

Quality of abdominal ultrasound image acquisition by novice practitioners following a minimal training session on healthy volunteers

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CLINICIAN'S CAPSULE

What is known about the topic?

Prehospital point of care ultrasound (POCUS) can aid in patient care decisions, but the ideal training regimen is unclear.

What did this study ask?

Can paramedics after a 1-hour didactic training session, generate adequate POCUS images when compared with emergency physicians.

What did this study find?

Physicians had a higher proportion of usable scans compared with paramedics (100% v. 61.4%).

Why does this study matter to clinicians?

Prehospital ultrasound is an evolving resource, but to determine a cost-effective method to train paramedics is essential.

the participant using a 5-point Likert scale and using the standardized QUICK Focused Assessment with Sonography in Trauma (FAST) assessment tool.

Results: Fourteen Critical care paramedics and four emergency department (ED) physicians were voluntarily recruited. Of paramedics, 57% had never used ultrasound before, 36% has used ultrasound without formal training, and 7% had previous training. Physicians had a higher proportion of usable scans compared with paramedics (100% v. 61.4%, Δ 38.6%; 95% confidence interval, 19.3–50.28).

Conclusions: Paramedics were not able to produce images of interpretable quality at the same frequency when compared with emergency medicine physicians. However, a 61.4% usable image rate for paramedics following a short 1-hour didactic training session is promising for future studies, which could incorporate a short hands-on tutorial while remaining cost-effective.

ABSTRACT

Background: Point of care ultrasound (POCUS) is an essential tool for physicians to guide treatment decisions in both hospital and prehospital settings. Despite the potential patient care and system utilization benefits of prehospital ultrasound, the financial burden of a “hands-on” training program for large numbers of paramedics remains a barrier to implementation. In this study, we conducted a prospective, observational, double-blinded study comparing paramedics to emergency physicians in their ability to generate usable abdominal ultrasound images after a 1-hour didactic training session.

Methods: Canadian aeromedical critical care paramedics were compared against emergency medicine physicians in their ability to generate adequate abdominal ultrasound images on five healthy volunteers. Quality of each scan was evaluated by a trained expert in POCUS who was blinded to the identity of

RÉSUMÉ

Contexte: L'échographie au chevet (EC) est un outil essentiel aux médecins : elle les guide dans les décisions relatives au traitement, et ce, en milieu tant hospitalier qu'extrahospitalier. Malgré les avantages que peut offrir l'échographie en phase préhospitalière pour les patients et les systèmes de soins de santé, le fardeau financier d'une formation pratique d'un grand nombre d'ambulanciers paramédicaux constitue un obstacle important à la mise en œuvre de la pratique. Aussi avons-nous réalisé une étude d'observation, prospective, à double insu, visant à comparer la capacité d'ambulanciers paramédicaux, avec celle d'urgentologues, à produire des images d'échographie abdominale de qualité suffisamment bonne pour être utilisables, et ce, après une séance de formation théorique de 1 heure.

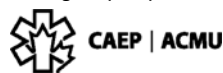
Méthode: L'étude, menée au Canada, consistait en la comparaison d'images d'échographie abdominale, quant à leur qualité

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© Canadian Association of Emergency Physicians 2020 CJEM 2020;22(Suppl 2):S74–S78

DOI 10.1017/cem.2020.29



CJEM • JCMU

2020;22 Suppl 2 S74

d'utilisation, produites par des paramédicaux en soins critiques navigants, sur 5 volontaires en bonne santé, avec celles produites par des urgentologues. La qualité de chacune des images a été évaluée par un spécialiste de l'EC tenu dans l'ignorance des participants, sur une échelle de Likert à 5 points et à l'aide de l'instrument d'évaluation normalisé QUICK FAST. **Résultats:** Ont participé à l'étude 14 paramédicaux en soins critiques et 4 urgentologues, tous volontaires. Parmi les ambulanciers paramédicaux, 57% n'avaient jamais pratiqué d'échographie, 36% avaient déjà pratiqué des échographies sans avoir reçu de formation structurée et 7% avaient déjà reçu une formation. Il est ressorti de l'étude que les médecins avaient produit un plus grand nombre d'images utilisables que les

ambulanciers paramédicaux (100% contre 61,4%; écart : 38,6%; IC à 95% : 19,3–50,28).

Conclusion: Les ambulanciers paramédicaux n'ont pas produit d'images de qualité suffisamment bonne pour être interprétables aussi souvent que les urgentologues. Toutefois, le fait que 61,4% des images produites par les ambulanciers paramédicaux étaient utilisables, et ce, après seulement une petite heure de formation théorique, laisse croire qu'il serait à la fois possible et rentable d'intégrer une courte formation pratique à l'aide d'un didacticiel dans des études futures.

Keywords: Prehospital / EMS, ultrasound, emergency medicine

INTRODUCTION

Point of care ultrasound (POCUS) is an essential tool for physicians to guide treatment decisions in both hospital and prehospital settings. The potential benefits of POCUS are well established for the extended Focused Assessment with Sonography in Trauma (eFAST), which identifies conditions such as hemoperitoneum, pneumothorax, cardiac standstill, and cardiac tamponade.^{1,2} Identifying these conditions can assist prehospital systems to triage patients, direct patients to appropriate treatment facilities, and decrease the time to activate important health care services.^{3,4} Currently, the applications of ultrasound by Emergency Medical Services are primarily used by countries where physicians are part of the prehospital team.⁵ In Canada, POCUS is beginning to be incorporated in the prehospital setting to help direct patient care, and studies are being performed to determine the best use of POCUS. A recent study by O'Dochartaigh et al. has found that patients with a high shock index from either medical or traumatic causes specifically benefit from the use of prehospital POCUS through improved triaging of patients in the field.⁶

Despite the potential patient care and system use benefits of prehospital ultrasound, the financial burden of an intensive "hands-on" training program for large numbers of paramedics remains a barrier to implementation. Currently, there is no consensus in the literature for the optimal training regimen for paramedics who are novice ultrasound users.^{7,8} Studies typically incorporate a combination of "hands-on" and didactic training sessions to teach paramedics how to perform eFAST exams. Determining the balance between cost and effectiveness of

training regimens is essential before implementing POCUS into large prehospital systems. In this study, we conducted a prospective, observational double-blinded study comparing paramedics to emergency physicians in their ability to generate usable abdominal ultrasound images after a 1-hour didactic training session.

METHODS

Study design

A prospective, observational, double-blinded study was conducted in which Canadian aeromedical critical care paramedics were compared against emergency medicine physicians (staff and residents) in their ability to generate adequate abdominal ultrasound images on five healthy volunteers after a 1-hour didactic training course. The trial used one ultrasound system (Philips Lumify S4-1 broadband phased array 4-1 MHz transducer) for all scans performed in this study.

Study setting

The training sessions and all scanning of volunteers took place at the Middlesex-London Paramedic Services Headquarters in London, Ontario, Canada.

Population

A letter asking for volunteers from the critical care paramedic contingent at two Orange Air Ambulance bases

(London and Toronto) was circulated through Ornge Management. Only travel expenses were covered. Five healthy volunteers were recruited by means of email to participate in this study from the general population. The volunteers were not compensated for their participation. Four emergency medicine physicians were recruited from a major academic health sciences center (London Health Sciences Centre), and formed the physician group. Physicians were not compensated for their participation. One day for training and ultrasound scanning was selected and occurred on May 21, 2019.

Intervention

A standardized 1-hour didactic training course was taught to all paramedics and emergency staff. The training course consisted of an introduction to the ultrasound system, including how to turn on the system, how to position the probe, and how to change gain and depth settings on the ultrasound device. The training then focused on identifying anatomic and ultrasonographic landmarks necessary for performing an appropriate abdominal ultrasound exam. The three areas of focus were the hepatorenal space, splenorenal space, and the retrovesicular/retrouterine pouch in the pelvis. The didactic session also included training for identifying signs of intraperitoneal free fluid.

Outcome measures

The primary outcome of this study was to determine if paramedics could produce usable scans after a 1-hour didactic training session. Overall quality of each scan was evaluated by a trained expert in POCUS who was blinded to the identity of the participant using a 5-point Likert scale from “Very Poor” to “Very Good.” Scans that were “Very Good,” “Good,” and “Average,” were considered to be usable for determining if the scan could be positive or negative for free fluid. Scans deemed “Poor” or “Very Poor” were considered unusable. Images were evaluated using the standardized QUICK FAST assessment tool.⁹ This tool was chosen as it outlines the important features in each anatomic area for this study. The components of the QUICK FAST assessment tool are outlined in the online Appendix 1.

Total assessment tool scores for each area were calculated and compared between paramedic and physician participants using standard t-tests.

Secondary outcomes included the time each participant required to complete the scans. This time was measured by an observing member of the research team and calculated from when the participant first grasped the probe to when the participant stated they had completed image acquisition.

Data analysis

All time outcomes were reported as means, standard deviations, and 95% confidence intervals (CIs) and were compared between groups using standard t-test. Overall proportion of usable scans was compared between paramedics and physicians and reported using the difference with 95% confidence intervals (CIs). All data analyses were completed using SPSS version 23.

RESULTS

Fourteen Critical care paramedics and four ED physicians (two staff physicians and two residents) were voluntarily recruited. The critical care paramedics were mostly ultrasound-naïve, whereas the emergency physicians all had ultrasound training. Of paramedic participants, 57% had never used ultrasound before, 36% has used ultrasound without formal training, and 7% had previous ultrasound training. Physicians had a higher proportion of usable scans compared with paramedics (100% versus 61.4%, $\Delta 38.6\%$; 95% CI, 19.3–50.28) (Table 1). When measuring average time to completion of each abdominal ultrasound scan, there was a statistically significant difference between emergency physicians compared with paramedics (2.91 minutes v. 5.24 minutes; $\Delta 2.33$ 95% CI, 1.01–3.64; $p = 0.002$).

DISCUSSION

Although novice ultrasound practitioners were not able to produce equivalent quality images at the same frequency as emergency physicians after a short didactic training, this was expected as paramedics have less overall ultrasound training and exposure than their physician counterparts. Of the scans obtained by paramedics, 61.4% were deemed to be of usable quality. Considering the very short training session, we consider this to be a positive outcome. Furthermore, we believe the number of usable scans could be improved with the addition of

Table 1. Comparison of scan quality by operator

		Novice user scans n(%)	"Expert" scans n(%)	
Scan quality				
Usable	Very good	11 (15.7)	17 (85.0)	$\Delta 38.57$ 95% CI 19.33–50.28
	Good	15 (21.4)	0 (0.00)	
	Average	17 (24.3)	3 (15.0)	
Unusable	Poor	19 (27.1)	0 (0.00)	
	Very poor	8 (11.4)	0 (0.00)	
Scores by region				
	Novice mean score† (SD)	"Expert" mean score† (SD)	Mean difference (95% CI)	P
Right upper quadrant	21.07 (5.28)	29.50 (0.58)	$\Delta 8.43$ (2.70–14.16)	$p = 0.007$
Left upper quadrant	17.43 (7.44)	29.0 (0.00)	$\Delta 11.57$ (3.50–19.64)	$p = 0.008$
Pelvis	17.00 (7.49)	22.75 (8.46)	$\Delta 5.75$ (-3.48–14.98)	$p = 0.205$

further hands-on training and/or real time feedback by experienced providers.

Our study adds to the body of literature examining the optimal ultrasound training regimen for paramedics as this training was conducted with live patients and, therefore, more indicative of real-world utility of ultrasound application(s) in the prehospital setting. In a study by Heegaard et al., 40 paramedics used ultrasound to obtain and interpret FAST and abdominal aortic ultrasound images on live patients in the field after a 6-hour training course.¹⁰ They found that only 7.7% of scans obtained in their study were deemed unusable by the blinded physician reviewer. This was significantly lower than what was found in our study. This difference could be in part due to differing methodologies as paramedics had a more extensive initial training session (3 hours of hands-on ultrasound training) and two 1-hour refresher training courses over the 1-year period during which the images were collected.

Recent studies have evaluated novel means to improve ultrasound image quality and interpretation with minimal training. Boniface et al. had 51 ultrasound naive paramedics undergo a 20-minute training program. A subsequent POCUS assessment on a live volunteer with a remote emergency physician providing real-time feedback by means of radio guiding image acquisition during the FAST examination resulted in success rates of 100% for obtaining adequate images.¹¹ Additionally, it was found that, under emergency medicine physician guidance, paramedics could obtain a complete FAST exam in 4.36 minutes. When compared with our study, paramedics required an average time of 5.24 minutes. Differences in methodology and the benefit of physician

guidance not only demonstrated a difference in scanning time but also that paramedics can produce usable scans efficiently.

Studies have also found that the presence of intra-abdominal fluid aids in the accurate interpretation and acquisition of images in FAST exams.¹² A study by Kim et al. trained six emergency medical technicians with 2 hours of didactic teaching and 2 hours of hands-on training. Patients that were scanned had already undergone abdominal CT imaging. Ultrasound images were interpreted by the emergency medical technicians and compared with radiology reports from CT scans. Sensitivity was 61.3% and specificity was 96.3% for the detection of peritoneal cavity fluid. However, they found that inpatients with large amounts of peritoneal fluid, the emergency medical technician ultrasound sensitivity improved significantly (86.2%). Given that none of the volunteers in our study had intraperitoneal free fluid, it is possible that generating adequate high-quality images could have been more challenging.

LIMITATIONS

The main limitation of our study is the ability to apply our findings to the field use of ultrasound technology for paramedics. Paramedics and emergency physicians were instructed to take as much time as needed to identify the anatomic areas of interest and then save representative images, which were then evaluated by our blinded expert reviewer. This process does not reflect real-world circumstances. Our live human volunteer patients also

did not have free fluid within their abdomen, so we are unable to comment as to the ability of paramedics to interpret the images they obtained or their ability to identify free fluid. We had a relatively small sample of both paramedics and emergency medicine physicians, making this difficult to determine if our findings would apply to the broader population.

CONCLUSION

This study aimed to determine if paramedics could generate usable ultrasound images after a short 1-hour didactic-only training session. Paramedics were not able to produce images of interpretable quality at the same frequency when compared with emergency medicine physicians. However, a 61.4% usable image rate for paramedics following a short 1-hour didactic training session is promising for future studies that could incorporate a short hands-on tutorial while remaining cost-effective. Further studies examining the optimal training time and modality, as well as utility of remote ultrasound technology, are needed to determine the optimal use of prehospital ultrasound in Ontario.

Supplemental material: The supplemental material for this article can be found at <https://doi.org/10.1017/cem.2020.29>.

Acknowledgments: This study was approved by the Western Health Science Research Ethics Board.

Competing interests: None.

Financial support: None.

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