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Questionnaire survey on point-of-care ultrasound utilization during cardiac arrest among emergency physicians in Hong Kong

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Abstract

Introduction: Although point-of-care ultrasound (POCUS) is recognized as a useful diagnostic and prognostic tool during the management of out-of-hospital cardiac arrest (OHCA), opposing viewpoints exist. The objectives of this study are to investigate the knowledge, attitude, and practice (KAP) in POCUS utilization during OHCA among emergency medicine (EM) physicians in Hong Kong and to identify their barriers.

Methods: A cross-sectional questionnaire was conducted among EM physicians in 9 accident and emergency departments in Hong Kong. The questionnaire assessed participants' demographics, knowledge, attitude, practices, and barriers on this issue. Composite scores for KAP were calculated. Subgroup analysis and multiple regression analysis were used to explore the correlation between KAP and participants' demographics. Participants' barriers were evaluated by binary and open-ended questions.

Results: A total of 224 questionnaires were distributed and 150 questionnaires were returned (response rate: 67.0%). Statistically significant associations of knowledge and attitude with practice were demonstrated (both $p < 0.001$). Independent predictors of more frequent POCUS use in OHCA included EM fellowship status ($p = 0.005$), receiving training on this issue ($p < 0.001$), and working in large hospitals ($p = 0.007$). The top-ranked barriers were chaotic environment (74%), no structural education on this practice (63%), and the lack of staff (61%).

Conclusions: The knowledge and attitude of performing POCUS during OHCA were demonstrated to enhance EM physicians' practice. By improving physicians' knowledge and removing the possible barriers they are facing, POCUS can be optimally utilized during OHCA to improve patient care.

KEYWORDS
cardiac arrest, emergency physicians, point-of-care ultrasound, questionnaire survey

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1 | INTRODUCTION

Nontraumatic out-of-hospital cardiac arrest (OHCA) is a global health care problem. In Hong Kong, 2.3% of the OHCA patients survived at least 30 days or survived hospital discharge and only 1.5% had a good neurological outcome.[1] With the advancement of technology, ultrasound machines have become more compact, lightweight, and less expensive. Being more easily accessible, bedside ultrasound now plays an essential role in making diagnosis in many emergency departments (EDs).[2] Many guidelines and protocols, such as the Sequential Echographic Scanning Assessing Mechanism Or Origin of Severe Shock of Indistinct Cause (SESAME)[3] and Cardiac Arrest Sonographic Assessment (CASA) protocols,[4] have been developed to guide this practice. Previous studies also suggested that POCUS is a useful adjunct during the management of cardiac arrest (CA),[5–7] identifying possible reversible causes (such as cardiac tamponade, pulmonary embolism (PE), and hypovolemia), detecting cardiac activity (prognostic value) and being used as a more accurate tool for pulse checking.[5–8] The American Heart Association updated the recommendation that POCUS may be applied to patients receiving cardiopulmonary resuscitation (CPR) to help assess myocardial contractility and to help identify potentially treatable causes of CA.[6]

Despite the above benefits, performing POCUS during OHCA is challenging and potentially harmful. Maintaining high quality CPR as per the Advanced Cardiovascular Life Support (ACLS) protocol is the most important element during resuscitation. Previous studies suggested that experienced physicians could also face difficulty in simultaneously obtaining adequate sonographic views as well as interpreting the images within the 10-s pulse check interval, leading to unintended prolonged CPR pauses.[9,10] Moreover, the "2020 Guidelines for CPR and Emergency Cardiovascular Care" published by the American Heart Association recommends against the use of POCUS for prognostication during CPR, though this recommendation does not preclude the use of ultrasound to identify potentially reversible causes of CA or detect the return of spontaneous circulation (ROSC).[11]

The practice of POCUS utilization during OHCA could be heterogeneous among emergency medicine (EM) physicians in Hong Kong and there are limited studies on the knowledge, attitude, and practice (KAP) on this issue. The objective of this study is to report the KAP of EM physicians in Hong Kong on POCUS utilization during OHCA and to investigate the associations between these three domains.

Moreover, we hypothesized that local EM physicians face multiple barriers to perform high-quality POCUS during OHCA. Possible barriers could be worrisome in hindering the resuscitation progress, lack of confidence in interpreting the POCUS findings in resuscitation situation, and lack of formal and structural training.[12,13] This study aims to explore their concerns and suggest ways to overcome those barriers.

2 | METHODS

2.1 | Study setting and participants

A multicenter cross-sectional questionnaire was conducted among the EM physicians currently working in 9 Accident and Emergency Departments (AEDs) in Hong Kong between May and June 2023. The questionnaire was conducted in the format of printed questionnaires written in English. Eligible participants were EM physicians registered with the Medical Council of Hong Kong, who were also registered as fellows or trainees with the Hong Kong College of EM (HKCEM). Physicians from other specialties who rotated to the AEDs for training purpose and physicians from other specialties who were practicing in AEDs on the basis of the special honorarium scheme (SHS) of hospital authority were excluded from taking part.

The questionnaires were distributed in person in 9 AEDs in Hong Kong. One site investigator was assigned in each participating ED to distribute and collect the questionnaires. Anonymous use of the collected data for research purposes was clearly stated at the start on the questionnaire. All questionnaires were completed on a voluntary basis.

2.2 | Questionnaire tool

A literature search found one questionnaire from a previous study.[12] Not only there are intrinsic differences in the EM training pathway and ultrasound competency rating standard between the United States and Hong Kong, the study also focused on identifying the barriers of EM physicians on POCUS utilization during OHCA with less focus on assessing their KAP. Further literature revealed no validated questionnaires that assessed the KAP of EM physicians on this issue. Choosing KAP as the primary tool allowed us to understand the view and practice of EM physicians on this issue. Therefore, relevant questions on KAP were designed based on a few studies concerning similar topics[3–13] and authors' experience, while the aforementioned questionnaire was only used as a reference. A preliminary questionnaire was designed and was then assessed independently by 5 senior EM specialists, where two of them were the instructors of ultrasound course. They provided expert opinions on the content and format of the questionnaire. They were asked to score each question based on their relevancy on a scale of 1–4 (whereby four indicates high

relevance). The content validity index was used as a measure of validity, in which all questions received a score greater than 3, with the majority scoring full marks. All other feedback was addressed.

The 5 domains in this questionnaire were: participants' demographic, KAP on POCUS utilization during OHCA, and miscellaneous. The questions was binary (yes/no), 5-point Likert scale, or open-ended. Table 1 lists the questions in the questionnaire, categorized by domain.

2.3 | Statistics

The internal consistency of this questionnaire was assessed by Cronbach's alpha. Descriptive analysis was reported for the responses received. Median and interquartile range were reported for continuous composite scores. Subgroup comparisons were performed using Kruskal–Wallis rank sum test. Multiple regression was used to predict the practice composite score based on the knowledge composite score, attitude composite score, and participants' demographics. Spearman's correlation coefficients were calculated between the three domains. Statistical analysis was performed with R version 4.2.2.

Sample size calculation was done using Slovin's formula: $n = N/(1 + Ne^2)$. There were 452 emergency physicians (N) in the Hospital Authority who satisfy our selection criteria. The acceptable margin of error (e) was considered 0.1 or less (above 90% accuracy). The number of samples needed (n) was therefore 82.

3 | RESULTS

Overall, 224 questionnaires were distributed to eligible physicians and 150 questionnaires were returned (response rate: 67.0%). The corresponding accuracy was calculated, using Slovin's formula, indicating a satisfactory accuracy (93.3%). A total of 42% of the respondents were fellows ($n = 63$) and 41.3% had ≥10 years of EM experience ($n = 62$).

A summary of the questionnaire responses is shown in Table 2. The questions are categorized into KAP. The responses for each question are categorized using a 5-point Likert scale and the distribution is shown. The Cronbach's alpha value of knowledge questions (Q1K–Q8K) was 0.78 and that of attitude questions (Q9aA–Q10A) was also 0.78. The high values indicate that there is high consistency in the response values for each participant across a set of questions within each category. The Cronbach's alpha value for the practice domain was not calculated as there was only one question.

The composite KAP scores of various subgroups are shown in Table 3. Participants with more than 10 years of EM experience had higher knowledge (median = 24, IQR = 22–27 vs. median = 21, IQR = 18–24; $p < 0.001$) and attitude composite scores (median = 23, IQR = 20.5–25.5 vs. median = 22, IQR = 19–23; $p = 0.002$) than those with less EM experience. However, a statistical significance was not observed for the practice score ($p = 0.103$), indicating their frequency in using POCUS during OHCA were similar despite the difference in knowledge and attitude. EM physicians with fellowship status all had higher KAP scores (K: median = 24, IQR = 23–27.5 vs. median = 20, IQR = 17.25–23.75; $p < 0.001$, A: median = 23, IQR = 21–25 vs. median = 21, IQR = 19–23; $p = 0.004$, p: median = 3, IQR = 2—4 vs. median = 2, IQR = 1.25–3; $p = 0.005$, respectively) than those without fellowship status, indicating that they were more knowledgeable and inclined to use POCUS when handling OHCA cases. In addition, higher trainees had better knowledge composite score than basic trainees (median = 22, IQR = 19–25 vs. median = 19, IQR = 16–21; $p < 0.001$) but there were no statistically significant differences in the attitude and practice composite scores (A: $p = 0.093$, P: $p = 0.115$).

The subgroup analysis showed no differences in KAP scores in terms of participants' status as an instructor of Basic Life Support (BLS) course or ACLS course (K: $p = 0.037$, A: $p = 0.066$, P: $p = 0.837$). By comparing participants having the last ultrasound course within 2 years or beyond 2 years, the KAP scores also showed no statistical significance (K: $p = 0.236$, A: $p = 0.255$, P: $p = 0.988$). Those who were instructors of ultrasound course at the point of questionnaire distribution had higher knowledge composite score (median = 33, IQR = 29–34.5 vs. median = 22, IQR = 19–25; $p < 0.001$). Nevertheless, the attitude and practice score differences were not statistically significant (A: $p = 0.131$, P: $p = 0.031$), indicating that this group of participants, despite having better knowledge, were not using POCUS during OHCA more frequently.

Participants who received specific training, lectures, or sharing on this topic had higher KAP scores (K: median = 24, IQR = 21–27 vs. median = 21, IQR = 17–24; $p < 0.001$, A: median = 23, IQR = 21.25–25 vs. median = 21, IQR = 18–23.25; $p = 0.001$, P: median = 3, IQR = 2–-4 vs. median = 2, IQR = 1.25–3; $p < 0.001$ respectively) than those who did not.

We also divided the participants into 2 groups according to their hospital capacity and we determined daily attendance to AEDs greater than or less than 400 patients as the threshold. Subgroup analysis showed no differences in knowledge and attitude composite scores (K: median = 24, IQR = 19–26 vs. median = 22, IQR = 18.25–24.75; $p = 0.072$, A: median = 23, IQR = 20–25 vs. median = 21, IQR = 18.5–24; $p = 0.022$). However, a statistically significant difference was observed in practice composite score (median = 3, IQR = 2–-4 vs. median = 2, IQR = 2–3; $p = 0.007$),

TABLE 1 Questions in the questionnaire.

No.	Questions	Remarks
Demographics of the participants:		
	Year of graduation, year of experience in EM, current hospital, current training/fellowship status, time interval of last ultrasound course, status as an ultrasound course/BLS/ACLS instructor, received training on POCUS during CA or not, number of beds and number of ultrasound machines available in resuscitation room, number of attendance per day in participant's hospital	
Knowledge on POCUS utilization in cardiac arrest (total score: 8–40)		
Q1K	Number of cardiac arrest cases you manage per month	5 choices provided in each question.
Q2K	Which best describe your training in POCUS	
Q3K	Rate your confidence in performing POCUS during non-critical situations	
Q4K	Rate your confidence in performing POCUS during the 10-s pulse check in cardiac arrest	Score range for each question: 1–5.
Q5K	Rate your confidence in performing POCUS during the 10-s pulse check with mechanical CPR device in-situ (e.g., LUCAS) in cardiac arrest	
Q6K	Rate your confidence in performing POCUS during ongoing chest compression	Q7K required participants to write in words
Q7K	State any 5 specific findings you would look for using POCUS during cardiac arrest	
Q8K	Do you know about the CASA-/SESAME-protocol?	
Attitude on POCUS utilization in cardiac arrest (total score: 6–30)		
Q9	Do you think POCUS utilization during cardiac arrest (CA) can help in the following situations? (a-e)	Score range of each sub-question: 0–4
Q9aA	Making diagnosis	
Q9bA	Detecting return of spontaneous circulation (ROSC)	
Q9cA	Determining the prognosis	
Q9dA	Determining termination of resuscitation	
Q9eA	Overall management	
Q10A	How likely do you think a positive finding in POCUS during CA will lead you to an intervention that can improve patient's survival or outcome?	1 (very unlikely) to 5 (very likely)
Practice on POCUS utilization in cardiac arrest (total score for Q13P: 1–5)		
Q13P	In the past 6 months, how frequent do you use POCUS in cardiac arrest cases	1 (never) to 5 (>75%)
Q14P	When you are using POCUS in CA cases, how frequent would you look for the following conditions: Cardiac tamponade, dilated right ventricle or evidence of pulmonary embolism (PE), pneumothorax, size of inferior vena cava (IVC), abdominal pathology, deep vein thrombosis (DVT), cardiac contractility, and carotid pulse using Doppler mode	Total 8 sub-questions 0 (never) to 4 (in all cases)
Q15P	What factors may affect your decision on POCUS use during cardiac arrest: Age, premorbid status, presentation in this episode, downtime, and medico-legal concerns	Total 5 sub-questions Yes/No
Q16P	What are the barriers for you to use POCUS during cardiac arrest: USG machine availability in R room, number of staff available, POCUS may hinder the ACLS process, chaotic environment, no structural education on this practice, no sufficient mentorship/supervision when doing so, resistance from seniors/other staffs, feeling non-confident to achieve good USG images, and feeling non-confident to proceed for intervention even POCUS showed significant findings	Total 9 sub-questions Yes/No
Q17P	At what stage will you attempt POCUS during the process of resuscitation?	Open-ended question
Q18P	Any other barriers that may stop you from doing POCUS during cardiac arrest?	Open-ended question
Miscellaneous		
Q11M	Do you think following a protocol for POCUS utilization during CA may help in resuscitation situation?	Yes/No
Q12M	Do you think implementing a standard protocol for POCUS utilization during CA should be considered?	Yes/No

Abbreviations: ACLS, advanced cardiovascular life support; CA, cardiac arrest; CASA, Cardiac Arrest Sonographic Assessment; CPR, cardiopulmonary resuscitation; LUCAS, Lund University Cardiopulmonary Assist System; POCUS, point-of-care ultrasound; R Room, resuscitation room; SESAME, Sequential Echographic Scanning Assessing Mechanism Or Origin of Severe Shock of Indistinct Cause; USG, ultrasound.

TABLE 2 Summary of questionnaire responses ($n = 150$).

	Scoring (5-point likert scale)				
Question	**1**	**2**	**3**	**4**	**5**
Knowledge					
Q1K	7 (4.67%)	51 (34%)	49 (32.67%)	31 (20.67%)	12 (8%)
Q2K	26 (17.33%)	19 (12.67%)	84 (56%)	15 (10%)	6 (4%)
Q3K	9 (6%)	7 (4.67%)	59 (39.33%)	67 (44.67%)	8 (5.33%)
Q4K	23 (15.33%)	37 (24.67%)	51 (34%)	31 (20.67%)	8 (5.33%)
Q5K	36 (24%)	44 (29.33%)	47 (31.33%)	20 (13.33%)	3 (2%)
Q6K	47 (31.33%)	43 (28.67%)	46 (30.67%)	12 (8%)	2 (1.33%)
Q7K	18 (12%)	2 (1.33%)	12 (8%)	21 (14%)	97 (64.67%)
Q8K	99 (66%)	35 (23.33%)	8 (5.33%)	8 (5.33%)	NA
Attitude					
Q9aA	1 (0.67%)	9 (6%)	31 (20.67%)	75 (50%)	30 (20%)
Q9bA	8 (5.33%)	12 (8%)	35 (23.33%)	65 (43.33%)	26 (17.33%)
Q9cA	6 (4%)	24 (16%)	45 (30%)	59 (39.33%)	12 (8%)
Q9dA	8 (5.33%)	11 (7.33%)	28 (18.67%)	69 (46%)	30 (20%)
Q9eA	1 (0.67%)	5 (3.33%)	46 (30.67%)	79 (52.67%)	15 (10%)
Q10A	5 (3.33%)	24 (16%)	38 (25.33%)	63 (42%)	17 (11.33%)
Practice					
Q13P	31 (20.67%)	54 (36%)	27 (18%)	21 (14%)	15 (10%)

Note: *Data are presented as No. (%). *Questions 9a–e were set as scores 0–4 in the questionnaire distributed. For precise reading, the scores were adjusted to 1–-5 accordingly in the above table. *For Practice category, only Q13P was shown in the above table.

showing EM physicians in large hospitals used POCUS during OHCA more frequently than those in small hospitals.

Results from multiple regression modeling (Table 4) show knowledge composite score, attitude composite score, fellowship status, received specific training or information about this topic and working in larger hospital were independent predictors for performing POCUS during OHCA more frequently (with $p < 0.001$, $p < 0.001$, $p = 0.004$, $p < 0.001$, and $p = 0.003$, respectively). Other variables, including EM experience, recency of taking an ultrasound course, and being a BLS or ACLS instructor are not reliable predictors. As this study aimed to look into the relationship between KAP of POCUS utilization in OHCA, Spearman's correlation coefficients were calculated to correlate these 3 domains. Their correlations were all statistically significant: knowledge and attitude ($r = 0.26$; $p = 0.001$), attitude and practice ($r = 0.31$; $p < 0.001$), knowledge and practice ($r = 0.55$; $p < 0.001$).

Regardless of the missing entries, 130 participants (89%) thought that a protocol for POCUS utilization during OHCA might help in resuscitation condition and 124 participants (84%) agreed that implementing a standard protocol should be considered. Participants believed the clinical presentation in that episode, downtime, premorbid status, age and medico-legal concerns would affect their decision on POCUS utilization during OHCA (positive response were 88%, 82%, 76%, 71%, 60%, respectively).

When asked about what specific findings they would look for using POCUS during OHCA, cardiac tamponade, cardiac contractility, and evidence of PE were the top choices ($n = 98$; 82%, $n = 98$; 79%, $n = 74$; 59%, respectively for participants looking for these findings frequently or in all cases). For finding pneumothorax, the size of inferior vena cava (IVC), and abdominal pathology, the responses were diverse from never to all cases. For evidence of deep vein thrombosis and checking carotid pulse using Doppler mode, most participants had never or very rarely looked for (around 70% and 66%, respectively).

Barriers for the participants to use POCUS during OHCA, in descending order of positive responses were: chaotic environment ($n = 110$; 74%), no structural education on this practice ($n = 94$; 63%), lack of staff

TABLE 3 Knowledge, attitude, and practice composite scores on POCUS utilization in cardiac arrest in various subgroups.

	Knowledge composite score		Attitude composite score		Practice composite score	
Questionnaire question	**Score**	***p* value**	**Score**	***p* value**	**Score**	***p* value**
Total (n = 150)						
EM experience		<0.001		0.002		0.103
- >10 years (n = 62)	24 (22–27)		23 (20.5–25.5)		3 (2–4)	
- </ = 10 years (n = 88)	21 (18–24)		22 (19–23)		2 (2–3)	
EM fellowship status		<0.001		0.004		0.005
- Fellow (n = 63)	24 (23–27.5)		23 (21–25)		3 (2–4)	
- Non-fellow (n = 87)	20 (17.25–23.75)		21 (19–23)		2 (1.25–3)	
EM trainee status		<0.001		0.093		0.115
- Higher trainee (n = 46)	22 (19–25)		20 (19–23)		2 (2–3)	
- Basic trainee (n = 33)	19 (16–21)		22 (20–24)		2 (1–3)	
Last USG course within 2 years		0.236		0.255		0.988
- Yes (n = 45)	21 (19–24)		22 (19–24)		2 (2–3)	
- No (n = 105)	23 (19–26)		22 (19–24)		2 (2–3)	
Current instructor of USG course		<0.001		0.131		0.031
- Yes (n = 7)	33 (29–34.5)		25 (22.75–25)		3.5 (3–4.75)	
- No (n = 143)	22 (19–25)		22 (19–24)		2 (2–3)	
Current instructor of BLS/ACLS course		0.037		0.066		0.873
- Yes (n = 19)	24 (22.5–27)		23 (22–26)		3 (2–3)	
- No (n = 131)	22 (18–25)		22 (19–24)		2 (2–3)	
Received training/lecture on POCUS use during CA		<0.001		0.001		<0.001
- Yes (n = 68)	24 (21–27)		23 (21.25–25)		3 (2–4)	
- No (n = 82)	21 (17–24)		21 (18–23.25)		2 (1.25–3)	
Hospital capacity (taking daily attendance > or </ = 400 as reference number)		0.072		0.022		0.007
- Large hospital	24 (19–26)		23 (20–25)		3 (2–4)	
- Small hospital	22 (18.25–24.75)		21 (18.5–24)		2 (2–3)	

Note: *Data are shown as median (interquartile range).

Abbreviations: ACLS, advanced cardiovascular life support; BLS, basic life support; CA, cardiac arrest; EM, emergency medicine; POCUS, point-of-care ultrasound; USG, ultrasound.

(n = 91; 61%), worrisome of POCUS hindering the ACLS process (n = 87; 58%), insufficient mentorship or supervision (n = 79; 54%), and lack of confidence to achieve good quality ultrasound images (n = 79; 54%). On the contrary, less than half of the participants found the following reasons prevent them from using POCUS during OHCA: resistance from seniors or other members of staff (n = 36; 24%), lack of confidence to proceed for intervention even POCUS showed significant findings (n = 67; 45%), and ultrasound machines availability in resuscitation room (n = 71; 48%). Each written answer was reviewed by the authors and summarized.

4 | DISCUSSION

Point-of-care ultrasound (POCUS) is well recognized by multiple renowned medical institutions and experts as a useful diagnostic and prognostic tool in the

TABLE 4 Multiple regression (standardized) predicting practical composite score.

Predictor	Unstandardized coefficients (B) [95% CI]	Standard error of B	Standardized coefficients (β)	t statistic	*p* value
K Composite score	0.13 [0.09–0.16]	1.07	0.53	7.36	<0.001
A composite score	0.1 [0.06–0.15]	1.19	0.33	4.19	<0.001
EM experience	0.31 [−0.1–0.73]	1.25	0.12	1.49	0.138
Fellow status	0.6 [0.2–1.01]	1.22	0.24	2.95	0.004
USG course within 2 years	0.02 [−0.42–0.47]	1.26	0.01	0.11	0.914
USG course instructor	1.15 [0.14–2.17]	1.24	0.19	2.24	0.027
BLS/ACLS instructor	−0.04 [−0.65 to 0.57]	1.26	−0.01	−0.13	0.898
POCUS during CA training	0.87 [0.49–1.26]	1.18	0.35	4.49	<0.001
Hospital capacity	0.6 [0.2–1]	1.22	0.24	2.99	0.003

Abbreviations: A composite score, attitude composite score; ACLS, advanced cardiovascular life support; BLS, basic life support; CA, cardiac arrest; CI, confidence intervals; EM, emergency medicine; K composite score, knowledge composite score; POCUS, point-of-care ultrasound; USG, Ultrasound.

management of nontraumatic OHCA.[5–8] However, during resuscitation in an emergency scenario, performing POCUS simultaneously and interpreting the obtained images accurately are deemed challenging. Many potential drawbacks and physicians' barriers arise. By addressing and overcoming these problems, POCUS can be optimally utilized during OHCA to improve patient care.

An important aspect of resuscitation during OHCA is to identify reversible causes (mnemonic of 5H's and 5T's). POCUS is an essential tool to look for a number of these reversible causes, especially in pulseless electrical activity (PEA) rhythm, though its role in shockable rhythm is arguable.[10] Cardiac tamponade was reported to cause 4%–15% of all nontraumatic CA cases, while PE caused 7.6% of these cases.[14] In our questionnaire (Question 14), the two conditions that most participants would use POCUS to look for during OHCA were cardiac tamponade and evidence of PE (scoring ≥3, in the score range of 0–4, in 80% and 60% of the participants, respectively). Other less frequent findings were pneumothorax, size of IVC, and abdominal pathology. Theoretically, when the above findings are confirmed, relevant interventions, such as pericardiocentesis and thrombolysis, should be performed. Nevertheless, in practice, the confidence level of the EM physicians on their POCUS findings is considerably important as improper diagnosis with inappropriate intervention performed can lead to lethal consequences. In our questionnaire (Questions 3–6), we asked the participants to rate their confidence level in performing POCUS during non-critical situations, during 10-s pulse check with or without a CPR device (e.g., a Lund University Cardiopulmonary Assist System (LUCAS) device) in situ and during ongoing manual chest compression. Most of the physicians rated lower confidence level in resuscitation situations than in non-critical situations, which could be due to time constraints and insufficient sonographic window to perform high-quality ultrasound. Therefore, despite realizing that POCUS helps in identifying reversible causes during resuscitation, lack of confidence to achieve conclusive sonographic images and subsequently proceed with proper interventions is one of the major barriers.

Regarding this barrier, protocols (such as the "SESAME" and "CASA" protocols) have been developed to guide EM physicians on POCUS utilization during OHCA.[3,4] They suggest a standard flow to look for the highest yield findings in sequence. Standard probes and sonographic windows are also suggested. Unexpectedly, 66% of responded EM physicians had never heard of the two protocols mentioned above (Question 8). However, over 80% of all respondents thought following a protocol on POCUS use is helpful in resuscitation situations. The underlying reasons being these guidelines help EM physicians to obtain better quality and more important clinical information without delaying the standard ACLS progress.[3,4,15] Therefore, in the future, implementing a standard protocol for POCUS utilization during OHCA in our locality should be considered.

The presence of cardiac activity on POCUS in nontraumatic, non-shockable CA patient was associated with improved odds for ROSC, survival-to-hospital admission, and survival-to-hospital discharge.[15–17] A study in the United States involving 169 patients showed no patient with sonographically identified cardiac standstill survived to leave the ED regardless of the initial electrical rhythm.[18] In Questions 9d and 14g of our questionnaire, high proportion of EM physicians frequently used POCUS during OHCA to look for

cardiac contractility and they perceived POCUS could help in determining termination of resuscitation. Moreover, a number of them indicated that they usually attempted POCUS at the stage of deciding the termination of resuscitation (Question 17). However, the REASON trial, a large multi-center, prospective observational study, showed that 0.6% (95% CI 0.3–2.3) of CA patients with no cardiac activity on POCUS could still survive to discharge.[19] Therefore, solely using POCUS for prognostication during CPR should be avoided.[11]

Another application of POCUS during OHCA is pulse checking. Manual pulse check can sometimes be difficult to perform due to patient habitus, performers' technique and distracting environment. A randomized controlled study done in 2019 showed that the time needed for carotid pulse detection in live subjects was not slower using POCUS compared to manual palpation. The study also demonstrated higher first attempt success rate and less variability in measurement times when using POCUS.[20] Moreover, manual pulse checking has poor sensitivity in patients with profound shock.[15,21] Pseudo-PEA, a severe shock state that is distinct from true electro-mechanical dissociation, is often missed without the help of POCUS. Its management could be different from conventional CA[22]. In our questionnaire (Question 14h), more than 60% of the participants had never or very rarely looked for carotid pulse using ultrasound with Doppler mode, implying this POCUS application is much overlooked. Therefore, it is crucial to advocate this application to EM physicians in Hong Kong, especially when they are handling a potential Pseudo-PEA condition.

The objective of our study is to identify the relationships between the KAP of EM physicians in Hong Kong on POCUS utilization during OHCA. Spearman's correlation tests and multiple regression modeling showed that knowledge and attitude had positive correlations and are predictive of the practice of POCUS during OHCA. Therefore, by increasing the specialist knowledge, confidence, and comfort for EM physicians, there would likely be a more frequent use of POCUS during OHCA. One way to increase their knowledge would be to provide specialty training, lectures or sharing on this topic. We can see in our questionnaire that those EM physicians received training or lecture on this topic have all KAP composite scores higher than the other participants.

The barriers of EM physicians to perform POCUS during OHCA can be divided into personal barriers and departmental barriers. Two personal barriers mentioned above are the lack of confidence in achieving good ultrasound images and the lack of confidence in delivering subsequent interventions. Another personal barrier is the lack of structural education on this practice (63%). From Table 3, the KAP composite scores of those received specialty training or lectures were statistically significant, while the scores of those receiving ultrasound course within 2 years were not statistically significant. Therefore, we should not expect that the existing routine ultrasound course would lead to more frequent POCUS utilization during OHCA. Instead, more specific lectures or structural training focusing on what, when, why, and how to perform POCUS during OHCA should be offered. Adding topics on "POCUS in CA" into current ultrasound course is also advised.

For departmental barriers, most participants found that the chaotic environment in the resuscitation room was a barrier. When managing an OHCA case, there is limited space to place an ultrasound machine beside the patient and there is no stable environment for the EM physicians to perform POCUS neatly. This condition is intrinsically unavoidable due to the level of urgency. It is important for the physicians to communicate with other staff members and voice out their needs when they are trying to perform POCUS on OHCA patients. Another departmental barrier was the lack of staff during resuscitation. The initial managements including securing the airway, setting up an intravenous assess for medication and chest compression take priority over other matters. As a significant amount of manpower is already taken up by these procedures, performing POCUS will need to be delayed if no additional physician is available. Therefore, it is advised to deploy an additional emergency physician in the resuscitation team specifically for performing POCUS if resources allow.

5 | LIMITATIONS

This study had a number of limitations. The first limitation is the questionnaire content. There was one questionnaire on similar topic found in American Journal of EM but we could not adopt the whole content as the situation in the United States was different from that in Hong Kong. In addition, the questionnaire was not externally validated either. The questionnaire was designed based on a few studies concerning similar topics and authors' experience. To improve the quality of the questionnaire used for this study, 5 senior EM specialists were invited to provide expert opinions and the Content Validity Index was assessed.

Secondly, the questionnaire relied on physicians reporting on self-assessed competencies and confidence levels. Reporting bias may exist, in which, over-reporting of socially desirable behaviors is well-known in various questionnaire studies. The reported answers in the attitude and practice categories might be overrated. Reviewing the AED records for OHCA cases and counting any documented POCUS findings would be a more objective way to assess EM physicians' practice, but this is very time-consuming and may raise

medical privacy issues. Moreover, only CASA protocol and SESAME protocol were mentioned in the questionnaire. Although they were two commonly discussed protocols on this issue, some physicians might know about other protocols instead and this led to under-reporting.

Thirdly, the KAP questions were set in five-point Likert scales for easy calculation of composite scores. This grading was set based on our understanding and we tried to divide the answers into 5 levels equally. This arbitrary scale was another limitation of this study.

Another limitation was that the response rate was 67.0%, which was borderline satisfactory. Nonetheless, a sample size calculation was done and the calculated accuracy using Slovin's formula was 93.3%. Moreover, this was a local study involving only nine hospitals in Hong Kong. Further research is required to assess the representativeness and generalizability of the study results.

6 | CONCLUSIONS

POCUS is as a useful diagnostic and prognostic tool used during the management of OHCA. In our study, the knowledge and attitude of performing POCUS during OHCA were demonstrated to enhance EM physicians' practice. By improving physicians' knowledge and removing the possible barriers they are facing, POCUS can be optimally utilized during OHCA to improve patient care.

AUTHOR CONTRIBUTIONS

Kwong Tat Lo: Study concept and design, Acquisition of data, Analysis and interpretation of data, Drafting of the manuscript, Critical revision for important intellectual content. **Chun Hei Kwok**: Analysis and interpretation of data. **Kenneth Kin Wing Suen**: Study concept and design, Critical revision for important intellectual content. All authors had full access to the data, contributed to the study, approved the final version for publication, and take responsibility for its accuracy and integrity.

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CONFLICT OF INTEREST STATEMENT

On behalf of all authors, we had no conflict of interest to disclose. No authors, or their institution, have received grants, consulting fees or honoraria, supporting for meeting travel, fees for participation in review activities such as data monitoring boards or statistical analysis, payment for writing or reviewing the manuscript, or provision of writing assistance, medicines, equipment, or administrative support. There were no financial relationships in the past 36 months with entities in the biomedical arena that could be perceived to influence, or that give the appearance of potentially influencing, in the submitted work. The authors have no conflict of interest to disclose.

AUTHORSHIP

All authors have read and approved the manuscript and the work is original and not plagiarized. There were no professional writing assistant nor other individual paid to provide manuscript support. Nobody except the listed authors had control over the data, over how the data were analyzed or interpreted, or over the wordings or conclusions used in the manuscript.

PRIOR OR SIMILAR PUBLICATIONS

There was no prior version of this manuscript submitted.

ORIGINAL RESEARCH

This manuscript was a questionnaire study which does not involve patients.

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DECLARATION

This paper was presented to the Education Committee of the Hong Kong College of Emergency Medicine during the Scientific Symposium on Emergency Medicine (SSEM) on 28 October 2023 for examination purpose.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

This study was approved by the Central Institutional Review Board (Central IRB Ref. No.: CIRB-2023-103-3). The study protocol conformed to the ethical guidelines of the Declaration of Helsinki. Verbal informed consent was obtained from each participant included in this study.

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PEER REVIEW

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.