted prior to the study and therefore, since the study was not blinded, the nurses may have felt a higher level of comfort because they were working with a physician that they knew and trusted. This relationship may not exist in a real-world tele-ICU clinical setting, given that the staff of the ICU and the tele-intensivist are geographically separate and often employees of different institutions.

One important implication we noted after conducting the RTMUS model with the clinical cohort was the increased "buy-in" of participants. While the use of diagnostic ultrasound by nurses and other non-physician providers at the bedside may increase provider level of comfort, the adoption of such technology into clinical practice may also add substantial time to routine bedside assessments. Thus, the benefits of employing a RTMUS model must be weighed against the time involved in performing the diagnostic study. Despite this, we believe the enhanced diagnostic capabilities offered by ultrasound may empower nurses and other non-physician providers and ultimately improve the care of their patients. Performing a larger-scale, appropriately powered trial is ultimately necessary to demonstrate proof of concept and generalisability to a more diverse group of nurses and other non-physician providers.

Conclusion

A brief training session improved the comfort level of ultrasound-inexperienced nurses and other non-physician providers with performing POCUS within a tele-ICU construct. The potential for minimal training to augment the comfort level of frontline-providers with tele-US will likely facilitate more widespread incorporation of this technology into tele-ICU-directed care. Thus, the concept of bedside nurses and other non-physician providers performing RTMUS assessments in a true to life ICU setting is feasible, and suggests a larger study is needed to demonstrate generalisability.

Contributions

Literature search: TD, AL, MM, AV; Study concept and design: MM, AL, AV; Data acquisition or interpretation of data: TD, PO, AP, MZ, AV; Drafting of the manuscript: TD, MM, PO, AV; Critical revision of manuscript: All authors; Statistical analysis: AV; Study supervision: MM, AV.

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Declarations of interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.iccn.2018.11.004.

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