Point-of-Care Ultrasound Training Among Intensivists in Singapore: A Multicentre Survey

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Abstract

Introduction: Point of care ultrasound (POCUS) has become essential in the management of critically ill patients. Multiple POCUS training courses exist, but are not widely adopted in Singapore. Given the discordance between training supply and demand, we aimed to uncover the learning needs and barriers among intensive care medicine (ICM) doctors locally. Materials and Methods: An anonymous online survey was carried out from January to April 2019 among ICM doctors from 6 major teaching hospitals in Singapore. Results: 66 out of 160 ICM specialists and trainees responded (41.3%). Although only 6% of respondents had current formal POCUS accreditation, the majority were already using critical care echocardiography (CCE) and pleural/ lung ultrasound. 93% supported having a local training programme. More than 50% of trainees wanted training in CCE, diaphragm/muscle ultrasound, airway ultrasound and ultrasound for neurological disease. More than 50% of specialists wanted training in diaphragm/muscle ultrasound, with mixed interests in other topics. The top 2 obstacles hindering POCUS training were lack of supervisors and locally based programmes. Conclusions: ICM doctors who responded were supportive of a local POCUS training programme. The programme’s curriculum should address the learning needs of the majority of learners, with diaphragm/muscle ultrasound being the top unmet need. The programme would need to develop supervisors and be as affordable as possible.

Key words: Continuing medical education, Cross-sectional survey, Intensive Care, Ultrasound

Introduction

Point-of-care ultrasound (POCUS) has become an essential tool for managing critically ill patients. Systematic application of POCUS techniques such as critical care echocardiography (CCE) and lung ultrasound may change or confirm a diagnosis in more than 80% of cases, decrease utilisation of chest X-ray and computed tomography scans, reduce mechanical ventilation duration and assist with haemodynamic optimisation and intravenous fluid titration. 1, 2 In cardiac arrest situations, protocolised focused ultrasound provided diagnostic information and altered management in 78% of patients. 3
Transthoracic echocardiography (TTE) and general ultrasound have traditionally been done, respectively, by cardiologists and diagnostic radiologists. Several drawbacks of the traditional arrangement exist. Firstly, ultrasound scans are often not contemporaneous and cannot help answer urgent clinical questions or directly influence the immediate treatment. Secondly, ultrasound image acquisition and reporting are separated, which hinders clinical correlation. Thirdly, it is not easily repeatable and is not suitable for tracking therapeutic responses or rapid clinical changes. Given the drawbacks of the traditional arrangement, managing intensivists should learn and apply POCUS at the bedside. International experts agree that general POCUS and basic CCE should be mandatory in the ICM training curriculum. Worldwide, assessment tools for CCE, and guidelines for training and competency in POCUS have been developed. However, no standardised curriculum has been universally adopted. For instance, a comparison of POCUS training programmes in Europe showed that there was a lack of agreement among five accreditation programmes.

Multiple courses and postgraduate programmes for POCUS training exist, such as the World Interactive Network Focused On Critical UltraSound (WINFOCUS), Rapid Assessment by Cardiac Echo (RACEplus) or Certificate in Clinician Performed Ultrasound (CCPU) by the Australasian Society for Ultrasound in Medicine (ASUM), but none has been widely adopted. For instance, a comparison of POCUS training programmes in Europe showed that there was a lack of agreement among five accreditation programmes.

Materials and Methods

Data Collection

Ethics approval was exempted by the National Healthcare Group-Domain Specific Review Board (2018/01134). Thereafter, we conducted an anonymous online survey of intensive care medicine (ICM) specialists and trainees in all 6 major teaching hospitals of Singapore. “Specialists” were defined as practising intensive care physicians who were accredited by the Singapore Specialist Accreditation Board and registered as such by the Singapore Medical Council. “Trainees” were defined as doctors who were undergoing specialist training in intensive care and had yet to complete the local exit examination. Data was collected between January and April 2019. A web-based online survey platform (SurveyMonkeyTM) was used. This platform was accessible only by the principal investigator, and the data were anonymised and encrypted. No financial support was received from any source. Participants were emailed the invitation to the survey via members of the study team, who were representatives of the ICUs in their respective hospitals. Reminders were sent via email and phone about 1 and 3 months after the initial invitation. Participants did not receive any renumeration for their participation.

Survey Construction

All members of the study team were certified intensive care specialists who perform and teach POCUS. The survey was primarily designed by 2 authors with every member of the study team providing feedback. Using a consensus approach, there were 3 rounds of email discussions and one in-person meeting to select the final 50 questions (see Supplement 1). The survey was then divided into 7 sections:

1. Demographics and characteristics of respondents
2. Current resources and usage
3. Individual practice
4. Individual training in POCUS
5. Perceived obstacles
6. Willingness to pay
7. Future practice and formal competency assessment needs

Sections of the survey pertaining to individual practice were designed with a 4-point Likert scale to assess frequency of performing POCUS or the level of agreement to statements, such as “daily”, “several times a week”, “hardly ever or never”, “strongly disagree”, “disagree”, “agree and “strongly agree”.

Abdominal ultrasound included FAST (Focused Abdominal Sonography in Trauma). Ultrasound for neurological disease included ultrasound to assess optic nerve sheath diameter (ONSD) or cerebral circulation. Ultrasound for vascular diagnostics included screening for abdominal aortic aneurysm or deep vein thrombosis.
Statistical Analysis

Categorical variables were presented as absolute numbers and percentages. Where statistical analysis to compare percentages was done, Fisher’s exact test was used. Thematic analysis was done by the first and last authors using the free text comments for the following question: “Any other ideas on how to implement critical care ultrasound training”. Missing data were not imputed.

Results

Demographics and Characteristics of Study Respondents

One hundred and sixty ICM specialists and trainees received the survey invitation, and 66 responded (response rate 41.3%) (Table 1). 57.6% of respondents were male, and the mean age was 38.8 years (standard deviation 7.3 years). Of the respondents, 13 (19.7%) were trainees and 53 (80.3%) were specialists. 11 (18%) respondents were participating in POCUS training programmes as faculty.

Current Resources and Usage

All 66 respondents had access to an ultrasound machine dedicated for use in the ICU (Table 2). 57 (89%) were familiar with the machines available in their department. For the majority of POCUS scans, the respondents did not record static, cine clips or reports in the electronic health records. Specifically, if recorded, 28 (42.4%) would only store POCUS reports, 36 (54.5%) static clips and 36 (54.5%) cine images in the ultrasound machine and not in picture archiving and communication systems (PACS), paper or electronic medical records. Thirteen (19.7%) reported that they would also save POCUS reports in electronic health records.

Individual Practice

All 66 respondents used real-time ultrasound to guide central venous catheter (CVC) insertion. Ultrasound for vascular access, CCE, and pleural/lung ultrasound were the most common types of POCUS scans done (Figure 1). For new admissions, the commonest

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Table 1. Characteristics of Respondents

| Years after graduation from basic medical degree | All respondents n=66 (%) |
|-----------------------------------------------|-------------------------|
| 1 to 5                                        | 3 (4.5)                 |
| 6 to 10                                       | 21 (31.8)               |
| 11 to 15                                      | 15 (22.7)               |
| 16 to 20                                      | 11 (16.7)               |
| 21 to 25                                      | 12 (18.2)               |
| 26 to 30                                      | 3 (4.5)                 |
| 31 to 35                                      | 1 (1.5)                 |

| Years since obtaining Intensive Care qualifications | All respondents n=66 (%) |
|------------------------------------------------------|-------------------------|
| 1 to 5                                               | 23 (34.8)               |
| 6 to 10                                              | 10 (15.2)               |
| 11 to 15                                             | 10 (15.2)               |
| 16 to 20                                             | 4 (6.1)                 |
| Not applicable (currently still training)            | 19 (28.8)               |

| Primary (base) specialty                             | All respondents n=66 (%) |
|------------------------------------------------------|-------------------------|
| Anaesthesiology                                     | 31 (47.0)               |
| Respiratory Medicine                                | 28 (42.4)               |
| General Medicine                                    | 6 (9.1)                 |
| Emergency Medicine                                  | 1 (1.5)                 |

| Completed an official ICM fellowship, local or overseas | All respondents n=66 (%) |
|---------------------------------------------------------|-------------------------|
| Yes                                                     | 40 (60.6)               |
| No                                                      | 7 (10.6)                |
| Not applicable (currently training)                    | 19 (28.8)               |

| Types of ICUs                                         | All respondents n=66 (%) |
|-------------------------------------------------------|-------------------------|
| Mixed medical and Surgical                            | 13 (20.3)               |
| Medical                                               | 27 (42.2)               |
| Surgical (general surgical, burns, neurosurgical)     | 24 (37.5)               |

ICM: Intensive Care Medicine, ICU: Intensive Care Unit
Table 2. Current POCUS Resources

| Resources                                      | n = 64 (%)* |
|------------------------------------------------|-------------|
| **Ultrasound machine dedicated for use in the ICU** |             |
| No                                            | 0 (0)       |
| Yes, but unsure about specifications          | 1 (1.5)     |
| Yes, without continuous and pulse-wave doppler imaging | 8 (12.5)   |
| Yes, with continuous, pulse-wave, but not tissue doppler | 27 (42.2) |
| Yes, with continuous, pulse-wave and tissue-doppler | 29 (45.3) |
| Not answered                                  | 2 (3.1)     |
| **Payoffs for POCUS scans**                   |             |
| None                                          | 28 (42.4)   |
| Only for institution or unit                  | 13 (19.7)   |
| Only for physician                            | 0 (0)       |
| For both institution or unit and physician    | 5 (7.6)     |
| Unknown                                       | 18 (27.3)   |

* n = 2 missing data  
ICU: Intensive care unit  
POCUS: Point-of-Care ultrasound

Fig 1. Most Common Types of POCUS Scans
POCUS performed was CCE (60/66, 90.9%) and pleural/lung ultrasound (52/66, 78.8%). Three (4.5%) responded that they did not routinely perform POCUS of any form for new admissions. Sixty-one (92.4%) agreed that the application of POCUS frequently changed the real-time management of ICU cases under their care; the 5 (7.6%) respondents who disagreed were all specialists. Prior to performing a percutaneous tracheostomy, among 31 respondents, 19 (61.3%) reported doing airway ultrasound routinely.  

**Individual Point-of-Care Ultrasound Training**  
POCUS or CCE courses attended by respondents included World Interactive Network Focused On Critical UltraSound (WINFOCUS) course (n=24), RACEplus course (n=23), Basic Assessment and Support in Intensive Care (BASIC) Transthoracic echocardiography course (n=18), the National Heart Centre Coronary Care Unit Symposium (n=5), and pre-conference workshops of international ICM congresses (n=27).  

Twenty-one out of 66 (32%) respondents had previous formal full TTE training, defined as having direct supervision for a stipulated minimum number of full TTE scans, by an accredited supervisor/sonographer. The commonest type of POCUS respondents received formal training in was CCE 42/64 (63.6%), followed by pleural/lung ultrasound 27/64 (40.9%), ultrasound for vascular access 21/64 (31.8%) and FAST 15/64 (22.7%). Less than 10% of respondents said they received training in each of the other types of POCUS (transoesophageal echocardiography (TEE), airway, abdominal/obstetric, diaphragm/muscle, ultrasound for neurological diseases). None received training in joint/bone ultrasound.  

Only 7 (6%) out of 62 respondents had current POCUS accreditation, such as Diploma in Clinical Ultrasound, European Association of Echocardiography/European Association of Cardiovascular Imaging (EAE/EACVI) TEE, Focused Intensive Care Echocardiography (FICE), or Postgraduate Certificate in Clinical Ultrasound. Two out of 66 (3%) answered that formal renewal of credentialing in POCUS was required by their institution. The median number of full TTE scans done by the respondents was 0 (range 0 to >100). In contrast, the median number of CCE scans done was 40 (range 0 to >100). Within the scope of CCE, 80.6% and 74.2% of respondents were comfortable with image acquisition and image interpretation, respectively. With regard to POCUS (including other types of scans, not just limited to CCE), 85.5% of respondents were confident with POCUS with clinical management. Fifteen (22.7%) stated that there was no need for competency assessment for management at the bedside.  

**Perceived Obstacles**  
The survey included a section on what respondents perceived as obstacles to advancing their own training in POCUS, and to explore the challenges that may arise in a future training programme. Of the 66 responses, the commonest obstacles reported were “lack of supervisors” (n=59, 89.4%), “programmes are only available overseas” (N=39, 59.1%), “lack of storage for clips and images” (n=20, 30.3%), “lack of time to scan” (n=20, 30.3%), “medico-legal implications” (20/66, 30.3%) and “inadequate knowledge” (n=18, 27.3%). Free text comments given were: “lack of time away from clinical and administrative work”, “lack of dedicated framework to allow to work towards an external accreditation” and “to be certified, need for adequate supervisor framework to log scans and more importantly to teach and improve technique”.  

**Willingness to Pay**  
For initial training and competency assessment, assuming it takes one year, respondents were willing to commit a median of 50 Singapore dollars (SGD) (range SGD0–200). The median number of hours per month a learner can commit to training was 12 hours (range 1 to 60 hours). For re-accreditation, assuming it is needed every 5 years, the median sum respondents were willing to commit was SGD32 (range SGD0–478).  

**Future Training and Competency Assessment Needs**  
Fifty-three respondents (93%) agreed that there was a need for a local POCUS training programme. Fifty-seven (72%) respondents agreed that there was a need for formal competency assessment in POCUS, while 4 (7%) disagreed.  

Regarding what respondents would like to receive formal training for, the top 2 choices overall were CCE (n=38), and diaphragm/muscle ultrasound (n=28). There were differences in what trainees and specialists wanted to receive for training (Table 3). Regarding which areas of POCUS respondents would like to receive formal competency assessment for, the top 3 choices were CCE (n=46), pleural/lung ultrasound (n=29) and vascular diagnostics (n=20).  

**Thematic Analysis on How to Implement POCUS Training**  
When surveyed on the preferred platforms for acquiring content knowledge, the majority indicated
that they preferred in-person lectures (40/66, 60.6%), web-based lectures (35/66, 53.0%), internet-based applications (26/66, 39.4%) and YouTube\textsuperscript{TM} (17/66, 25.8%). Only 1 respondent opted for social media such as Facebook\textsuperscript{TM} or Twitter\textsuperscript{TM}. Other respondents (7/66, 12.2%) suggested learning from books and on-the-job training. Thematic analysis was done for the qualitative free text comments on how to implement POCUS training, revealing themes associated with accessibility, curriculum and credibility (Table 4).

**Discussion**

**Key Findings**

One hundred and sixty ICM specialists and trainees received the survey invitation, and 66 responded (41.3%). Although only 6% of respondents had current formal POCUS accreditation, the majority of ICM doctors were already using it frequently. Ninety three percent supported having a local training programme. Additional POCUS training requested but not frequently available now were TEE, airway and diaphragm/muscle ultrasound. More than 50% of trainees wanted training in CCE, diaphragm/muscle ultrasound, airway ultrasound, and ultrasound for neurological disease. More than 50% of specialists wanted training in diaphragm/muscle ultrasound, with mixed interests in other topics. Training in ultrasound for vascular access was not highly requested, likely because it is part of base-specialty training (such as in Anaesthesiology or Respiratory Medicine), prior to entering ICM training. The top 2 obstacles hindering formal POCUS training were lack of supervisors and locally based programs.

**Relation to Previous Literature**

All respondents had access to an ultrasound machine dedicated for use in the ICU, which is more than ICUs in Brazil, 64%\textsuperscript{11} and 83–95% in USA.\textsuperscript{12} All the respondents used real-time ultrasound for CVC insertion, which is in line with international guidelines.\textsuperscript{13} 85% and 83% of respondents here reported using CCE and lung ultrasound, respectively, at least several times a week during their ICU practice, which is similar to ICUs in Australia (94% and 83% respectively).\textsuperscript{10} The 3 most common POCUS modalities in ICUs locally (CCE, lung ultrasound and ultrasound for CVC insertion) were slightly different from USA (procedural guidance, vascular access, CCE),\textsuperscript{12} or Brazil where lung ultrasound was only performed by 8.5%.\textsuperscript{11}

The majority of respondents had exposure to 1 to 2-day training courses, but far fewer had exposure to formal training programmes, board examinations or overseas diploma programmes with remote supervision. This is unlike respondents from Australian ICUs who predominantly had training through courses by ASUM or diploma courses,\textsuperscript{10} or USA, who had training through national programmes.\textsuperscript{12}

| Table 3. Requests for formal training |
|--------------------------------------|
|                                    | All n=66 (%) | Trainee n=19 (%) | Specialist n=47 (%) | P-value |
| CCE                                 | 38 (57.6)    | 17 (89.5)        | 21 (44.7)           | 0.001   |
| Diaphragm and muscle ultrasound     | 38 (57.6)    | 14 (73.7)        | 24 (51.1)           | 0.108   |
| Airway ultrasound                   | 27 (40.9)    | 12 (63.2)        | 15 (31.9)           | 0.028   |
| Ultrasound for Vascular diagnostics | 27 (40.9)    | 9 (47.4)         | 18 (38.3)           | 0.584   |
| Ultrasound for Neurological disease | 27 (40.9)    | 12 (63.2)        | 15 (31.9)           | 0.028   |
| TEE                                 | 25 (38.9)    | 5 (26.3)         | 20 (42.6)           | 0.270   |
| Abdominal or obstetric ultrasound   | 24 (36.4)    | 9 (47.4)         | 15 (31.9)           | 0.268   |
| Pleural and lung ultrasound         | 24 (36.4)    | 11 (57.9)        | 13 (27.7)           | 0.027   |
| Ultrasound for Joints, bones, soft tissue | 18 (27.3)    | 6 (31.6)        | 12 (25.5)           | 0.761   |
| Ultrasound for vascular access      | 12 (18.2)    | 5 (26.3)         | 7 (14.9)            | 0.304   |

CCE: Critical care echocardiography
TEE: Transesophageal echocardiography
Table 4. Thematic analysis for comments on “any other ideas on how to implement POCUS training”

| Theme                      | Sub-theme                              | Number of comments | Verbatim comments                                                                 |
|----------------------------|----------------------------------------|--------------------|------------------------------------------------------------------------------------|
| Accessibility              | Increase training opportunities        | 7                  | Regular training at CME                                                             |
|                            |                                        |                    | Regular series of lectures                                                          |
|                            |                                        |                    | Have more courses in Singapore                                                     |
|                            | Increase mentor availability           | 2                  | More mentors, especially those that implement POCUS in their daily practice         |
|                            |                                        |                    | “Grand-father” clause for those who are already doing and train the rest of the intensivists first |
|                            | Accessibility                          | 2                  | More machines/more machines dedicated to training in echocardiography              |
|                            |                                        |                    | Use ultrasound probes that can connect to the handphone                             |
|                            | Protected time                         | 2                  | Departmental support to release trainers/trainees for teaching/learning            |
|                            |                                        |                    | Dedicated bedside teaching by a dedicated supervisor in normal, ward and ICU patients once to twice a week |
|                            | Make training affordable               | 3                  | Has to be inexpensive                                                              |
|                            |                                        |                    | Institution sponsored training                                                     |
|                            | Provide online learning resources      | 3                  | Educational videos on SICM website                                                  |
|                            |                                        |                    | Online based learning with submission of cases                                     |
|                            |                                        |                    | Online e-learning module and training videos                                       |
|                            | Curriculum                             | 13                 | Have a structured syllabus                                                         |
|                            | Standardise teaching and assessment    |                    | Make it part of ICM training/required competency. Integrate it into residency training for Anaesthesiology, Respiratory medicine or internal medicine |
|                            |                                        |                    | A framework whereby time can be set aside for training and whereby scans can be recorded then assessed by a suitable person |
|                            |                                        |                    | Create a competency checklist                                                      |
|                            |                                        |                    | Standardised curriculum—too many different courses                                |
|                            |                                        |                    | Standardised reporting. Move towards formal credentialing                           |
|                            |                                        |                    | Initial teaching followed by regular bedside practice with supervision. Teaching in terms of attending course and workshop will not make one competent in doing so, it is regular practice at bedside that makes one competent |
|                            | Provide hands-on practice              | 1                  | Have competency maintenance                                                        |
|                            | Provide continuing education           | 1                  | Have refresher courses                                                             |
| Credibility                | Ensure competency of teachers          | 3                  | Tap on cardiologists, echocardiographers for training; apprentice to sonographers  |
|                            |                                        |                    | Having appropriately trained mentors                                               |
|                            |                                        |                    | Determine who can assess competency for trainees                                   |
|                            | Collaborate with external accreditation bodies | 2                  | Credentialing first and collaboration with accredited body                         |
|                            |                                        |                    | Conjoint accreditation of critical care ultrasound training with international training bodies would enhance buy-in for the training programme |
|                            | Avoid excessive regulation             | 1                  | Should not have reaccreditation. Waste of time                                     |

CME: Continuing Medical Education; ICU: Intensive Care Unit; ICM: Intensive Care Medicine; POCUS: Point-of-care Ultrasound; SICM: Society of Intensive Care Medicine (Singapore)
The majority of respondents stated “lack of standardised competencies”, “lack of supervisors” and “training programmes are only available overseas” as the top barriers to embarking on formal training. This is similar to studies done in other regions. Locally, among internal medicine physicians, lack and cost of an ultrasound machine were also significant barriers to learning. Importantly, lack of equipment or resistance from other ultrasound providers did not appear as one of the barriers in this survey. Lengthy and costly overseas programmes may not be necessary for competency in specific areas of POCUS, such as pleural and lung ultrasound or CCE. Local learners want to do things cheaply and quickly, not aligning with most international curricula.

**Study Implications**

Currently in Singapore, POCUS training is not mandatory for specialty accreditation in ICM. Nonetheless, almost all respondents agreed there is a need for a local POCUS training programme and formal competency assessment, which is in agreement with international statements on training standards for POCUS in ICU.

More respondents were comfortable with image acquisition than with image interpretation for CCE, which confirmed that CCE needs special attention to training, as it has been shown that individual domains of CCE are picked up differentially.

While overall learning needs may be similar across various populations, some local differences would exist. Hence, training cannot depend entirely on a common global curriculum; local modifications and enhancements would be necessary.

Respondents’ suggestions on ways to improve POCUS training locally included: having a structured curriculum; and, after having attended courses, having continued supervision by trained mentors in the hospital. Respondents still wanted in-person lectures and teaching. Given the above, web-based teaching will not fulfil learning needs. Teaching and faculty development need to be done locally. Respondents asking for protected time to learn is an indicator of the reality of POCUS practice. As such, for training to succeed in an authentic clinical environment, supervision and learning needs to be like teaching bedside physical examination and storage needs to be point-of-care.

**Strengths and Limitations**

This is the first nation-wide survey in an Asian country on the practice of POCUS amongst ICM physicians. The limitations of this study include a low moderate response rate of 41.3%, which may affect the representativeness of the results. However, this is comparable to email survey response rates in other medical publications. Participation bias is possible as physicians who use POCUS regularly may be keener to participate in the survey. Based on this survey, ICM specialists appear to want a programme, but with only 19.7% of respondents being ICM trainees, the sample may be too small to confidently determine their interest.

**Conclusions**

Our survey showed that ICM physicians who responded were supportive of a local POCUS training programme. The programme’s curriculum should include modules that address the learning needs for the majority of trainees and intensivists, diaphragm/muscle ultrasound being the top unmet need. Additionally, the programme would need to develop supervisors and be as affordable as possible.

**REFERENCES**

1. Pontet J, Yic C, Diaz-Gómez JL, Rodríguez P, Sviridenko I, Méndez D, et al. Impact of an ultrasound-driven diagnostic protocol at early intensive-care stay: a randomized-controlled trial. Ultrasound J. 2019 Sep 30;11(1).

2. Zieleskiewicz L, Muller L, Lakhal K, Meresse Z, Arbelot C, Bertrand P-M, et al. Point-of-care ultrasound in intensive care units: assessment of 1073 procedures in a multicentric, prospective, observational study. Intensive Care Med 2015 Sep;41(9):1638–47.

3. Breitkreutz R, Price S, Steiger H V, Seeger FH, Ilper H, Ackermann H, et al. Focused echocardiographic evaluation in life support and peri-resuscitation of emergency patients: A prospective trial. Resuscitation. 2010 Nov;81(11):1527–33.
1. Your age (in years)*
   - 1-5
   - 6-10
   - 11-15
   - 16-20
   - 21-30
   - 31-40
   - 41-50
   - 51-60
   - 61-65
   - 66 or older

2. Your gender
   - Female
   - Male

3. Years after graduation from basic medical degree
   - Less than 5
   - 5-10
   - 11-15
   - 16-20
   - 21-25
   - 26-30
   - 31-35
   - 36-40
   - 41-45
   - 46-50
   - 51-55
   - 56-60
   - 61-65
   - 66 or older

4. Are you doing ICM Advanced specialty training currently?
   - Yes
   - No

5. Primary specialty
   - Anaesthesiology
   - Cardiology
   - Emergency Medicine
   - General Internal Medicine
   - Hospice Medicine
   - Other Primary specialty

6. Completed ICM Fellowship (eg ICM-AST, overseas HIMDF or the equivalent)
   - Yes
   - No

Other Primary specialty

5. Primary specialty

4. Are you doing ICM Advanced specialty training currently?

3. Years after graduation from basic medical degree

2. Your gender

1. Your age (in years)*

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**Supplement 1. Online Survey Form**

Dear esteemed colleagues,

On behalf of Society of Intensive Care Medicine—National Investigator for Clinical Epidemiology and Research (SICM-NICER), we would like to invite you to spend 10 minutes to participate in this survey. The purpose of this survey is to study the current practice of Critical care ultrasonography (CCUS) by Intensive Care Specialists and Trainees in Singapore, to understand the resources available for training and the current learning needs. As a research study we aim to contribute to the growing literature on CCUS and aim to publish our findings in due course.

Participation in this survey is anonymous and voluntary. We deeply appreciate your time in completing this survey as it will give us valuable insights into developing Critical care ultrasonography training and research in Singapore. Proceeding to the next page of the survey implies consent to participate in this study. This survey is conducted solely for the purposes of research and is not part of competency assessment. Once again, we thank you sincerely for your time.

Warm regards,

The SICM Ultrasound for Practice Enhancement in Real-time at the Bedside Collaboration (SUPERB) study team

Drs Lau Yie Hui, See Kay Choong, Sean Loth, Shala Siddiqui, Tan Chee Keat, Chia Yew Woon, Claudia Tien, Jonathan Tan

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**Survey Questions**

1. Were you able to complete the entire survey in 10 minutes?
   - Yes
   - No

2. Do you agree to participate in this survey?
   - Yes
   - No

3. Would you be interested in participating in future surveys?
   - Yes
   - No

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**Survey Form**

Table: POCUS Among Singapore Intensivists—Yie Hui Lau et al
### Current resources and usage

| Question | Options |
|----------|---------|
| 1. Ultrasound machine dedicated for use in the ICU available? | No, Yes, with continuous and pulsed wave Doppler imaging, Yes, with continuous and pulsed wave Doppler, but not tissue Doppler, Yes, with continuous, pulsed wave and tissue Doppler, Other (please specify) |
| 2. I'm familiar with the use of ultrasound machines currently available in the department (for any type of scan)? | Strongly disagree, Disagree, Agree, Strongly agree |
| 3. Storage of CCUS report (tick all that apply) | None, Stored in the ultrasound machine, Stored in the paper-based medical record, Stored in the electronic health record, Stored in the picture archiving and communication system (PACS) |
| 4. CCUS recording of static clips (tick all that apply) | None, Stored in the ultrasound machine, Stored in the paper-based medical record, Stored in the electronic health record, Stored in the picture archiving and communication system (PACS) |
| 5. CCUS recording of cine images (tick all that apply) | None, Stored in the ultrasound machine, Stored in the paper-based medical record, Stored in the electronic health record, Stored in the picture archiving and communication system (PACS) |
| 6. Payoffs | None, Only for institution/unit, Only for physician, For both institution/unit and physician, Unknown |
| 7. Place of work | Private, Public |
| 8. Number of Intensive care beds in the unit (excluding high dependency beds) |
| 9. Number of high dependency beds in the unit (under the care of an intensivist) |
| 10. What patient demographic does your ICU cater to? | Paediatric, Adult, Mixed (adults and paediatrics) |

### 7. Years since obtaining Intensive Care qualifications
- 1-5
- 6-10
- 11-15
- 16-20
- 21-25
- 26-30
- 31-35
- >35
- Not applicable (currently still in training)
**Individual practice**

1. I routinely use real-time Ultrasonography for CVP insertion
   - Yes
   - No

2. How often do you perform CCE (Critical care echocardiography) in your daily practice?
   - Daily
   - Several times a week
   - Hardly ever
   - Never

3. How often do you perform TEE (Transesophageal echocardiography) in your ICU practice?
   - Daily
   - Several times a week
   - Hardly ever
   - Never

4. How often do you perform Pleural and lung US in your ICU practice?
   - Daily
   - Several times a week
   - Hardly ever
   - Never

5. How often do you perform Ultrasonography for Diaphragm and muscle in your ICU practice?
   - Daily
   - Several times a week
   - Hardly ever
   - Never

6. How often do you perform Abdominal ultrasound (including FAST) /obstetric in your ICU practice?
   - Daily
   - Several times a week
   - Hardly ever
   - Never

7. How often do you perform Ultrasonography for Vascular access in your ICU practice?
   - Daily
   - Several times a week
   - Hardly ever
   - Never

8. How often do you perform Vascular diagnostics (AAA, DVT) in your ICU practice?
   - Daily
   - Several times a week
   - Hardly ever
   - Never

9. How often do you perform Neurological Ultrasound (ONSD, cerebral circulation) in your ICU practice?
   - Daily
   - Several times a week
   - Hardly ever
   - Never

10. How often do you perform Ultrasonography for Joints, bones and soft tissue in your ICU practice?
    - Daily
    - Several times a week
    - Hardly ever
    - Never

**Critical care ultrasound training**

1. Previous CCUS courses attended (check all that apply)
   - WINFOCUS
   - BASIC TTE
   - RACEPLUS
   - NHC CCU SYMPOSIUM
   - Others: eg Other preconference workshops

2. Formal* Echocardiography attachments / electives / training (eg with Cardiology / during ICM fellowship) of at least one month duration (*Formal= direct supervision for minimum number of scans, with assigned supervisor)
   - Yes
   - No

3. Received Formal* ultrasound training in (check those which apply)
   - TEE
   - CCE (Critical care echocardiography)
   - Airway
   - Pleural and lung ultrasound
   - Diaphragm and muscle
   - Abdominal ultrasound
   - Diastolic dysfunction
   - Abdominal diagnostics
   - FAST
   - Vascular access
   - Vascular diagnostics (AAA, DVT)
   - Neurological (ONSD, cerebral circulation)
   - Joints, bones and soft tissue
   - Other (please specify)

11. How often do you perform Airway ultrasound in your ICU practice? (check those which apply, may have more than 1 answer)
    - Routinely pre-percutaneous tracheostomy
    - Sometimes pre-percutaneous tracheostomy
    - Daily
    - Several times a week
    - Hardly ever
    - Never

12. The application of CCUS has frequently changed the real-time management of ICU cases under my care
    - Strongly disagree
    - Disagree
    - Agree
    - Strongly agree

13. If the indications exist, I routinely scan new ICU admissions with (check all that apply)
    - Critical care echocardiography
    - Pleural and lung ultrasound
    - Abdominal ultrasound
    - Diaphragm and muscle ultrasound
    - Optic nerve sheath diameter
    - Abdominal ultrasound
    - Other (please specify)

14. How often do you perform Pleural ultrasound in your ICU practice?
    - Daily
    - Several times a week
    - Hardly ever
    - Never

15. How often do you perform Optic nerve sheath diameter ultrasound in your ICU practice?
    - Daily
    - Several times a week
    - Hardly ever
    - Never

16. If the indications exist, I routinely scan new ICU admissions with (check all that apply)
    - Critical care echocardiography
    - Pleural and lung ultrasound
    - Abdominal ultrasound
    - Diaphragm and muscle ultrasound
    - Optic nerve sheath diameter
    - Abdominal ultrasound
    - Other (please specify)

17. The application of CCUS has frequently changed the real-time management of ICU cases under my care
    - Strongly disagree
    - Disagree
    - Agree
    - Strongly agree

18. If the indications exist, I routinely scan new ICU admissions with (check all that apply)
    - Critical care echocardiography
    - Pleural and lung ultrasound
    - Abdominal ultrasound
    - Diaphragm and muscle ultrasound
    - Optic nerve sheath diameter
    - Abdominal ultrasound
    - Other (please specify)

19. The application of CCUS has frequently changed the real-time management of ICU cases under my care
    - Strongly disagree
    - Disagree
    - Agree
    - Strongly agree

20. If the indications exist, I routinely scan new ICU admissions with (check all that apply)
    - Critical care echocardiography
    - Pleural and lung ultrasound
    - Abdominal ultrasound
    - Diaphragm and muscle ultrasound
    - Optic nerve sheath diameter
    - Abdominal ultrasound
    - Other (please specify)

21. The application of CCUS has frequently changed the real-time management of ICU cases under my care
    - Strongly disagree
    - Disagree
    - Agree
    - Strongly agree

22. If the indications exist, I routinely scan new ICU admissions with (check all that apply)
    - Critical care echocardiography
    - Pleural and lung ultrasound
    - Abdominal ultrasound
    - Diaphragm and muscle ultrasound
    - Optic nerve sheath diameter
    - Abdominal ultrasound
    - Other (please specify)
1. What are the perceived obstacles when embarking on a formal training program for CCUS currently? (Check those which apply)

- Lack of supervisors
- Overseas (eg ASUM, BSE, EDEC) programs are costly
- Lack of ultrasound equipment
- Lack of storage for clips and images
- Lack of time to scan
- No need for competency assessment for management at the bedside
- Medico-legal implications
- Inadequate knowledge
- Inadequate practice opportunities
- Others

2. Other (please specify):

3. I would like to receive formal ultrasound training for...

- Critical care echocardiography
- Transesophageal echocardiography
- Airway ultrasound
- Pleural and lung ultrasound
- Diaphragm and muscle
- Abdominal / obstetric
- Vascular access
- Vascular diagnostics (AAA, DVT)
- Neurological disease (WBB, cerebral circulation)
- Joints, bones and soft tissue
- Others (please specify):

4. Formal initial credentialing/ accreditation done? (if yes, name of CCUS accreditation)*

- Available
- Not available

5. Is your formal credentialing/ accreditation current?*

- Yes
- No

6. Is formal renewal of credentialing/ accreditation of CCUS accreditation required by your institution?*

- Yes
- No

7. Number of full TTE scans done (same views required when done by a professional sonographer)*

- 0
- 1-5
- >5-30
- >30-50
- >50

8. Number of Critical care echocardiography (CCE) scans done

- 0
- 1-5
- >5-30
- >30-50
- >50

9. I’m comfortable with image acquisition for Critical care echocardiography (CCE)*

- Strongly disagree
- Disagree
- Agree
- Strongly agree

10. I’m confident with ultrasound image interpretation of Critical care echocardiography (CCE) images*

- Strongly disagree
- Disagree
- Agree
- Strongly agree

11. I’m confident with integrating CCUS with clinical management*

- Strongly disagree
- Disagree
- Agree
- Strongly agree
Future formal competency assessment needs

1. I think there is a need for formal competency assessment in CCUS.
   - Yes
   - No
   - Unsure

Comments:

2. I think there is a need for a local CCUS training program.
   - Strongly agree
   - Agree
   - Disagree
   - Strongly disagree

3. I would like to receive formal competency assessment for (check those which apply):
   - Critical care echocardiography
   - Transesophageal echocardiography
   - Thoracic and lung ultrasound
   - Diaphragms and muscle
   - Abdominal/obstetric
   - Vascular access
   - Vascular diagnostics (AAA, DVT)
   - Neurological (ONSD, cerebral circulation)
   - Arteries, veins and soft tissue
   - Others:

Resource availability

1. For initial training, assuming it takes one year, what is the number of hours per month a learner can commit to CCUS training and competency assessment?
   - 0
   - 90
   - 180

2. For initial training, assuming it takes one year, what is the amount of money (in Singapore Dollars) a learner can commit to CCUS training and competency assessment?
   - 0
   - 1500
   - 3000

3. For reaccreditation, assuming reaccreditation is needed every 5 years, amount of money in Singapore Dollars one can commit to reaccreditation?
   - 0
   - 1500
   - 3000

4. Any other ideas on how to implement critical care ultrasound training?

4. What is your preferred platform for acquiring content knowledge?
   - In-person lectures
   - Website lectures
   - Internet-based app (e.g., Elearn)
   - YouTube
   - Social media like Facebook, Twitter
   - Other (please specify):