Research:
Emergency medicine residents’ acquisition of POCUS knowledge

Review:
Paramedic POCUS, Turning Our Heads to the Prehospital Side of the Fence:

Case Report:
When all claims that it is necrotizing fasciitis but Point of care ultrasound (POCUS) proves the opposite!

POCUS to FOCUS

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Emergency medicine residents’ acquisition of point-of-care ultrasound knowledge and their satisfaction with the flipped classroom andragogy

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Abstract

Background: One of the traditional approaches for knowledge transfer in medical education is through face-to-face (F2F) teaching. We aimed to evaluate the acquisition of knowledge about point-of-care ultrasound (POCUS) and learner’s satisfaction with the flipped classroom (FC) teaching approach. Methods: This was a prospective, mixed-method, crossover study and included 29 emergency medicine (EM) residents in current training program. Over a period of three months, each resident was exposed to F2F and FC teaching models in a crossover manner. There was a multiple-choice questions (MCQ) test before and after each educational intervention (F2F & FC). Two months after each educational intervention a final MCQ test was administered to assess the retention of knowledge between the two approaches. After each educational approach feedback was sought from a selected group of residents concerning the acceptability of the two educational approaches through a semi structured interview. Results: A total of 29 EM residents participated in this study. The numbers of residents by year of post-graduation training were seven (24.14%) PGY-1, eight (27.59%) PGY-2, six (20.69%) PGY-3, and eight (27.59%) PGY-4. The baseline mean score was 15.82 using MCQs test mean scores. For the face-to-face teaching model, the difference between pre and post-intervention scores was 2.7 (95% CI 2.1 to 3.3, p=0.001); whereas, for the flipped classroom teaching model, the difference was 3.93 (95% CI 3.2 to 4.5, p=0.001). At two months post-intervention, for face-to-face teaching model, the MCQ assessment showed an increase of 1.7 (95% CI 1.1 to 2.2, p=0.001) mean scores when compared to the pre-intervention mean scores; whereas, for the flipped classroom model this difference was significantly higher, recorded as 4.48 (95% CI 3.7 to 5.1, p=0.001). Finally, the difference between mean scores for F2F and FC teaching models was 2.75 (95% CI 1.87 to 3.64, p=0.001) at two months post-intervention. Overall, the participants expressed a preference for the FC teaching methodology. Conclusion: Both F2F and FC teaching methods resulted in significant and sustained improvements in POCUS knowledge base. The FC teaching method accomplished higher test scores than the F2F teaching method both at the end of the teaching and after two months of completing the educational program.

Introduction

Point-of-care ultrasound (POCUS) is an extremely useful skill set for emergency physicians in rapid identification of pathologies at bedside [1]. Emergency medicine (EM) has a long history of teaching and training residents in bedside ultrasound teaching. POCUS has become an extended part of medical examination for the emergency physician. The Accreditation Council for Medical Education (ACGME) milestones project recognizes POCUS as one of the core skills included in emergency procedures list [1].

The effective instructional teaching strategies include active, passive and mixed learning. Active learning encourages the learners to understand the educational material, partake in the educational session and work together with colleagues and the faculty [2-4]. The traditional POCUS teaching of EM residents is delivered through didactics followed by demonstration of POCUS skills and subsequent completion of a logbook while working in clinical areas under the supervision of faculty. The didactic teaching is usually considered as a one-way transmission of information from the lecturer to the students. The students then assimilate and apply this knowledge outside the lecture-room environment. The lecturing approach in delivering knowledge seems to be a popular approach among millennial learners, followed by learning through collaborative learning and learning by doing [5-7].

Lately, the flipped classroom (FC) has become a popular method of delivering knowledge. Two essential components of the FC are access to online educational material and a face to face component [8]. It could be argued that the FC could be the reverse of the traditional face-to-face (F2F) classroom method of teaching. However, in the FC the learners develop additional understanding about the topic through watching videos, podcasts or interactive lecture slides online before the didactic teaching. The F2F component of the FC is utilized to understand the topic further and clarify any misconceptions or ambiguities with the help of the faculty [8]. The FC is increasingly being used in medical education with successful outcomes in improving knowledge [9]. In addition to medicine, other allied specialties such as pharmacy and clinical epidemiology have also utilized the FC method of teaching [10, 11]. However, the usefulness of the FC has been questioned by a few studies in assessing students’ satisfaction in learning neuroanatomy [12], and in nursing
Table 1. Summary and comparison of the test scores at a different time periods.

<table>
<thead>
<tr>
<th>Serial no</th>
<th>Variable</th>
<th>MCQ mean score difference</th>
<th>95% Confidence Interval</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Comparing PostF2F V PreF2F</td>
<td>2.72</td>
<td>2.14 to 3.29</td>
<td>0.001</td>
</tr>
<tr>
<td>2</td>
<td>Comparing PostFC V PreFC</td>
<td>3.93</td>
<td>3.29 to 4.56</td>
<td>0.001</td>
</tr>
<tr>
<td>3</td>
<td>Comparing PostF2F2months V PreF2F</td>
<td>1.72</td>
<td>1.16 to 2.29</td>
<td>0.001</td>
</tr>
<tr>
<td>4</td>
<td>Comparing PostFC2months V PreFC</td>
<td>4.48</td>
<td>3.77 to 5.19</td>
<td>0.001</td>
</tr>
<tr>
<td>8</td>
<td>Comparing PostFC2months VPostF2F2months V</td>
<td>2.75</td>
<td>1.87 to 3.64</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Pref2F – MCQ Test conducted before the F2F; PrefC- MCQ Test conducted before the FC; Posttest F2F – MCQ Test conducted immediately after F2F; Posttest FC – MCQ Test conducted immediately after FC; PostF2F2months – MCQ Test conducted after two months of F2F; PostF2F2months – MCQ Test conducted after two months of FC.

students groups [13]. In addition, there is a lack of evidence regarding teaching POCUS through FC in the assessment of common EM indications such as Abdominal Aortic Aneurysm (AAA), cardiac POCUS in arrest situations, and Extended Focused Assessment with Sonography for Trauma (E-FAST).

The aim of this study was to assess knowledge acquisition of POCUS by EM residents by FC teaching in comparison to the F2F model. The secondary aim was to evaluate the learner satisfaction with FC and the F2F model in learning POCUS.

Methods

Subjects and Settings

Our EM residency training is a four-year program, accredited by ACGME- International (ACGEM-I), and had 39 residents in training at the time of this study. It is a teaching hospital, and POCUS teaching faculty are available on the shop floor on a 24/7 basis. The first POCUS teaching session and MCQ test was attended by 29 residents. Although remaining POCUS teaching sessions were attended by more residents, only those 29 who attended the first session were included in the analysis.

Design and data collection

Between January and March 2017, a total of five teaching conferences were delivered on different aspects of point-of-care ultrasound. Three of those sessions were delivered using the F2F didactic teaching approach, while two sessions were delivered as FC approach. The F2F approach consisted of our traditional PowerPoint (Microsoft Corporation, Chicago, IL, USA) format through a projector and some discussion towards the end. The FC slides were prepared including embedded links to short videos and self-assessment questions to stimulate learning. The online educational material and learning objectives was sent three days before the didactic part of FC session. The didactic part of FC session lasted 45 minutes and was dedicated to answering any queries and clarifying the concepts.

The same MCQ test was administered before and after each educational approach to reduce bias. The first test (Pretest) was administered before any educational intervention and covered various aspects of POCUS knowledge in the above-mentioned subject areas. Result range was between 0 and 25 since there were 25 items on this test (and on all tests given in this study). Next, all residents underwent standard face-to-face (F2F) teaching on distinct subunits within POCUS knowledge areas. In a few weeks, when this F2F teaching was finished, the residents took a test assessing the POCUS knowledge subset that had been covered in the F2F lectures. This test administered immediately after the F2F teaching was coded as the PostF2F test. The same groups of residents were exposed to the second educational intervention i.e. (FC). All of the residents underwent FC teaching on distinct POCUS knowledge areas that were different from those covered by F2F approach. In a few weeks, when FC was finished, the residents took a test assessing the POCUS knowledge subset that had been covered in the FC. This test, administered immediately after the FC, was coded as the PostFC test. Approximately 2 months after the educational interventions (F2F lectures and FC lectures) the residents underwent final MCQ tests assessing the material that had been presented in the F2F and FC approaches. (PostF2F2months & PostFC2months).

After each educational approach feedback was sought from selected group of six residents concerning the appropriateness of the two educational approaches through a brief ten minutes semi structured interview. Different residents participated in the two interviews. The free text comments were written down by one study author.
The data were collected in Microsoft Excel sheet for Mac 2013 (Microsoft Corporation, Redmond, WA.) The Shapiro-Wilk test was used to assess the distributions of test scores. The data was normally distributed and presented as mean (Standard deviation). Analyses were conducted with STATA 14 MP, with significance defined at p 0.05 and confidence intervals (CIs) reported at the 95% level. Thematic analysis was used to describe the comments written during semistructured structured interviews.

Results

A total of 29 residents participated in each educational intervention (F2F & FC). There were nine females (31.03%) and twenty males (68.97%) participants. The number of residents by year of post-graduation training were seven (24.14%) PGY-1, eight (27.59%) PGY-2, six (20.69%) PGY-3, and eight (27.59%) PGY-4. The PostF2F score improvement from PreF2F was 2.7 points with a 95% confidence interval (CI) of 2.1 to 3.3 points (P value 0.001), whereas PostFC score improvement from PreFC was 3.93 points with 95% confidence interval (CI) 3.2 to 4.5 (P value 0.001). Similarly PostF2F2months from PreF2F showed an improvement of 1.7 points with 95% confidence interval (CI) 1.1 to 2.2 (P value of 0.001). PostFC2months score improvement from preFC was 4.48 points with 95% confidence interval (CI) 3.7 to 5.1 (P value of 0.001). The PostFC2months and the postF2F2months showed a mean score of 1 with 95% confidence interval (CI) 0.71 to 1.2 (P value of 0.001). The PostFC score improvement from postF2F was 1.20 points with 95% confidence interval (CI) 0.37 to 2.04 (P value of 0.001). Finally, comparing the PostFC2months score improvement from PostF2F2months was 2.75 points with 95% confidence interval (CI) 1.87 to 3.64 (P value of 0.001) (Table 1).

On average, the residents spent 15 – 60 minutes at home for the online part of FC sessions. Comments were invited from the residents after each educational intervention (Table 2). Residents remarked that the lecture was “interesting in the beginning” but later became “boring” due to the length of the lecture hence preferred “shorter lectures”. Residents commented that they were more attentive, and learned more during FC session and expressed a preference to have teaching through the FC methodology. The residents felt that FC teaching was “very stimulating”, “engaging throughout”, they were able to inquire further about the topic, remained alert during the educational session, and “retained most of the educational material”. The also suggested a preference for FC teaching approach for future medical education.

Discussion

This study was designed to assess acquisition of POCUS knowledge through two educational approaches. Both educational approaches (F2F and FC) resulted in improving the knowledge of POCUS among the residents. The improvement in the acquisition of knowledge continued at two months post intervention assessment. FC educational approach resulted in statistically enhanced retention of knowledge both immediately and at two months. Generally the residents felt encouraged to learn through FC methodology as compared to the traditional F2F classroom teaching.

There are several possible reasons for the effectiveness of FC as compared to traditional F2F in acquisition of knowledge related to POCUS. Firstly, FC appears to offer bespoke study approach in which residents have liberty and flexibility to study before the shared teaching session [14]. Secondly, the attention span in a lecture attends to be low, usually 10-20 minutes from the beginning of the lecture [15]. Thirdly, the residents had the liberty of accessing other relevant websites to develop deeper understanding of the topics before attending the classroom which is usually not possible in the didactics. Fourthly, the residents in the flipped classroom actually spend more time in acquiring the knowledge as compared to F2F teaching. Our findings of enhanced knowledge acquisition and retention through FC methodology are consistent with previous studies [16, 17].

In our study of the FC approach, the residents expressed greater engagement, more satisfaction, decreased boredom and active involvement during the didactic component of the FC methodology. The residents felt that in FC
approach, they were able to retain more information and this was reflected in the results of the MCQ test scores, immediately and at 2 months. Our study results are similar to the results of higher satisfaction reported in the radiology teaching for medical students undergoing the FC teaching approach [18]. An increasing number of educational institutions outside medicine have been utilizing FC approach of teaching with successful outcomes [19, 20].

We have identified several limitations to this study. The sample size was small. Only twenty nine residents from one teaching hospital participated. Our FC approach may not be generalizable as each FC approach is dependent on the needs of the learners, faculty preferences and locally available resources. However the present study was conducted in the largest teaching hospital in the country. There was no randomization in the selection of study population. The FC method required additional work for the residents at home which ranged between 15-60 minutes. We have only assessed the acquisition of theoretical knowledge and not its translation into clinical skills. However, it could be argued that neither FC nor the traditional F2F teaching approaches may be best suitable for attaining POCUS skills. MCQ tests were used for the assessment and retention of knowledge. For the evaluation of critical and higher level thinking skills as described by Blooms taxonomy, the assessment should have included short answers, and coursework which would involve additional work for the residents and faculty [21].

In spite of the limitations in our study, FC appears to be a popular method in acquisition and retention of knowledge related to different aspects of POCUS. We recommend future studies utilizing the FC approach to evaluate the acquisition of knowledge and skills related to POCUS. The future studies should include outcomes based on Kirkpatrick’s classification of higher level thinking measures—perception, attitude and alteration in knowledge and skill sets.

Conclusion

Both F2F and FC teaching methods resulted in significant and sustained improvements in POCUS knowledge. The FC teaching method was associated with even more improvement than the F2F teaching method, as assessed both at the conclusion of the teaching and after two months of completing the educational program. While there are potential confounders (e.g. the order of teaching methods was not randomized), the results strongly support movement to a FC teaching for at least some material; the FC approach is certainly no worse, and appears significantly better, than traditional F2F teaching. Residents appear to have a preference for FC method of instruction (Table 2).

References

Paramedic POCUS, Turning Our Heads to the Prehospital Side of the Fence: A Narrative Review of Education, Training and Future Direction

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Background
Portable ultrasound is a burgeoning technology with unrealized potential at a critical point in its evolution [1]. Francis Galton first generated ultrasound waves in 1876; however, it wasn’t until 1940 that ultrasound was first applied to clinical medicine [2]. Reaching a “tipping point”, ultrasound is being rapidly assimilated into many medical specialties beyond radiology, now in the hands of non-radiologist, non-cardiologist novel users [2]. Diagnostic medical ultrasound has been widely incorporated into emergency departments since the early 1980’s; however, machine size and cost has limited its use to the hospital setting [3]. The democratization of ultrasound to paramedicine could alter clinical decision-making, improve time to perioperative care, and enhance triage capabilities [1-3]. An augmented ultrasound physical examination would allow for treasurable clinical findings otherwise unobtainable to paramedics, revolutionizing prehospital medicine in a manner that is unprecedented by other tools in the arsenal of emergent care.

Demands on the healthcare system are rapidly increasing due to population age and growth, igniting an increased reliance on paramedics to carry out assessments and treatments traditionally performed by physicians [4]. Unlike the controlled environment of the emergency department or operating room, a paramedic work ecosystem can be described as austere, subject to immense variability in setting, lighting, and noise [5]. Workspaces range broadly from an ambulance or helicopter to an elevator, staircase, curbside, grocery store aisle, or living room floor [5]. Prehospital providers formulate diagnoses based on impartial information with no access to medical records [5]. Auscultation is one of the few assessments available to paramedics; however, it is difficult to perform in the back of a moving ambulance or on a crowded street [5]. The diagnostic potency of ultrasound, its portability, and ease of use are well-suited features for translation to the unpredictable arena of prehospital medicine [6]. Despite these benefits, ultrasound use in paramedic services across North America has been estimated to be as little as 4.1% [7].

If portable ultrasound was originally intended as an advent of military triage in resource limited settings, why has it failed to become an integral part of paramedic practice [1, 6]? The first emergency ultrasound curriculum was introduced by Mateer et al. in 1994, and has since entered the core curriculum required for residency in emergency medicine [2]. Paramedicine has not yet seen the same integration of ultrasound into teaching curriculums, despite the fact that hand held ultrasound (HHU), as previously mentioned, was arguably designed for out-of-hospital use [1, 6]. The primary objective of this narrative review is to provide insight into the paramedic scope of practice and structure of paramedic services in Ontario. The second objective is to review the literature describing paramedic education in goal directed ultrasound in the following three clinical contexts: focused assessment sonography in trauma (FAST), pneumothorax, and cardiac standstill.

Structure of Paramedic Services
The origin of paramedicine is highly unique. Evolving out of the mortician industry, spanning a 40-year lifespan, prehospital medicine has undergone enormous transformation in both structure and practice [8]. Currently, in Ontario, paramedics work for one or more of 51 municipally run paramedic services regulated under the Ambulance Act (1990) [8]. Ontario has 8 Base Hospital Programs (BHP) which operate as extensions of the Ministry of Health and Long Term Care (MOHLTC) [8].

Seven base hospital programs provide medical direction to land ambulance services, while one base hospital oversees air ambulance utilization [8]. With the exclusion of Saskatchewan, New Brunswick, Alberta, and Nova Scotia, paramedics across Canada are not self-regulated health care professionals [8]. Therefore, all paramedics in Ontario operate under the medical license of their respective base hospital physicians [8]. In Canada,
Paramedics treat and/or transport approximately 2 million patients annually, while in the United States patient contacts are between 25 and 30 million [5].

**Paramedic Scope of Practice**

In Canada, paramedic skill sets are variable by service, region, and province. Training or accreditation is partitioned into three levels of care in Ontario: primary care paramedic (PCP), advanced care paramedic (ACP), and critical care paramedic (CCP) [9, 10]. There is an emerging fourth tier of non-emergent care in the community setting, still in a state of development in Canada, commonly referred to as extended care paramedics (ECP) or community paramedics (CP) [4, 9].

The PCP level requires a two-year community college program and successful completion of a provincial examination, the Advanced Emergency Medical Care Assistant (A-EMCA) [9]. PCPs can administer 10 symptom relief medications, including epinephrine, diphenhydramine, dimenhydrinate, salbutamol, acetylsalicylic acid, acetaminophen, ibuprofen, ketorolac, nitroglycerin, and naloxone through oral, intra-nasal, nebulized, intramuscular, and intravenous routes [9]. PCPs perform 12-lead electrocardiographic interpretations and initiate hospital bypass protocols for acute STEMI (ST elevation myocardial infarction), ischemic stroke, burns, and trauma [9]. PCPs also provide basic life support care through oxygen therapy, ETCO2 monitoring, cardiopulmonary resuscitation, manual defibrillation, and are trained in bag-valve-mask ventilation and insertion of supra-glottic airways [9].

Advanced care paramedics (ACP) undergo an additional year of didactic, in-hospital, and in-field training [9]. ACPs can administer medications through all routes described above, as well as intraosseous, endotracheal, and external jugular sites [9]. ACPs perform orotracheal and nasotracheal intubation, needle thoracotomy, and synchronized cardioversion, and external transcutaneous cardiac pacing [4, 9]. Advanced care paramedics administer narcotics, antiarrhythmic agents, and inotropes [4, 9].

While PCPs and ACPs work predominately in land ambulance services, critical care paramedics (CCP) have an additional two years of didactic, clinical, and preceptorship training to work in fixed and rotary wing aircrafts [9, 10]. Functioning as a mobile intensive care unit, CCPs have a very extensive pharmacological scope; they also administer blood and blood products [9]. CCPs perform tasks such as interpreting CT-scans of the head and chest X-rays, monitoring intra-aortic balloon pumps, pulmonary artery, central venous, and arterial lines, as well as performing lab value and blood gas analyses [9]. Community paramedics (CP) are often ACPs with new competencies facilitating assessment and treatment of minor injuries and chronic illness surveillance, though the role and aims of CPs are tailored to the needs of each individual community [4]. CPs commonly treat patients at home and in long-term care facilities. They also provide referrals to more appropriate resources within the community in attempt to offset emergency department congestion and EMS call volume [4, 11, 12]. Evolving well beyond stabilization and transport, paramedics are an integral link in the chain of care, providing on-the-spot diagnosis and intervention for a wide range of clinical conditions and maladies [4, 5, 9].

**POCUS in Paramedic Services**

Understanding paramedic use of ultrasound is challenging, since the majority of paramedic POCUS literature is limited to physician run aeromedical emergency services comprising diverse teams of physicians, flight nurses, and sonographers [3, 13]. Prehospital ultrasound is more commonly found in Europe, described in literature of physician-run emergency services in Germany, France and Italy [3, 14]. European prehospital medical providers spend more prolonged periods of time managing and treating patients when compared to their North American counterparts [3]. In North America, paramedic services place a heavy focus on rapid transport times and limiting on scene time, which may explain the slower adoption of ultrasound into prehospital algorithms of care [3]. Throughout Canada, there are currently no published studies on the use of ultrasound in land ambulance services.

**Focused Assessment Sonography in Trauma (FAST)**

Abdominal and pelvic injuries are a major cause of early death after severe trauma [13]. The FAST exam is a goal directed sonographic assessment of intraperitoneal and pericardial spaces for free fluid whereas the EFAST exam also includes evaluation of pleural spaces [13]. Numerous studies have evaluated the training requirements of physician performed FAST ultrasound assessments; however, far fewer studies have given considerable attention to curricula for teaching paramedics FAST and EFAST exams [1, 6, 13, 15, 16, 17-29]. It is reasonable to hypothesize that paramedics with less training may require more extensive educational programs than physicians to perform ultrasound assessments such as the FAST exam.

Educational programs for FAST exams tailored to
Paramedics have ranged widely from four hours over one day to 13 hours over two months of training, with most curricula using a one-day or weekend course [25]. Heegard et al. enrolled 116 paramedics to learn FAST and abdominal aortic ultrasound assessments [17, 25]. The course consisted of a six-hour didactic and practical component with two one-hour refresher courses at three and eight months following the initiation of the course [17, 25]. Over the course of the study, 104 patients were scanned during ground transport and 84 received a full paramedic performed FAST exam [17, 25]. The mean duration to perform the exam was 156 seconds, paramedics were unable to acquire images in as few as 7.7% of patients, and with 100% agreement between paramedic and physician scans [17, 25].

Walcher et al. utilized five anesthetists and four paramedics in a one-day didactic and hands on course using healthy human volunteers and patients with peritoneal dialysis or ascites [25, 26]. Throughout the study, 39 FAST exams were performed in the field and the mean duration of the exam was 174 seconds with both a sensitivity (Sn) and specificity (Sp) of 100% [25, 26]. Computed Tomography (CT) served as the gold standard used to compare paramedic ultrasound findings [25, 26].

Kim et al. trained six level 1 emergency medical technicians (EMT’s) on FAST in a two-hour didactic and two-hour practical training program performed on EMT volunteers [25, 27]. A convenience sample of 240 patients receiving abdominal CT within 24 hours of FAST exams was utilized and the abdominal CT served as an evaluative benchmark [25, 27]. The duration of the FAST exam performed by EMTs was 124.9 seconds, Sn was 61.3% and Sp was 96.3% for the detection of peritoneal cavity fluid, while positive predictive value was 89.1% and negative predictive value was 83.2% [25, 27].

Press et al. trained 33 paramedics and nurses to perform extended FAST exams (FAST and pleural assessments) on consenting in-flight trauma patients. Training consisted of three hours didactic and eight hours practical over a two-month period [13, 25]. In addition, the course utilized pocket flashcards, six Internet based modules, an experiential scan on the helicopter, a one-hour review session, written tests, and an objective structure clinical examination (OSCE) [13, 25]. Course design was unique in its longitudinal scope and multi-faceted approach blending both traditional and Internet based training [13, 25]. Out of 33 paramedics, 27 passed OSCE on first assessment and the remaining six passed after a four-hour remedial session [13, 25].

Unluer et al. conducted a study using four senior paramedics, involving a four-hour didactic and four-hour practical training program for FAST to detect free fluid in the peritoneum of 127 patients admitted to the emergency department following trauma [25, 29]. The exam was performed in less than four minutes, with a Sn of 84.62% and Sp of 97.37%, compared to the gold standard of ultrasound and computerized abdominal tomography (CAT) scan interpretation by radiologists [25, 29].

The sensitivities of paramedic performed FAST exams ranged from 61.3% to 100%, and specificities ranged from 96.3% to 100% [25]. The duration of FAST examination was variable, with a mean time between 124.9 seconds to less than four minutes [25]. These studies demonstrate that with a combination of didactic and practical education, FAST can be effectively taught to paramedics in as little as a one-day course to reach a specificity greater than 96% [25]. A study involving physicians evaluating peritoneal free fluid without identifying parenchymal organ pathology yielded similar results in a one day course, achieving a specificity of 99% [28]. Paramedics perform the FAST exam with comparable accuracy to that of the results from condensed training curricula for physicians, disproving the notion that paramedics require more extensive training to acquire the same skills.

Studies investigating differences in acquisition and retention of FAST skills between paramedics and physicians may be of value to inform and shape clinical practice guidelines. To date, there are only scant studies available which compare the performance of FAST exams by paramedics across different levels of care, regions, or countries. It is currently not known if the results of these studies are generalizable to other settings.

**Pneumothorax**

Prehospital detection of a pneumothorax is currently limited to auscultation and pertinent physical examination findings such as paradoxical chest rise and fall [30]. The sensitivity of auscultating breath sounds to diagnose a pneumothorax is cited to be as low as 58% in the hospital setting and is imaginably even lower in the prehospital setting [30]. If correctly identified, tension pneumothorax is a life-threatening condition treatable prior to arrival at the emergency department by means of needle decompression [30]. Pleural ultrasound, for the detection of a pneumothorax, has been taught to paramedics in a shorter time than the FAST exam, in as little as 10 minutes, achieving a Sn of 82% and Sp of 94% [25].
A systematic review by McCallum et al. described six studies of paramedic pleural ultrasound training [25]. Between four and 33 paramedics participated in the studies, possessing varying levels of training from EMT to advanced and critical care paramedics [25]. The majority of the studies utilized the absence of sonographic lung sliding (SLS) as the sole marker of pneumothorax [13, 25, 30, 32-35]. The highest Sn (97%) was achieved in a study by Lyon et al, which utilized a 25-minute didactic and practical training model on a cadaver [25, 32]. Conversely, the study yielding the least favorable results was a 75-minute curriculum by Roline et al, wherein only 54% of lung ultrasound images were deemed adequate for interpretation [25, 33].

Preliminary studies have suggested image acquisition and interpretation are independent skills, meaning acquiring an image of diagnostic quality does not necessarily mean the paramedic can adequately interpret the image [25]. More in-depth studies combining acquisition and interpretation have used training curricula that ranged between 25 minutes and 10 hours [25]. The most comprehensive paramedic training program for lung sliding incorporated three markers of pneumothorax: SLS, comet tail artifact and stratosphere signs [25, 34]. This study had the lowest Sn (81%) and Sp (85%); however, paramedics still achieved a sensitivity and specificity comparable with sonographer over-reads [25, 34]. One study conducted a follow up assessment nine months post training, demonstrating skill maintenance of 100% sensitivity and specificity [25, 32]. Two studies described successful application of pleural ultrasound in the field, although no outcome data on patient care is available [32, 35].

The aforementioned studies suggest pleural ultrasound, for the detection of pneumothorax, can be effectively taught to paramedics of varying levels with minimal time investment [25, 30, 32-35]. Discussed elsewhere, pleural ultrasound may have additional application in the field, such as hemothorax, pleural effusion, pneumonia, as well as assisting in the diagnosis of various acute on chronic pulmonary conditions [31, 36].

Ultrasound in Cardiac Standstill

Despite various reviews showcasing cardiac ultrasound to differentiate various etiologies of shock, very few discuss the ability for paramedics to assess only cardiac standstill [25]. Patients in a pulseless electrical activity (PEA) account for up to 30% of out-of-hospital cardiac arrest victims [37]. Both the European and American ACLS guidelines stress the significance of identifying and treating reversible causes of PEA [37-40]. In the prehospital setting, paramedics do not have the capacity to visualize cardiac kinesis, which would, for example, allow the differentiation between true PEA (TPEA) and pseudo PEA (PPEA) [3]. Patients without cardiac standstill have a significantly higher likelihood of survival than patients with cardiac standstill [37]. Equipping paramedics with a mechanical lens to view cardiac activity could improve survival rate in the TPEA and PPEA cardiac arrest subset by informing decisions to continue or cease in-field resuscitation efforts [3, 25].

For paramedics to identify cardiac standstill they must be proficient in both cardiac ultrasound image acquisition and interpretation. A prospective educational interventional pilot study by Chin et al. demonstrated 20 paramedics in Houston, Texas had difficulty acquiring cardiac ultrasound images in a one-hour didactic and one-hour hands-on practical training session [30]. Images were scored on a six-point scale, the Cardiac Ultrasound Structural Assessment Scale (CUSAS), developed by Backlund et al. [30, 41]. All paramedics achieved a CUSAS score of three, which required partial ventricular visualization [30]. However, an “adequate image” required a CUSAS score of six and only 11 out of 20 paramedics (55%) were able to obtain passing scores [30]. Views of the heart were acquired in less than 10 seconds for 16 paramedics, one paramedic took approximately 90 seconds, and others ranged between 10-25 seconds [30]. Throughout the study, no observations were made on difficulty of particular cardiac windows over others or long term retention [30].

Chin et al. demonstrated that paramedics had less difficulty interpreting cardiac standstill on prerecorded ultrasound images than acquiring sonographic cardiac views [30]. There was no association between image acquisition and recognition given just over half of the paramedics achieved passing CUSAS scores, yet the average scores for image recognition was high, 9.1 out of 10 [30]. This study also evaluated lung ultrasound for the detection of a pneumothorax, recording the time it took paramedics to obtain clear views of the pleural line [30]. When comparing lung and cardiac acquisition skills, paramedics obtained views of the pleural lines more quickly than cardiac views, (<5 sec vs. 10-25 sec), which suggests cardiac scanning might be more nuanced than pleural ultrasound [30].

Rooney et al. performed a small prospective educational study on cardiac standstill detection with four paramedics after a three-hour training session [42]. Training consisted of two hours of didactic training and one hour hands-on training of the subxiphoid, apical four chamber and left
parasternal long axis view on human subjects [42]. For a scan to be judged as adequate, a minimum score of four on a six-point structural assessment scale was required [42]. Nineteen patients were enrolled in the study, but two exams were excluded as they were deemed inadequate for interpretation [43]. Paramedics were able to accurately record 17 cases of cardiac activity and two cases of cardiac standstill [42]. The study results showed 89% of paramedics were successful in obtaining cardiac POCUS images and 100% were able to differentiate between cardiac activity from cardiac standstill [42].

To date, there is no standardized training delineating optimal length and modality of curricula for novel users of cardiac POCUS to achieve and maintain a high level of competency [42, 43]. Emphasis on a number of proctored scans to acquire competency can deter from the need to innovatively blend traditional and non-traditional components of effective training curriculums [13]. A state of the art review of educational curricula of cardiac POCUS in undergraduate medical training cited similar challenges to those described with paramedic education of cardiac ultrasound [43]. In both cohorts of paramedics and undergraduate medical students, scanning the heart accordingly was a more readily absorbable skill than interpreting cardiac ultrasound images [30, 42, 43].

Future Direction

The point of care does not begin in the emergency department, but rather prior to arrival at the hospital in the prehospital setting. In-hospital and prehospital medicine are two sides of the same coin; though head and tail can be discussed separately, they cannot be separated but viewed instead as a dual continuum in a patient’s journey [44]. Prehospital ultrasound not only augments the physical examination but also provides a chronological map of patient condition to inform in-hospital management and serves as a potential reference point in the event of patient deterioration [15]. As the Canadian Patient Safety Institute asserts, patients ‘depend on many people doing the right thing at the right time’ and they depend on a ‘system of care’, which requires continuous collaboration between healthcare providers [45].

Technological innovation commonly outpaces evidence and there are numerous barriers that can impede the process of acquiring that evidence. Although training curricula on paramedic ultrasound remains heterogeneous, and robust outcome data is yet to be generated, existing literature discussed herein supports ultrasound use by paramedics. Despite numerous applications of paramedic POCUS, usage of ultrasound in the prehospital setting remains surprisingly low [7]. A cross-sectional survey of emergency medical services directors across North America indicate the most significant barrier was cost of equipment and training (89.4% of 255 respondents) [7]. Cost benefit analyses on ultrasound usage would be a valuable contribution to inform paramedic services on decisions surrounding implementation [7, 46]. Other prevalent barriers to implementation include high variability in the level of training of paramedic users and restrictions of time a paramedic can spend with a patient [7, 46]. Constraints of time are a defining feature that distinguishes the Anglo-American from Franco-German models of emergency medical services [46, 47]. As previously stated, paramedic services in North America follow the Anglo-American model, which aims to keep on scene, transport and transfer of care times to a minimum [46, 47]. The type of emergency medical model in place is an important factor to consider when discussing potential alterations to prehospital interventions and practices [46]. It is possible that the starting point for successfully implementing POCUS in paramedicine in Canada may be in the community setting. Being a predominantly non-transported patient demographic, reflecting an evolution towards the Franco-German model of emergency prehospital care, paramedics can spend more time performing additional assessments with their patients [46, 47]. Although it is not yet a standard of care, paramedics across all levels of training have demonstrated proficiency in acquiring POCUS skills with brief training periods in both traumatic and non-traumatic patient populations. Challenges in skill acquisition and retention are not insurmountable. Systematic approaches to non-physician training are in order to ensure quality assurance is given sufficiently high priority [15]. A plethora of ultrasound exams not described in this review also possess potential for implementation in the prehospital setting. Some of these exams include rapid ultrasound for shock and hypotension (RUSH), ultrasound for shock, trauma and resuscitation (USTAR), and POCUS for fracture identification [48]. The FAST exam often dominates discussions on prehospital ultrasound use; however, the highest yield of paramedic POCUS may lay in under-examined, non-traumatic patient populations [49]. More rigorous academic investigation produced by multi-disciplinary teams of experts and novel users is required to determine if paramedic POCUS can ultimately effect clinical decision making and improve patient outcome.
References:


41. Backlund B, Bonnett C, Faragher J, et al. Pilot study to determine the feasibility of training Army National Guard medics to perform


Case Report

When all claims that it is necrotizing fasciitis but Point of care ultrasound (POCUS) proves the opposite!

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Introduction

Soft tissue ultrasound (ST-USS) has been shown to be of utmost importance in assessing patients with soft tissue infections in the emergency department or critical care unit. It aids in guiding the management of soft tissue infection based on the sonographic findings. In this case report, all clinical and biochemical parameters were in favour of the diagnosis of necrotizing fasciitis, however, Point of Care ultrasound (PoCUS) of the soft tissue did not show any features suggestive of necrotizing fasciitis. This was confirmed by the intraoperative findings of healthy intact fascia.

Case presentation

A 24-year-old female of African descent, presented to the Rashid Hospital Trauma Center with a complaint of painful right leg swelling of one week duration. The patient looked ill and was somnolent. She was febrile (38.2°C), and tachycardic (110 bpm). Local examination of the leg showed cellulitis changes with multiple blisters and necrotic patches (Figure 1). Laboratory tests showed leukocytosis of 14.4 $10^3/\mu L$ (3.6-11 $10^3/\mu L$), Hb 14.1 g/dL (11-15 g/dL), hyponatraemia of 125 mmol/L (136-145 mmol/L), CRP 560.9 mg/L (0.3-5 mg/L) and procalcitonin 50.6 ng/mL (more than 10 ng/mL represents a high likelihood of severe sepsis).

Urgent surgical consultation was obtained and broad-spectrum antibiotics were initiated. Soft tissue ultrasound was performed by linear probe and showed superficial cellulitis with no fascial thickening nor sub-fascial fluid (clean fascia sign, Figure 2). However, due to clinical suspicion, the patient was referred for urgent surgical debridement for possible necrotizing fasciitis. Intraoperative findings were only positive for a superficial inflammatory process and the fascia was found to be healthy and intact. The patient was labelled as a case of complicated

Figure 1. Cellulitis changes with multiple blisters and necrotic patches.
erysipelas and managed with daily dressing and antibiotics. The patient improved over a period of 2 weeks and was discharged home successfully.

**Discussion**

ST-USS has both diagnostic and therapeutic implications when used in the emergency department. It aids in differentiating abscesses from cellulitis and identifying necrotizing fasciitis in clinically suspected cases of soft tissue infections [1]. Clinical evaluation tends to be incorrect in 25-50% of cases. ST-USS may decrease unnecessary incision and drainage procedures [2].

In necrotizing fasciitis, there tends to be sonographic features such as thickened fascia, gas shadows, supra- and sub-facial fluid collections (dirty fascia sign) [3]. This helps in guiding early diagnosis and recognition of such cases to prompt surgical intervention.

**Conclusion**

This case demonstrates the utility of soft tissue ultrasound to have advantages over clinical and biochemical markers in the diagnosis necrotizing fasciitis.

**References**


Visit the online article to view additional content from this case: pocusjournal.com/article/2018-03-01p13-14
Introduction

Point of care ultrasound (POCUS) plays an important role in the Emergency Department or in any Critical Care Unit. In our case, we present how a POCUS mnemonic guided us in diagnosing two fatal conditions in a single case.

Case presentation

An 82-year-old male patient presented to our emergency with a syncopal attack; triage vital signs were BP 112/67 mmHg, HR 167 beats per minute (irregularly irregular), RR 18/min, SPO2 97%, temperature 36.3°C. The patient was transferred to a resuscitation room. ECG showed rapid atrial fibrillation (AF, online Figure S1). As the onset of AF was uncertain, rate control therapy was initiated. The patient was asymptomatic except for mild abdominal pain. The patient's laboratory results revealed: D-dimer 3.89 mg/L (normal level <0.5 mg/L), serum Lactate 7.3 mmol/L (0.5 - 2.2 mmol/L), troponin T 0.21 ng/ml (between 0.1-2.0 ng/mL is high risk for this lab suggesting myocardial damage), cardiac Pro-BNP 8290 pg/ml (<125). These lab results were suggested a critical underlying pathology. With the onset of AF and elevated D-dimer, the differential included pulmonary embolism. However, the patient denied having any breathing difficulty or chest pain, and had no clinical signs of deep vein thrombosis (DVT). The patient maintained oxygen saturation at room air (>95%). Differential included mesenteric ischemia from an acute embolic event given the high lactate and abdominal pain.

We utilized the ACUTE mnemonic [1] to help us in the evaluation of patients presenting with an acute abdomen (Table 1). Using a curvilinear probe we scanned the Abdominal Aorta, Inferior vena cava, and assessed for per-

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<tr>
<th>Table 1. ACUTE ABDOMEN mnemonic (Part A) for critical causes of acute abdomen.</th>
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Figure 1. Dilated small bowel loop 3 cm, thickened bowel loops 3 mm wall thickness with free fluid. * free fluid
forated viscus, free fluid in the abdomen, and ectopic pregnancy using the ACUTE mnemonic. The only positive finding in our patient was free fluid in right upper quadrant and pelvic area with a dilated small bowel loop 3 cm, thickened bowel loops 3 mm wall thickness (Figure 1). Therefore, the next plan of action was to perform a CT abdomen with contrast to evaluate for mesenteric ischemia.

Meanwhile, the patient became hypotensive with a blood pressure of 75/45mmHg, sinus tachycardia (spontaneously converted) and hypoxia. Resuscitation was initiated in our patient while we went back to POCUS to look for causes of hypotension by using the LOW BP mnemonic [2] (Table 2). A curvilinear probe was used for this scan for lung, cardiac, IVC, AA, and free fluid; and a linear probe was used for the DVT scan. The scan was negative except for free fluid in the abdomen (previous finding) and positive for DVT in the right femoral vein (Figure 2). We then planned to include a pulmonary angiogram to rule out pulmonary embolism.

The CT scan showed left side pulmonary embolism at the level of the bifurcation of the left main pulmonary artery extending into the lower lobe segmental branches (Figure 3), perforated viscus (Figure 4), and prostate mass (Figure 5). The patient was referred to surgical, medical, urology, and the cardiology teams. The patient was transferred to the operating room for exploratory laparotomy with intra-operative findings of perforation of the 2nd part of the duodenum. The patient was admitted to the surgical ICU and his condition improved gradually; enoxaparin was started. After 15 days, the patient was discharged from hospital.

Discussion
The use of POCUS is becoming widely established as a standard of care within Emergency and Intensive Care Departments. It is a safe, non-invasive tool, used as an extension of our clinical examinations; which can help answer focused questions and rule in or rule out life-threatening diagnoses rapidly. LOW BP and ACUTE ABDO MEN both are new mnemonics, specially designed to

Table 2. LOW BP mnemonic for undifferentiated shock evaluation.

| L | Lung | Pulmonary embolism: |
|   |   | RV strain. Abnormal RV is equal or more in size to LV |
|   |   | Cardiogenic shock: |
|   |   | Reduce LV contractility or Poor EF |
|   |   | Pericardial tamponade: |
|   |   | hypoechoic fluid collection around the heart. |
|   |   | Hypovolemia: |
|   |   | collapsed chamber, hyper dynamic LV |
| o | Cardiac Output | Hypovolemic and distributive shocks: |
|   |   | IVC < 1.5cm, collapsing >50% on inspiration |
|   |   | Obstructive and cardiogenic shocks: |
|   |   | IVC > 2.5cm, collapsing less than 50% |
| w | Water ( IVC ) | Leaking AAA? |
|   |   | Intraperitoneal hypoechoic fluid. Aortic aneurysm > 3cm. |
|   |   | Intraperitoneal free fluid? |
|   |   | Pleural effusion? |
|   |   | loss of mirror image of liver/spleen at Rt/Lt diaphragmatic areas |
| B | Blood in cavity (FAST,AAA and pleural space) | Ectopic pregnancy and Pipes |
|   |   | Ectopic pregnancy: |
|   |   | intraperitoneal hypoechoic fluid, empty uterus or extra-uterine gestational sac |
|   |   | DVT: |
|   |   | non compressible veins, direct clot visualization |

Figure 2. Right femoral vein incompressible, with absent Doppler flow in femoral vein confirmed DVT.

Figure 3. CT pulmonary angiogram showed left side pulmonary embolism.
Table 3. ACUTE ABDOMEN mnemonic (Part B) for other surgical causes of acute abdomen.

<table>
<thead>
<tr>
<th>A</th>
<th>Appendicitis</th>
<th>Non-compressible blind loop, with diameter of &gt; 6 mm, with or without appendicolith.</th>
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<tbody>
<tr>
<td>B</td>
<td>Biliary tract</td>
<td>Gallbladder stone, sonographic murphy, dilated common bile duct, thickened anterior wall of gallbladder, pericholecystic fluid.</td>
</tr>
<tr>
<td>D</td>
<td>Distended bowel loop</td>
<td>Dilated small bowel loop &gt; 3 cm · Decrease bowel peristalsis</td>
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<tr>
<td>O</td>
<td>Obstructive uropathy</td>
<td>Hydronephrosis, absent ureteral jet.</td>
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<tr>
<td>M</td>
<td>Men: testicular torsion</td>
<td>Hypoechoic testis compare to normal, Reduce or no perfusion.</td>
</tr>
<tr>
<td>E</td>
<td>Women: ovarian torsion</td>
<td>Adnexal mass &gt;4cm, Pelvic free fluid or Reduced blood flow on Doppler.</td>
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address critical emergency approach of ABC (Airway, Breathing then Circulation). In the LOW BP mnemonic (Figure 5), it starts with causes of shock attributed to the ‘Breathing’ part of ABC, with letter L symbolizing Lung consisting of Pneumothorax and Pulmonary Edema. This is followed by the ‘Circulatory’ causes of shock composed of Cardiac output, IVC, Free fluid, AAA, pregnancy, DVT and PE. On the other hand, ACUTE ABDOMEN (Table 3) begins with the most critical cause: Abdominal Aortic Aneurysm. Other surgical causes of acute abdomen are listed in "ABDOMEN" as part of the mnemonic (Table 3): Appendicitis, biliary tract disease, distended bowel loop, obstructive uropathy, Men: testicular torsion, and Women: ovarian torsion. Moreover, our mnemonics exhibit certain characteristics that make them easy to remember, such as they follow an anatomical approach and each mnemonic title represents the problem it is designed to address.

Conclusion

POCUS played a prominent role in the management and decision making process for this patient and a lot of other patients. Having an algorithmic approach with the ACUTE ABDOMEN, and LOW BP mnemonics will help Emergency Physicians or any Critical Care Physician rule out serious conditions that can be easily missed.

References:

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