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Use of Handheld Versus Standard Ultrasound Devices in Ultrasound Rotation at the Emergency Department

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Abstract

BACKGROUND: Recently, handheld ultrasound equipment has come to replace standard machines in the training of emergency medicine residents. However, there have been few studies examining how this change has affected medical education.

AIM: We aimed to compare standard and handheld ultrasound machines as educational tools in the emergency medicine residency program.

METHODS: A cross-sectional survey of 17 emergency medicine residents at Srinagarind Hospital emergency department were trained to use point-of-care ultrasound and provided with handheld ultrasound devices during their 2-week ultrasound rotations, which took place between July 2019 and May 2020. Participants were given a 25-question survey comparing their learning experiences with standard versus handheld ultrasound machines. Data were analyzed using an independent sample t-test, and $p < 0.05$ was considered statistically significant.

RESULTS: The response rate was 100%. At the baseline survey, most participants rated their learning experience as greater than 4 out of 5 with both ultrasound devices. They rated the learning experience with the handheld device as being more enjoyable and accessible but not to a statistically significant extent. There were also no significant differences in participants' ratings of image quality or the ease of obtaining images. However, they rated the handheld device as being more useful and convenient ($p < 0.001$ and 0.034, respectively).

CONCLUSIONS: The handheld ultrasound machine is useful in the training of emergency medicine residents. Further studies should be conducted to evaluate residents' competency in using these devices.

Introduction

Point-of-care ultrasound (POCUS) is an essential procedure in the emergency department that aids in diagnosis and in performing (particularly invasive) emergency procedures. The use of ultrasound is currently part of residency training in many medical schools. In emergency medicine, POCUS is a core competency in terms of both training and practice.

However, POCUS education depends on the availability of instruments and experts to act as supervisors [1], [2]. Most medical schools with curricula that include POCUS training use standard ultrasound machines, as they tend to produce higher-quality images and have higher ultrasound function. However, these machines can be prohibitively expensive for some programs. Due to its low cost, small size, portability, and suitability for bedside procedures, the handheld ultrasound is now commonly used in emergency departments [2], [3], [4].

In Thailand, however, the handheld ultrasound is a novel technology and there have been no studies examining its use in the training of emergency medicine residents. In this study, we aimed to compare the training experiences of emergency medical residents using handheld versus standard ultrasound machines.

Methods

Study design

This was a cross-sectional, single-center, and analytical study in a tertiary university hospital in Thailand. Ethical approval was provided by the Khon Kaen University Ethics Committee for Human Research, and the study was registered with the Thai Clinical Trials Registry (HE631274).

Participants

Emergency medicine residents at the Khon Kaen University Faculty of Medicine Emergency Medicine Department on their ultrasound rotation

were enrolled to this study. No monetary incentive was provided. Written informed consent was obtained from each participant before enrollment.

Sample size

We included all emergency medicine residents on their ultrasound rotation between July 2019 and May 2020.

Ultrasound curriculum

The ultrasound curriculum at the Khon Kaen University Emergency Medicine Department was first introduced in July 2019 as part of the program for 1st-year residents (however, non-1st-year residents may also choose to participate). It consists of a 2-week rotation at the emergency department, during which we provide instruction in the use of both handheld and standard ultrasound machines. Residents also train in bedside ultrasound with a supervisor who is a specialist in POCUS, the journal club, reviewing of ultrasound images, topics included a basic introduction to ultrasound technology, cardiac, lung, abdomen, inferior vena cava (IVC), aorta, and ultrasound protocols such as FAST examination, RUSH protocol, and CASA protocol.

Ultrasound equipment

The handheld ultrasound machine used was the Butterfly IQ (2D array, 9000 micro-machined sensors, USA). Images can be obtained in B, M, color Doppler, and power Doppler mode. Presets include cardiac, cardiac deep, abdomen, abdomen deep, aorta and gall bladder, lung, FAST, vascular, musculoskeletal, nerve, obstetric, small organ, and pediatric.

The standard ultrasound machine was the Mindray M9, which is the model we use in the emergency department. Images can be obtained in B, M, color Doppler, and power Doppler mode. In addition, there are more cardiac ultrasound functions such as Tissue Doppler Imaging. We provided curvilinear, linear, and phased array probes.

The evaluation

During their 2-week ultrasound rotation, the participants trained using both standard and handheld machines. At the end of their rotation, they took a self-administered using a 5-point Likert scale via Google Forms. An email containing a link to the survey was sent to each participant. The survey consisted of 25 questions about participants' experiences using the two devices. The survey and collected data were host by emergency medicine department. To ensure anonymity, yet allow contact with non-responders, each participant was given access to a personalized but de-identified online survey. Two email reminders were sent to non-responders over a period of 1 week to encourage survey completion.

The primary outcome of this study was participants' experience using the handheld versus standard ultrasound in their training.

Statistical analysis

Mean Likert scale values and standard deviations (SDs) for each electronic survey response were used to represent overall participant agreement. Participant perceptions were presented as frequencies with percentages. Responses were summarized into five categories to reflect agreement: Strongly agree (5), agree (4), neutral (neither agree nor disagree) (3), disagree (2), and strongly disagree (1). An independent sample t-test was used for statistical comparisons, with two-tailed $p < 0.05$ being considered statistically significant. All data analyses were performed using Stata version 10.1 (StataCorp, College Station, TX).

Results

During the period from July 2019 to May 2020, we had a total of 17 first (n = 7), second (n = 5), and 3rd year (n = 5) emergency medicine residents on ultrasound rotation, 52.94% (n = 9) of whom were male. The average number of scans was 5–10 times/week/person (Table 1). The response rate was 100% (n = 17).

Table 1: Participant characteristics

Characteristics	n (%)
Sex	
Male	9 (52.94)
Female	8 (47.06)
Year of residency	
1st-year	7 (41.18)
2nd-year	5 (29.41)
3rd-year	5 (29.41)
Number of scans per week per person	
5–10	6 (35.29)
11–15	6 (35.29)
16–20	0 (0)
21–25	4 (23.53)
>25	1 (5.88)

We asked participants to rate their enjoyment of the experience, its accessibility, their improvement with regard to scanning ability and image interpretation, the usefulness of ultrasound rotation (short learning experience), and the usefulness of the emergency medicine residency program (longitudinal learning experience). Agreement was high across all items in with regard to both the handheld and standard ultrasound devices (mean score >4). Participants rated the handheld ultrasound as being more enjoyable and accessible but not to a statistically significant extent (Table 2).

Participants were also asked to rate the ease of obtaining images and image quality with each

Table 2: Likert scores pertaining to learning experience in each device

Learning experience	Likert score, Mean ± SD		p-value
	Standard us	Handheld us	
Enjoyable	4.53 ± 0.72	4.76 ± 0.42	0.259
Accessible	4.59 ± 0.71	4.82 ± 0.38	0.244
Improved scanning ability	4.82 ± 0.39	4.76 ± 0.55	0.726
Improved image interpretation ability	4.71 ± 0.59	4.71 ± 0.46	>0.999
Usefulness as part of a short learning experience	4.82 ± 0.39	4.88 ± 0.32	0.641
Usefulness in longitudinal learning	4.71 ± 0.59	4.71 ± 0.46	>0.999

SD: Standard deviation.

device in each of eight views: cardiac, lung, abdomen, kidney and urinary bladder (KUB), obstetrics and gynecology, soft tissue, vascular, aorta, and IVC. Participants rated the standard ultrasound machine higher in terms of ease of obtaining most cardiac views, except for the apical four-chamber view. However, they rated the ease of the handheld device higher for assessing soft tissue and vascular views, though this difference was not statistically significant (Table 3).

Table 3: Likert scores pertaining to ease of obtaining images in each device

Ultrasound views	Ease of obtaining image Likert score; Mean ± SD		p-value
	Standard us	Handheld us	
Cardiac			
PSLX view	3.71 ± 0.69	3.53 ± 0.78	0.495
PSX view	3.47 ± 0.62	3.35 ± 0.76	0.632
Subcostal view	3.53 ± 0.85	3.24 ± 0.73	0.301
Apical four chamber view	2.76 ± 0.64	3.18 ± 0.62	0.074
Abdomen	3.94 ± 0.93	3.94 ± 0.73	>0.999
Lung	3.94 ± 0.87	3.88 ± 0.68	0.833
OB-GYN	3.29 ± 0.67	3.24 ± 0.55	0.786
KUB	3.76 ± 0.81	3.65 ± 0.59	0.641
Soft tissue	3.47 ± 0.78	3.82 ± 0.78	0.210
Vascular	3.12 ± 0.76	3.65 ± 0.90	0.082
Aorta and IVC	3.65 ± 0.76	3.65 ± 0.59	>0.999

SD: Standard deviation, KUB: Kidney and urinary bladder, OB-GYN: Obstetrics and gynecology, IVC: Inferior vena cava, PSLX: Parasternal long axis, PSX: Parasternal short axis.

In terms of image quality, participants rated the standard device higher for cardiac views and the handheld device higher for soft tissue and vascular views. However, these differences were not statistically significant (Table 4).

Table 4: Likert scores pertaining to image quality in each device

Ultrasound views	Image quality Likert score; Mean ± SD		p-value
	Standard us	Handheld us	
Cardiac	3.82 ± 0.78	3.71 ± 0.57	0.631
Abdomen	4.06 ± 0.80	4.06 ± 0.80	>0.999
Lung	4.06 ± 0.80	4.18 ± 0.78	0.678
OB-GYN	3.47 ± 0.78	3.65 ± 0.84	0.540
KUB	3.94 ± 0.80	3.94 ± 0.73	>0.999
Soft tissue	3.88 ± 0.68	4.12 ± 0.83	0.386
Vascular	3.88 ± 0.83	4.00 ± 0.77	0.680
Aorta and IVC	4.00 ± 0.91	4.00 ± 0.77	>0.999

SD: Standard deviation, KUB: Kidney and urinary bladder, OB-GYN: Obstetrics and gynecology, IVC: Inferior vena cava.

In terms of the device qualification, the handheld device scored higher in all areas. Moreover, the handheld device was rated significantly higher in terms of convenience in bedside procedures and usefulness to the patient (Table 5).

Table 5: Likert scores pertaining to device qualification

Device qualification	Likert score; Mean ± SD		p-value
	Standard us	Handheld us	
Ease of use	4.18 ± 0.73	4.41 ± 0.49	0.282
Convenience	3.94 ± 0.81	4.53 ± 0.70	0.034
Usefulness for the patient	3.82 ± 0.86	4.82 ± 0.38	<0.001

SD: Standard deviation

Discussion

This study found no significant difference between handheld standard ultrasound machines in terms of the learning experience. Nevertheless, participants rated the handheld device as being easy to access and enjoyable. This is consistent with the results of a study of Galusko *et al*. [5], which found teaching medical students the basics of ultrasound using novel handheld devices to be feasible and effective. It is likely that the size and portability of the devices made learning in a crowded emergency department easier. Both short- and long-term learning scores for the two devices were similar in our study. However, a study by Ireson *et al*. [6] conducted in 1st-year anatomy students found that the handheld device was easy to use and beneficial for insonation training as a part of the longitudinal learning experience across all school years.

Participants in our study rated the standard ultrasound as easier in terms of both obtaining cardiac images and cardiac image quality. Previous studies [7], [8], [9], [10], [11], [12] have reported high levels of confidence in using the handheld ultrasound device to obtain cardiac images, even after short training sessions but did not report on image quality. The handheld ultrasound we used in this study has only one transducer to obtain all image views, which was wider than the standard echocardiography probe, making it difficult to access the patient's rib space to obtain an image. The handheld ultrasound, however, received higher scores for soft tissue and vascular images in terms of both ease and quality. Most studies about vascular ultrasound focused on ultrasound-guided peripheral intravenous access, for which they recommended a handheld device [13], [14], [15], [16]. They did not, however, report on ease of obtaining images or image quality.

Participants rated the handheld ultrasound as being useful and convenient. This was consistent with a study by Shokoohi *et al*. [17], which found that 70% of clinical educators reported using POCUS very frequently or often in aiding diagnosis, 45% used POCUS frequently or often in determining treatment, 31% used POCUS in monitoring the clinical course of patients, and 16% reported frequent use of POCUS for the procedural applications.

This was the first study to examine the use of handheld ultrasound devices in an emergency medicine residency ultrasound rotation. It was limited in that we had only one handheld device, meaning that these findings may not be generalizable to other types/brands. Another limitation was the small sample size [18], [19], [20], [21], [22], which was due to limitations in the number of teachers, ultrasound devices, and residents on this rotation.

Conclusion

These findings suggest that handheld ultrasound devices can be beneficial as learning tools for emergency medicine residents. Participants enjoyed the learning experience and felt that these devices were useful for patients and made it convenient to perform the procedure.

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