


Status and perception of point-of-care ultrasound education in Korean medical schools

A national cross-sectional study

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Abstract

As point-of-care ultrasound (POCUS) is increasingly being used in clinical settings, ultrasound education is expanding into student curricula. We aimed to determine the status and awareness of POCUS education in Korean medical schools using a nationwide cross-sectional survey. In October 2021, a survey questionnaire consisting of 20 questions was distributed via e-mail to professors in the emergency medicine (EM) departments of Korean medical schools. The questionnaire encompassed 19 multiple-choice questions covering demographics, current education, perceptions, and barriers, and the final question was an open-ended inquiry seeking suggestions for POCUS education. All EM departments of the 40 medical schools responded, of which only 13 (33%) reported providing POCUS education. The implementation of POCUS education primarily occurred in the third and fourth years, with less than 4 hours of dedicated training time. Five schools offered a hands-on education. Among schools offering ultrasound education, POCUS training for trauma cases is the most common. Eight schools had designated professors responsible for POCUS education and only 2 possessed educational ultrasound devices. Of the respondents, 64% expressed the belief that POCUS education for medical students is necessary, whereas 36%, including those with neutral opinions, did not anticipate its importance. The identified barriers to POCUS education included faculty shortages (83%), infrastructure limitations (76%), training time constraints (74%), and a limited awareness of POCUS (29%). POCUS education in Korean medical schools was limited to a minority of EM departments (33%). To successfully implement POCUS education in medical curricula, it is crucial to clarify learning objectives, enhance faculty recognition, and improve the infrastructure. These findings provide valuable insights for advancing ultrasound training in medical schools to ensure the provision of high-quality POCUS education for future healthcare professionals.

Abbreviations: ED = emergency department, EM = emergency medicine, EP = emergency physician, POCUS = point-of-care ultrasound, SECCI = society of emergency and critical care image.

Keywords: emergency medicine, Korea, medical education, nationwide survey, point-of-care ultrasound

1. Introduction

The concept of point-of-care ultrasound (POCUS) has emerged as a useful tool that helps clinicians make decisions to properly evaluate and treat patients.^[1–3] As the application of ultrasound increases in patient care, the concept of POCUS has emerged. POCUS is defined as the acquisition, interpretation, and immediate clinical integration of an ultrasound

image performed by a treating clinician at the patient's bedside.^[4] With the development of ultrasound devices and the improvement in its portability over the past 20 years, its use has been expanded to various medical fields,^[3,5,6] and ultrasound has been described as “the stethoscope of the 21st century.”^[3] Several studies have reported that POCUS ultimately increases the accuracy of diagnosis and enables prompt

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initiation of the appropriate treatment, reduces the incidence of complications that may occur during a procedure, and increases the confidence and decision-making ability of the attending physician.^[5,7,8]

As POCUS is increasingly being used in clinical settings, ultrasound education is expanding beyond residency training in student curricula. In countries such as the United States and Canada, ultrasound is taught in preclinical and clinical periods for medical students,^[9–16] and some medical schools offer portable ultrasound devices to all medical students.^[17] Davis et al stated that the addition of ultrasound training in medical school curricula boosted medical students' confidence in ultrasound scanning.^[9] Furthermore, most medical students who received ultrasound training reported that the integrated ultrasound training course increased their grasp of anatomy and would be useful in their future specialties.^[9,14–16,18–21]

A recent nationwide cross-sectional study of emergency physicians (EPs) working at emergency medical centers in Korea found that 96% of EPs used ultrasound and 76% of emergency medicine (EM) residents received ultrasound training.^[22] However, the present state of POCUS education for Korean medical students is unknown. Given the increasing need for ultrasound implementation by primary care physicians and an array of different specialties, it is necessary to review current ultrasound education for medical students and determine whether there be incorporated into the curriculum. Therefore, this study investigated; the status of POCUS education for medical students, the perceptions of professors regarding POCUS education and potential obstacles to implementing POCUS education in Korean medical schools.

2. Materials and methods

We only used digitally encrypted names and contacts for the participants' personal information. This study was conducted in accordance with the 2013 Declaration of Helsinki, and was reviewed and approved by our Institutional Review Board as an exempt study with an informed consent waiver. (IRB File Number:2021-04-180-002).

2.1. Study design and setting

This cross-sectional study was conducted in October 2021, at a medical school in South Korea. Using a survey, we investigated the status and perception of POCUS education in Korean medical schools.

2.2. Population

We targeted professors from EM departments of Korean medical schools. EM is one of the specialized departments that uses POCUS the most.^[23] In addition, the medical school curriculum is so complex that it is difficult for professors who do not actively participate in education to become aware of it. Therefore, we targeted the professors in charge of student education or the heads of the respective EM departments of all 40 medical schools in Korea, all of whom had sufficient understanding of the medical school curriculum related to POCUS.

2.3. Study protocol

The phone numbers of each EM department were obtained from the medical school's website. Each department was contacted and provided with the study information, and the questionnaire was delivered via e-mail. We asked 1 individual from each institution to answer questions about their perception of POCUS education. The questionnaire was sent on October 8, 2021. On October 15, 2021, a second survey was sent to schools that did

not respond. On October 25, 2021, a third survey was sent to schools that had not responded to the second survey.

2.4. Contents of the survey

The questionnaire consisted of 20 questions, of which 19 were multiple-choice questions (six were sub-questions), and 1 was an open-ended question. The multiple-choice questions included 12 multiple-response questions and a 5-point Likert-scale response question on perceptions related to expanding POCUS education. The multiple-choice questions consisted of 4 parts: demographics of medical schools, current POCUS education, perceptions of POCUS education, and obstacles to POCUS education (Figure S1, Supplemental Digital Content, <http://links.lww.com/MD/M340> and Appendix 1, Supplemental Digital Content, <http://links.lww.com/MD/M341>). The last open-ended question asked for a description of the respondents' overall suggestions on POCUS education, including its advantages, disadvantages, and necessary improvements. POCUS education was defined in the questionnaire as "theoretical and practical training on the clinical application of ultrasound through the manipulation of ultrasound devices and image acquisition, as well as interpretation of ultrasound images." The fields of POCUS education were classified according to the core application of the American College of Emergency Physicians.^[24] Two professors of EM with expertise in POCUS and 1 professor of medical education defined POCUS education and evaluated the clarity and relevance of the questions and the completeness of the questionnaire through a literature review and online discussions for 3 months. Experts ranked the items on a scale of 0 to 5 points, and the items were chosen if the average score for each item was at least 4 points and everyone agreed. This survey was critically reviewed by the Research Division of the Society of Emergency and Critical Care Image, and we completed the survey-based on their feedback.

2.5. Data analysis

One questionnaire was administered per institution, and additional responses regarding perceptions of POCUS education were collected in instances of multiple respondents at 1 institution. Standard descriptive statistics were used for the quantitative analysis of the collected statistical data. Data were analyzed using frequencies and percentages for dichotomous and categorical variables, respectively. A percentage was provided in the respondents' denominator for each question.

The open-ended question identified and classified common themes in professors' perspectives on POCUS education to supplement the quantitative survey findings. This adjunct analysis employed an exploratory approach that applied a constructivist paradigm.^[25,26] Two members of the study team coded free-text responses to barriers to POCUS education for students, with a third available to deal with inconsistencies. SPSS ver. 28 (IBM Corporation, Armonk, NY,) was used for statistical analyses.

3. Results

All 40 medical schools in Korea responded; thus, the response rate was 100%. For the 2 universities, there were 4 and 1 additional response, respectively; the additional 5 responses were included for the perception of POCUS education.

3.1. Demographics of medical schools (Table 1)

Of the 40 medical schools, 10 (25%) were national public medical schools and 30 (75%) were private medical schools. Regarding the number of students, 40% of medical schools had 51 to 100 students, 33% had fewer than 50 students, and 27% had more than 101 students. In most schools, emergency departments (EDs) offer clerkships and pre-clerkship clinical education

Table 1
Demographics of Korean medical schools (n = 40).

Characteristics	Responders, No. (%)*
Type of medical school	
Public medical school	10 (25)
Private medical school	30 (75)
Number of students in medical school	
1–50	13 (33)
51–100	16 (40)
Over 100	11 (27)
Curriculum implemented by the emergency medicine department*	
Pre-medicine	6 (15)
Basic medicine	2 (5)
Pre-clerkship clinical education course	37 (93)
Clinical clerkship preparation	24 (60)
Clerkship	40 (100)
Location	
Seoul	12 (30)
Incheon and Gyeonggi	7 (18)
Central region	7 (18)
Southern region	14 (34)

* Multiple-response questionnaire.

courses. Only 2 medical schools offered basic medical education courses. Nineteen medical schools (48%) were located in Seoul and Gyeonggi regions.

3.2. Status of point-of-care ultrasound education for medical students (Table 2, Table S1, Supplemental Digital Content, <http://links.lww.com/MD/M342>)

At the time of the survey, 13 EM departments (33%) in 40 medical schools had been conducting POCUS education for medical students. Of these, 4 (30%) were national public schools and 9 (70%) were private medical schools. While 5 (38%) had fewer than 50 students, 3 (23%) had more than 100 students. In terms of the timing of education, POCUS education was mainly implemented in the third and fourth years, with a training time of 30 to 120 minutes per student per year. One medical school had a POCUS education class of 240 minutes in the first year. Three medical schools reported that they provided POCUS education to students in 2 years: year 2/year 3, year 3/year 4, and year 2/year 4, respectively. Classrooms were the most common teaching location (8; 62%), followed by the clinical field within the ED (5; 38%). The simulation center has been reported to be a teaching place in medical schools.

Regarding teaching and learning methods, lectures were most commonly used in 8 schools (62%). Case discussions were conducted in 2 schools (15%), and demonstrations of phantoms or standardized patients were conducted in 2 schools (15%). Five schools (39%) held hands-on sessions, with all 5 using standardized patients, and 2 schools additionally practiced with real patients. None of the schools conducted hands-on sessions using the phantoms. Hands-on sessions accounted for <25% of the total training time in 2 schools, 51% to 75% in 1 school, and over 75% in 2 schools. In the hands-on session, the ratio of instructors to students was 1:4 in 3 schools and 1:5 and 1:3 in 1 school each.

Regarding the responses regarding evaluation after education, the option without evaluation was the most selected, with 8 responses (62%). Among the medical schools that conducted the evaluation, 4 performed a knowledge assessment, 2 performed practical assessments of ultrasound scans, and 1 performed an evaluation of attitude. Eight schools (62%) stated that they had professors in charge of the POCUS education. Two were public medical schools, and 6 were private medical schools. Of the 8 schools, 4 had fewer than 50 students, 2 had 51 to 100 students,

and 2 had 101 or more students. Two schools responded that they had ultrasound equipment for their education. Both were private medical schools, with fewer than 50 students.

In response to the POCUS education content, the number of responses for the diagnosis of pathological findings using ultrasound was the highest (8; 62%), followed by those for understanding the anatomy of organs using ultrasound (7; 54%), ultrasound physics and knobology (6; 46%), image scanning skills (6; 46%), patient monitoring and treatment response evaluation using ultrasound (6; 46%), implementation of procedures (6; 46%), concept and knowledge of POCUS (4; 31%), and physiological function evaluation using ultrasound (2; 15%), which were found to be the least taught (Fig. 1). In the question regarding the specific applications of POCUS education contents, most medical schools answered that they had implemented POCUS education for trauma. 62% of the schools indicated a positive response for cardiac/hemodynamic evaluation, and POCUS education related to thoracic and airway evaluation and procedures was imparted to 46% of the schools (Fig. 2). Procedure-related POCUS education was conducted in 6 medical schools, most of which indicated that line-access-related education was conducted. Ultrasound-guided paracentesis, thoracentesis, pericardiocentesis, and arthrocentesis were taught in 4, 3, 2, and 1 school(s), respectively.

3.3. Perception of professors regarding point-of-care ultrasound education for medical students (Table 3)

POCUS education for medical students was considered necessary by 29 respondents (64%) and deemed unnecessary by 16 (36%). Thirteen (87%) answered that it was not necessary because the priority of POCUS education was lower than that of other education, and 8 (53%) said that they expected students to have limited comprehension of ultrasonography education. Three respondents thought that simply studying image interpretation was sufficient at the student level and 2 stated that there would be little learning effect on other subjects through POCUS education. When asked whether POCUS education should be mandatory, 25 respondents (58%) answered that it should be elective, rather than mandatory. In response to the prospect of expanding POCUS education in the future, 42% disagreed, including neutral responses, and 58% believed it would expand. When asked about the appropriate hours of POCUS training annually, 24 respondents (57%) stated that it should be 5 hours or less; 10 (24%), 5 (12%), and 3 (7%) stated that it should be 6 to 10, 11 to 20, and 21 hours or more, respectively.

Detailed opinions on the necessity of POCUS education for students, identified through the responses to Question 20, included both positive and negative answers. Respondents in favor of POCUS education stated that “learning the basic concepts on POCUS in medical school would enable better use of POCUS after becoming a doctor” and “POCUS education would help student understand anatomy and clinical medicine before clerkship.” On the contrary, participants against POCUS education stated that “not all students need to learn because not all clinicians use ultrasound” and “training to perform ultrasound scans is beyond the scope of students’ learning.”

3.4. Barriers to point-of-care ultrasound education for medical students (Table 4)

In the multiple-choice questions about the barriers to POCUS education targeting students, the lack of faculty responsible for POCUS education was the most highlighted (83%), followed by the lack of infrastructure (76%), sufficient educational time (74%), and awareness of the usefulness of POCUS education (29%) (Table 3).

Question 20, an open-ended inquiry, generated a number of perspectives on barriers to POCUS education (Table 4).

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Table 2
Status of POCUS education in medical schools (n = 13).

*Medical school	†Type	Student size	Year of curriculum				Education time (min)	Education place			Teaching and learning method				Infrastructure				
			1	2	3	4		Classroom	Clinical field	Simulation center	Lecture	Case discussion	Demonstration	Hands-on	Assessment	Faculty	Machine		
A	P	≤50	+	-	-	-	240	+	-	-	-	-	-	-	-	-	+	+	
B	N	≤50	-	+	+	-	90 (30, 60)	+	+	-	-	-	-	-	-	-	-	-	-
C	N	>100	-	-	+	-	120 (60, 60)	+	-	-	-	-	-	-	-	-	-	+	-
D	P	51-100	-	+	-	-	60	+	-	-	-	-	-	-	-	-	-	+	-
E	P	51-100	-	-	+	-	120	-	+	-	-	-	-	-	-	-	-	-	-
F	P	≤50	-	+	+	-	240 (180, 60)	+	-	-	-	-	-	-	-	-	-	+	-
G	P	≤50	-	-	-	+	120	+	-	+	-	-	-	-	-	-	-	+	-
H	P	≤50	-	-	-	+	120	+	-	-	-	-	-	-	-	-	-	+	-
I	P	51-100	-	-	-	+	120	-	-	-	-	-	-	-	-	-	-	-	NR
J	N	51-100	-	-	+	-	120	+	-	-	-	-	-	-	-	-	-	-	-
K	P	51-100	-	-	-	+	30	+	-	-	-	-	-	-	-	-	-	+	-
L	N	>100	-	-	-	+	60	-	-	-	-	-	-	-	-	-	-	+	-
M	P	>100	-	-	-	+	60	-	-	-	-	-	-	-	-	-	-	+	-

- = negative or none, + = positive or available, N = national public medical school, NR = no response, P = private medical school, POCUS = point-of-care ultrasound.

* Medical school names are anonymous, randomly arranged in alphabetical order.

† Type, type of medical school.

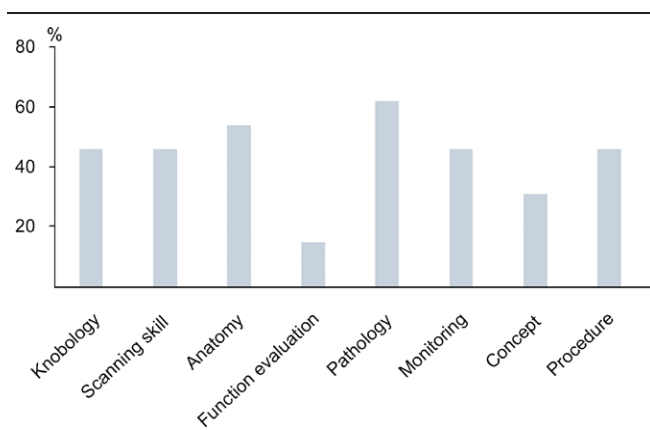


Figure 1. POCUS education content (n = 13) Knowledge, ultrasound physics, and knobology; scanning skills; image scanning skills; anatomy; understanding the anatomy of organs using ultrasound; function evaluation and physiological function evaluation using ultrasound; pathology, diagnosis of pathological findings using ultrasound; monitoring, patient monitoring, and treatment response evaluation using ultrasound; procedure, implementation of procedures using ultrasound; and concept, concept, and knowledge of POCUS. POCUS = point-of-care ultrasound.

As for the faculty shortage, answers such as “Lack of faculty with expertise in teaching ultrasound,” “lack of participation by professors from other departments,” and “no reward for professor’s ultrasound training” were included. In terms of infrastructure, there was a lack of equipment, standardized patients, and educational programs. Participants responded that “because POCUS training is often conducted with ultrasound equipment for clinical practice in the ED, education is often interrupted in the midway,” and “the simulator is too expensive to purchase in a medical school.” There is a suggestion to utilize the picture archiving and communication system as a tool for feedback and assessment to vitalize education. The inability to recruit standardized patients for hands-on education has also been mentioned as a challenge in POCUS education. In addition, the absence of defined learning objectives appropriate to the students’ level and the difficulty in coordinating opinions on learning content among departments concerned with ultrasound education are issues that need to be addressed. There have been concerns that additional POCUS training in the EM clerkship program is not possible, because it is already overburdened by cardiopulmonary resuscitation and clinical procedures. Moreover, the possibilities for residents and interns to use POCUS should be expanded to establish an educational environment where students may be naturally exposed to it.

4. Discussion and conclusions

As a nationwide study in which all medical schools in Korea participated, this study offers the first overview of POCUS education for Korean medical students. Additionally, the perceptions of the education program directors regarding POCUS education for medical students were explored. According to the results of our study, only approximately one-third of the EM departments in medical schools provided POCUS education, and the methods of instruction and assessment were insufficient to optimize the educational effect. Two-thirds of the EM professors agreed on the need for POCUS education for students; however, many of them were unclear about the educational goals of POCUS and complained about a poor educational environment. These results are not only baseline data for Korean medical schools but could also play an important role in establishing or redesigning a POCUS education curriculum in many countries where ultrasound education for students is not active.

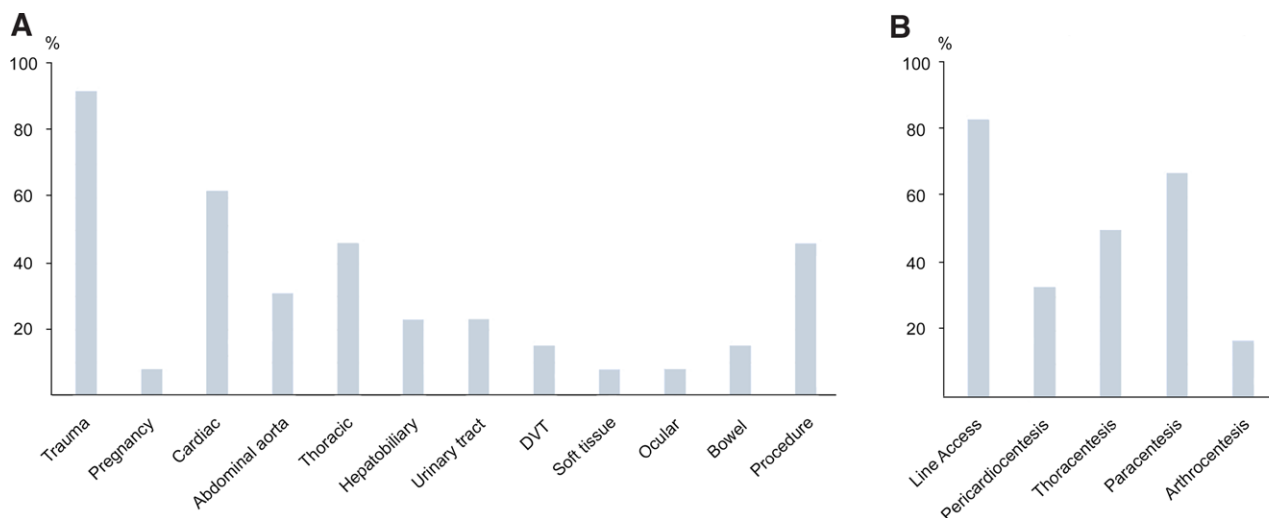


Figure 2. Specific applications of POCUS education content. (A) Specific applications of POCUS education content (n = 13). (B) Ultrasound-guided procedure (n = 6). Pregnancy, intrauterine pregnancy/ectopic pregnancy; cardiac, cardiac/hemodynamic assessment; thoracic, lung/airway; DVT, deep vein thrombosis; soft tissue, soft tissue/musculoskeletal; procedure, procedural guidance; line access, securing a venous line (central venous catheterization, etc). POCUS = point-of-care ultrasound.

Research on the effects of ultrasound education on medical students is underway in several countries. According to a systematic review,^[9] ultrasound education mainly consists of hands-on sessions (79%), while the educational content mainly consists of cardiac POCUS (34%), abdominal POCUS (32%), and focused assessment with sonography for trauma (26%). A recent study on ultrasound education in the United States reported that 81% of students had an integrated curriculum and 19% had a separate ultrasound curriculum.^[9,23] Several reports have shown that the advantages of ultrasound education for students include better understanding of anatomical relationships and physiological concepts, improved diagnostic and physical examination skills, and safer procedural guidance.^[9,17,18]

Our study showed that the average training time was less than 4 hours in 13 medical schools that implemented POCUS education within their curriculum, and many respondents stated that the shortage of education time was a significant hurdle. An increase in ultrasound training hours is directly correlated with an increase in POCUS use.^[27,28] According to a recent report in the United States, 40% of medical schools devoted 5 or fewer hours to a monthly ultrasound curriculum, while 20% reported that students spend 6 to more than 20 hours per month.^[23] Although a direct comparison was impossible because the results of our study cannot accurately reflect the total ultrasound education time within the curriculum, it appears clear that the current training hours in Korean medical schools are insufficient to achieve practical training.

The number of contents and specific applications covered in POCUS education varied from school to school, ranging from 1 to 8 in content and 1 to 12 in terms of fields. In addition, some respondents had difficulty deciding on the depth and scope of the learning content. In Korea, there is no clear guide for the goals or purposes of POCUS education in medical schools. The goals and objectives of POCUS education for medical students must be defined to minimize confusion among education providers and to enable consistent and systematic education. Furthermore, when setting the learning objectives of POCUS, it is important to maintain alignment with those of existing ultrasound education conducted separately for each subject to prevent unnecessary duplication of the curriculum.

Regarding instruction and assessment methods, lectures were the most commonly used, and hands-on training was offered in only 5 schools. Student assessment was performed in less than half of the medical schools, and knowledge was assessed twice

as much as skills. Even in medical schools that offer hands-on training, less than half conduct assessments of ultrasound skills. In recent studies, lectures and supervised hands-on training have been suggested as educational strategies in the ultrasound curriculum, and hands-on sessions in particular are pivotal to nurture.^[29,30] Considering that the teaching and assessment of ultrasound skills usually require dedicated faculty, ultrasound equipment, and sufficient time, it could be difficult to build an effective and efficient education system in the current educational environment, which lacks these 3 components.

In our study, only 8 out of the 40 schools (20%) had ultrasound teaching faculty. In addition, the shortage of faculty engaged in POCUS education turned out to be the most important issue to be solved for POCUS education. The inactive participation of other departments was stated as part of the reason for the faculty shortage. POCUS is applied to various organ systems, and it is impossible for the EM faculty to cover all fields alone. In several studies, the presence of a professor in charge of POCUS education was directly correlated with the frequency of POCUS use.^[27,28] To expand POCUS education, it should be a priority to secure sufficient faculty members with the ability to provide POCUS education in cooperation with other specialized departments, such as the radiology, cardiology, and obstetrics and gynecology, which have traditionally been in charge of ultrasound education for medical students.

The lack of infrastructure has also been cited as a major obstacle in POCUS education. In this study, only 2 of the 40 medical schools in Korea had ultrasound equipment for educational purposes. In response to the open-ended questions, the respondents reported discontinuing training while using medical ultrasound devices for education. This was in stark contrast to a recent study conducted in the United States, in which 79% of respondents had educational ultrasound devices.^[23] Besides the equipment, in an open-ended question, 1 respondent stated that securing standardized patients as a model for ultrasound was the most difficult problem in hands-on POCUS education. Although it is important to perform an ultrasound scan directly for effective training, it is difficult for students to scan standardized patients, and the phantom or simulator model is not popular because of its high price. Therefore, sufficient equipment and methods for hands-on education should be devised for effective POCUS training.

According to a study conducted in the United States in 2021, 94% of academic medical school deans agreed that POCUS

Table 3
Perception of POCUS education for medical students.

Characteristics	Responders, No. (%)
Need for POCUS education for students (n = 45)	
Yes	29 (64)
No	16 (36)
Why is POCUS training not required* (n = 15)	
Scanned image learning is enough	3 (20)
Educational understanding is expected to be low	8 (53)
Low educational priority for POCUS	13 (87)
Little effect of promoting learning in other subjects	2 (13)
Need for POCUS education for mandatory education (n = 43)	
Yes, mandatory	18 (42)
No, optional	25 (58)
Appropriate POCUS education year* (n = 37)	
Basic medicine curriculum	2 (5)
Preclinical period	9 (24)
Clinical clerkship preparation course	14 (38)
Clinical period	32 (86)
Whether to expand POCUS education in the future† (n = 43)	
Not extended	4 (9)
Neutral	14 (33)
Extended	25 (58)
Appropriate POCUS education hours per year (n = 42)	
5 h or less	24 (57)
6–10 h	10 (24)
11–20 h	5 (12)
Over 21 h	3 (7)
Barriers* (n = 42)	
Lack of awareness of the usefulness of POCUS education	12 (29)
Lack of faculty responsible for POCUS education	35 (83)
Lack of infrastructure	32 (76)
Lack of sufficient educational time	31 (74)

POCUS = point-of-care ultrasound.

* Multiple-response questionnaire.

† In the answer, strongly disagree or disagree denote "not extended," whereas agree or strongly agree denote "extended."

education was necessary for medical students.^[19] In our study, 64% of the respondents agreed to POCUS training for medical students, and 42% preferred compulsory education. The low priority of POCUS education within the curriculum and the negative expectations of students' level of understanding of POCUS were the main reasons why POCUS education was considered unnecessary for medical students. Other responses were as follows: "POCUS is not used by all physicians, so it is not necessary to educate all students" and "students only need to be able to interpret images." However, most clinical departments use POCUS in various domains including diagnosis, treatment, patient monitoring, and several procedures performed under ultrasound guidance. In particular, as patient safety issues are increasingly emphasized and to avoid radiation exposure risks, many invasive procedures, if possible, should be performed under ultrasound guidance. As a result, increasing awareness of the utility of ultrasound among medical school professors appears to be a critical first step toward the application and growth of POCUS education in medical schools.

This survey-based study had several limitations. First, it may not accurately represent the entire POCUS educational programme for each medical school. In most schools, EDs offered clerkships and pre-clerkship clinical education courses. Therefore, it was not possible to investigate the POCUS education provided in the preclinical education course. In addition, despite targeting professors in charge of student education, who design ED education programs in coordination with the entire curriculum, there could be missing information about POCUS education programs run by other specialties, such as radiology, cardiology, and obstetrics-gynecology. However, perceptions, in particular on the difficulties of POCUS education, did not differ significantly between ED and other specialties. Second, we could not analyze perceptions according to the participants' prior experiences in POCUS education. Educators' perspectives on POCUS education may differ depending on their experiences. Most of them were thought to have experienced POCUS education for residents rather than for

Table 4
Common themes and specific comments in the qualitative analysis of open-ended questions about barriers of POCUS education for students (n = 44).

Themes	Subthemes	Comments
Awareness of POCUS education	Importance of US education	<ul style="list-style-type: none"> • Not only the POCUS but ultrasound education itself is not emphasized within the curriculum • POCUS education has never been considered in ED clerkship because it was regarded as a field of radiology.
Faculty	Faculty recruitment	<ul style="list-style-type: none"> • It is difficult to find faculty with expertise in US training • There is insufficient participation of professors from other departments
Infrastructure	Faculty reward Equipment	<ul style="list-style-type: none"> • There is no reward for professors who focus on US training • Because US training is often conducted with US equipment for clinical practice, education is often interrupted
	Standardized patients Standardized education program	<ul style="list-style-type: none"> • Simulator is too expensive to purchase in medical school • It is necessary to utilize PACS as a tool for feedback and assessment • It is difficult to recruit standardized patients available for hands-on US education • There is no guide on the learning objectives, teaching, and learning methods, and student assessment
Educational time	Rigid curriculum of medical school	<ul style="list-style-type: none"> • It is unclear as to what level of content students should be taught about US • It is not easy to coordinate learning content between related departments • Because the emergency medicine clerkship program already teaches CPR and clinical procedures, there is no room for additional POCUS training • The current clerkship period is too short for POCUS training that requires repeated practice and feedback
Others	Student motivation	<ul style="list-style-type: none"> • POCUS is not popular among students • After training, students have few opportunities to apply US in other curricula • In order to develop an educational environment in which students are naturally exposed to POCUS, opportunities for residents and interns to use POCUS should be increased

Note: This table was created from free-text responses to Question 20.

CPR = cardiopulmonary resuscitation, PACS = picture archiving communication system, POCUS = point-of-care ultrasound, US = ultrasound.

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students. The 2 have many similarities; however, there may be differences in the learning objectives and the context in which education takes place. Although information on experience was available to some respondents through an open-ended question, it was insufficient for use as data for analysis. Third, the respondents may have had different views on POCUS education because the scope and content of POCUS education are diverse. The questionnaire included a definition of POCUS education that served as a guide for participants to answer the questionnaire items. However, these subtle differences in POCUS education may have affected our results. Finally, due to the small number of medical schools that offered POCUS education, it was impossible to derive statistical significance through an additional subgroup analysis of the details of the status of POCUS education and its perception according to the demographic characteristics of medical schools, such as the type of school, location, and student size. If POCUS education becomes more popular and expands to include more medical schools in Korea in the future, additional research on its educational effects and actual applications would be necessary.

In conclusion, a minority (33%) of EM departments conduct POCUS education in Korean medical schools. To effectively implement POCUS education in medical students, it is vital to clarify their learning objectives and competencies. Additionally, efforts should be made to enhance faculty recognition of its value, strengthen infrastructure, such as faculty development and educational equipment, and implement standardized teaching and evaluation methods. These findings provide valuable insights for advancing ultrasound training in medical schools to ensure the provision of high-quality POCUS education for future healthcare professionals.

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