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REVIEW ARTICLE/BRIEF REVIEW

Acquiring and maintaining point-of-care ultrasound (POCUS) competence for anesthesiologists

L'acquisition et le maintien des compétences en échographie au chevet (POCUS) pour les anesthésiologistes

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Abstract

Purpose *Point-of-care ultrasound (POCUS) involves the bedside use of ultrasound to answer specific diagnostic questions and to assess real-time physiologic responses to treatment. Although POCUS has become a well-established resource for emergency and critical care physicians, anesthesiologists are still working to obtain POCUS skills and to incorporate them into routine practice. This review defines the benefits of POCUS to anesthesia practice, identifies challenges to establishing POCUS in routine anesthesia care, and offers solutions to help guide its incorporation going forward.*

Principal findings *Benefits to POCUS include improving the sensitivity and specificity of the physical examination and helping to guide patient treatment. The challenges to establishing POCUS as a standard in anesthesia practice include developing and maintaining competence. There is a need to develop standards of practice and a common language between specialties to facilitate training and create guidelines regarding patient management.*

Conclusions *Presently, our specialty requires consensus by expert stakeholders to address issues of competence, certification, development of standards and terminology, and the management of unexpected diagnoses. To promote POCUS competency in our discipline, we support its incorporation into anesthesiology curricula and training programs and the continuing professional development of POCUS-related activities at a national level.*

Résumé

Objectif *L'échographie au chevet (ou POCUS, pour point-of-care ultrasound) est l'utilisation de l'échographie au chevet du patient afin de répondre à des questions diagnostiques spécifiques et d'évaluer les réponses physiologiques à un traitement en temps réel. Bien que l'échographie au chevet soit devenue un outil bien établi pour les médecins intensivistes et urgentologues, les anesthésiologistes continuent de travailler à l'acquisition de ces compétences et à leur intégration dans leur pratique quotidienne. Ce compte-rendu décrit les avantages de l'échographie au chevet en ce qui touche à la pratique de l'anesthésie, identifie les défis rencontrés lorsqu'on souhaite établir l'échographie au chevet dans les soins anesthésiques de routine, et propose des solutions afin d'orienter son intégration future.*

Constatations principales *Les avantages de l'échographie au chevet comprennent l'amélioration de la sensibilité et de la spécificité de l'examen physique et l'obtention de renseignements aidant à guider le traitement des patients. Les défis à l'établissement de l'échographie au chevet en tant que norme dans la pratique de l'anesthésie comprennent l'acquisition et le maintien des compétences. Il faut mettre au point des normes de pratique et une terminologie communes à toutes les*

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spécialités afin de faciliter la formation et de créer des lignes directrices concernant la prise en charge des patients.

Conclusion *À l'heure actuelle, notre spécialité a besoin d'un consensus déterminé par des experts afin d'aborder les questions de compétence, de certification, de mise au point de normes et de terminologie, ainsi que la prise en charge des diagnostics imprévus. Afin de promouvoir la compétence en échographie au chevet dans notre spécialité, nous soutenons son intégration dans les programmes d'enseignement et de formation en anesthésiologie ainsi que dans le développement professionnel continu d'activités liées à l'échographie au chevet à l'échelle nationale.*

Table 1 Potential uses of POCUS in anesthesiology

Diagnostic	Procedural
Ultrasound-assisted physical examination[4-6]	Regional anesthesia[7,8]
Transthoracic echocardiography[9-14]	Vascular access[15-19]
Transesophageal echocardiography [20-23]	Arterial access[24-26]
Lung ultrasound[5,27-31]	Airway management[32-36]
Volume assessment[3,5,10,37-39]	Thoracentesis[15,40-44]
Abdominal ultrasound[37,45-48]	Pericardiocentesis[43,49,50]
Gastric content[51-53]	Recruitment maneuvers[54-57]
DVT assessment[15]	Neuraxial access[58,59]
Intracranial pressure[60-62]	

DVT = deep venous thrombosis, POCUS = point-of-care ultrasound

J. Forbes once wrote *'that [the stethoscope] will ever come into general use…is extremely doubtful; because its beneficial application requires much time and gives a good bit of trouble both to the patient and the practitioner'* (1821, Preface to Laennec's treatise). Today it appears ironically short sighted given the stethoscope's wide use across disciplines and professions. Indeed, this statement provides an interesting context for the application of what has emerged as the new "stethoscope" of 21st century medicine: the ultrasound.

This is a time of considerable change and growth for the specialty of anesthesia. As perioperative physicians, anesthesiologists are developing a greater presence in the hospital outside of their traditional roles in the operating room. Furthermore, our trainees have recently seen a paradigm shift in the way their curriculum is delivered as a competency-based model of education. In addition to these changes are advancements in technologies that create new learning requirements for the anesthesiologist. Point-of-care ultrasound (POCUS) is emerging as a new competency requirement for anesthesia care.

The use of ultrasound as a diagnostic tool in medicine has existed since 1941[1] and intraoperative echocardiography was described in 1972.[2] Nonetheless, the concept of POCUS is a much more recent development. Point-of-care ultrasound is defined as the use of ultrasound at the patient's bedside to answer specific diagnostic questions and/or view real-time physiologic responses to various treatments.[3,4] Point-of-care ultrasound encompasses numerous imaging protocols for an expanding target of organ systems and its use includes diagnostic and procedural functions (Table 1).

Anesthesiologists have played an important role in the use of ultrasound technology to assess cardiac function,[63] achieve vascular access, and guide regional anesthesia.[64,65] Nonetheless, as a specialty we have not as readily embraced the perioperative use of POCUS nor have we yet made it a mandatory competency for our trainees and practitioners. In contrast, Emergency Medicine and Critical Care Medicine specialties have recognized the utility of POCUS at the bedside, incorporating it into routine practice and making it a component of residency training.[3,37,49,66] As POCUS evolves to becoming ever-more portable, producing higher quality images, and is increasingly available in all areas of the hospital, it behoves anesthesiologists to realize their affinity with this technology and leverage it for patient care. There are numerous applications of POCUS in clinical anesthesia: transthoracic echocardiography (TTE) or focused cardiac ultrasound (FoCUS), brain, airway, lung, gastric and abdominal evaluation, assessment of deep venous thrombosis, intracranial pressure assessment, ultrasound-guided procedures including vascular and airway access, regional anesthesia, drainage of pleural and pericardial effusions, assessing adequacy of recruitment maneuvers, and evaluation of splanchnic perfusion, to name a few. The interest in POCUS has been explosive. A MEDLINE search for the terms "POCUS", "point-of-care-ultrasound", or "bedside ultrasound" showed that only 60 articles were published in 1990 compared with 1,030 in 2016. To facilitate the implementation of POCUS into anesthesia care, there has been strong advocacy for its integration into residency and postgraduate training,[5,38,46,65,67-72] with convincing evidence that POCUS is a skill that can be readily acquired at all levels of training.[5,11,46,47,69,73] Despite the numerous applications, great potential for patient care, and recent growth in the use of POCUS in anesthesia, there are still barriers that prevent it from being a current standard practice and challenges in establishing anesthesia-specific guidelines.

The purpose of this review is to outline the benefits of POCUS to anesthesia practice, identify challenges in establishing POCUS into anesthesia care, and offer some potential solutions to facilitate its integration into our specialty.

Education and training

Why do we need training in POCUS?

There are many benefits to using POCUS for patient care. For example, POCUS can alter patient management including changes to diagnosis[47] and directing the administration of inotropes, vasopressors and fluids,[14,74] with evolving evidence for mortality benefit.[75,76] Point-of-care ultrasound has been shown to affect the choice of anesthetic technique and types of monitoring perioperatively.[14,76] It can also affect surgical management, the decision to cancel or delay surgery or to alter the surgical approach.[14,76,77] Furthermore, it may affect postoperative disposition and the decision to transfer to higher acuity units.[77] A recent systematic review has summarized POCUS-related changes in surgical and critical care patient management[74] (Table 2).

Point-of-care ultrasound can significantly improve the sensitivity and specificity of the physical examination[4-6,76,87-90] even in relatively naïve learners. For example, with only four hours of training, medical students were able to accurately identify moderate or severe left ventricular dysfunction.[6] Similarly, anesthesiology trainees, after only two hours of instruction, could accurately identify aortic valve pathology.[11]

There is mounting evidence that POCUS can improve patient outcomes. For example, Canty *et al.* found that a preoperative focused cardiac ultrasound (FoCUS) protocol (an application of POCUS) was associated with improved mortality in patients with elevated cardiac risk undergoing hip surgery.[76] Kanji *et al.* showed a decrease in acute kidney injury and survival benefit associated with echo-guided therapy using standard FoCUS views to direct treatment with fluids *vs* inotropes.[75] Zanobetti *et al.*, in a prospective observational trial, found that a POCUS-driven protocol reduced time to correctly identify the etiology of acute dyspnea in patients presenting to the emergency room.[31] Similarly, Laursen *et al.* showed that POCUS of the heart, lungs, and deep vessels helped to achieve a more accurate and rapid diagnosis of patients presenting with respiratory symptoms in the emergency department.[91] Ford *et al.* showed that POCUS for lung examination is more sensitive and specific than either chest radiography and/or clinical examination, even when performed by POCUS novices after only 50 mentored lung scans.[30] In a randomized controlled trial, *Jones et al.* found that a POCUS-driven protocol could increase the accuracy and timeliness of diagnosis of the underlying etiology of hypotension in non-trauma patients.[92] In another randomized controlled trial, Ferrada *et al.* showed mortality benefit, lower volumes of administered intravenous fluids, and fewer delays to surgical management with the use of POCUS (a limited transthoracic echocardiogram assessing cardiac contractility, the inferior vena cava fullness, and the presence or absence of a pericardial effusion) as a hemodynamic monitoring tool for trauma patients presenting in shock.[13]

There are numerous examples of how POCUS can benefit perioperative patient care. For example, POCUS can be used to confirm appropriate urinary catheter insertion, to help diagnose a phrenic nerve injury, or to assess intra-abdominal or intra-thoracic bleeding. In a relatively short period of time ultrasound has become recognized as a "gold standard" to help guide regional anesthesia and vascular access. Understanding the benefits of POCUS provides the impetus to learn and maintain the requisite skills.

How do we develop competence in POCUS?

Competence is described in terms of the requisite knowledge, skills and judgement to perform a task or behaviour.[93,94] In contrast, *certification* involves a regulatory body recognizing individuals who have showed competence in a task,[93] and *credentialing* is the assessment of the qualifications to practice. There is no consensus regarding the required level of training to achieve competence with POCUS[71,95] or how this can be assessed.[71] While there are established training guidelines and standards in emergency medicine and critical care for various ultrasound applications[3,66] as well as international guidelines,[27,48,67] this is not the case for the anesthesia specialty. While guidelines produced by other specialties are of relevance, developing anesthesia-specific standards would be preferable considering our unique scope of practice.

To achieve competence in POCUS, anesthesiologists need to acquire the ultrasound skills necessary for identifying normal anatomy and physiology and evaluating changes from baseline. Superior skill with POCUS requires familiarity with the equipment, the psychomotor skills to handle a probe and acquire adequate images, and sufficient knowledge and experience for correct interpretation of the scans. To achieve and maintain competency with POCUS, both practice (in either a simulated or clinical environment) and

Table 2 Changes in management following FoCUS compared with clinical assessment

Authors	Medical management*	Surgical management†	Anesthetic management‡	Anesthetic medication§	Inotropes/vasopressors‖	Fluids**	Disposition††
Botker *et al.*[78]	4%	7%	3%	2%	0%	3%	6%
Canty and Royse[79]	40%	-	-	-	-	16%	-
Canty *et al.*[77]	36%	46%	13%	-	11%	12%	34%
Canty *et al.*[76]	52%	-	52%	-	-	-	-
Canty *et al.*[80]	30%	14%	-	-	-	-	-
Cowie[81]	51%	31%	37%	12%	9%	4%	27%
Cowie[82]	-	-	-	-	-	3%	-
Joseph *et al.*[83]	35%	16%	-	-	-	12%	-
Kanji *et al.*[75]	-	-	-	-	25%	-	-
Manasia *et al.*[84]	37%	-	-	-	21%	-	-
Orme *et al.*[85]	38%	-	-	19%	8%	7%	5%
Stanko *et al.*[86]	39%	7%	-2	-	-	-	4%

*Medical management defined as anesthetic technique, anesthetic drug selection, inotrope, vasopressor, or fluid use (type or amount)

†Surgical management defined as surgery or postoperative disposition

‡Anesthetic management defined by change in anesthetic technique (general, neuraxial, or regional anesthesia) or change in decision about invasive monitoring

§Anesthetic medication as defined by a change in anesthetic drug or dose

‖Inotropes/vasopressors defined by a change in the type or dosage

**Fluids defined by change in type or amount of fluid administered

††Disposition as defined by change in postoperative disposition to intensive care unit, high acuity unit, or ward, or by preoperative transesophageal echocardiography or cardiology referral

Values expressed as proportion of cases where focused cardiac ultrasound (FoCUS) was used

Modified from: *Heiberg J, El-Ansary D, Canty DJ, Royse AG, Royse CF*. Focused echocardiography: a systematic review of diagnostic and clinical decision-making in anaesthesia and critical care. Anaesthesia 2016; 71: 1091-100.[74]

coaching are recommended.[4] Experts within a department are critical to support ongoing mentoring and can serve as an invaluable resource for difficult cases. The increased use of POCUS by various specialties necessitates a common language and interpretation of findings to treat patients in a coordinated and consistent manner.

It is crucial that the operator recognizes his or her limits by understanding when a poor image should be disregarded and seeking assistance from more experienced colleagues when required.[96] Radiologists have questioned the competence of other specialists to use ultrasound to assess patients and have expressed concerns about the potential for missed or incorrect diagnoses.[97] While these concerns may have seemed warranted, they have not been supported by the evolving literature concerned with ultrasound assessment of cardiac function.[24,27] Interestingly, similar concerns had previously been expressed regarding the use of ultrasound for regional anesthesia; instead, complications have decreased with the introduction of ultrasound-guided techniques.[8] Controversy also arose with the use of ultrasound for vascular access and intraoperative transesophageal echocardiography (TEE), both of which are now standards of anesthesia practice taught during residency training.[65]

Point-of-care ultrasound, like all procedures, must achieve the highest possible benefit-to-risk ratio. As with any assessment, POCUS findings must be interpreted within the patient's clinical context. When POCUS provides equivocal information, the practitioner should seek a second opinion and consider additional imaging strategies. As well, the operator must bear in mind that POCUS only provides a "snapshot in time" and additional scans may be required as conditions change. In these cases, imaging is used to track dynamic changes, in contrast to a diagnostic interpretation made *post hoc* by a radiologist. The issue of what to do with unexpected findings or new diagnoses needs to be considered. For example, *Spencer et al.* recommend all patients with unanticipated abnormal cardiac findings be referred for subsequent comprehensive formal echocardiography.[98] While this represents a safe and conservative approach, it will undoubtedly generate an increased number of referrals, procedures, and associated healthcare costs.

Should certification be required?

With the growth of POCUS, there are considerations for certification including the process by which an education or regulatory body recognizes individuals who have showed competence[93] and the access to appropriate training before certification. Hospitals and departments should engage in these dialogues, given their roles in credentialing anesthesiologists for practice.

Obtaining the required skills in POCUS will present changing challenges to anesthesiologists during the lifelong learning continuum. For trainees, these skills may have already been introduced in medical school and will be reinforced during their residency curriculum. For anesthesiologists currently in practice, POCUS skills may be acquired through a combination of courses, conferences, ultrasound rounds, and workshops. Maintenance of skills can involve a formal process including a mandated minimum number of targeted scans.[53]

Training, certification, and demonstration of competence have been important considerations during the development of echocardiography, and this experience provides a valuable reference point for comparison with the emergence of POCUS. The National Board of Echocardiography in the United States has developed specific requirements for certification in basic[99] and advanced[100] perioperative TEE, as well as transthoracic echocardiography (TTE), and comprehensive echocardiography.[101] In Canada, however, the Canadian Society of Echocardiography (CSE), through the Canadian Cardiovascular Society, provides only guidelines, as opposed to certification.[102] In addition, the Royal College of Physicians Surgeons of Canada (RCPSC) offers an Area of Focused Competence (AFC) diploma as formal recognition of training for adult echocardiography, requiring a minimum of six blocks of training with the performance of 150 complete TTEs and interpretation of 450.[57]

When considering the development of competence with cardiac ultrasound, Royse has proposed the "expertise triangle" where the foundation of the triangle is populated by the general acute care practitioners with the skills to use POCUS to supplement the physical examination, progressing upwards to those with increasing expertise with surface sonography, TTE, and TEE diagnostic skills, while the pinnacle represents experts with mastery of skills to perform, interpret, and teach echocardiography.[5]

The CSE training guidelines mirror this concept where Level 1 echocardiographers are expected to be able to perform a focused though not comprehensive TTE scan.[102] Level 2 echocardiographers are expected to be able to independently perform and interpret comprehensive TTE, with exposure to TEE, stress, and contrast modalities. At the pinnacle, Level 3, there is an expectation of proficiency with advanced TTE and TEE and skill to train and supervise trainees including those working in an echocardiography laboratory. By analogy, with POCUS, it is anticipated that most practitioners would fall into the bottom two levels, where the main purpose of POCUS would be to complement the physical examination. More advanced diagnostic skills would be in the domain of experts with fellowship or subspecialty training.

Certification in POCUS is complex given its expanding range of diagnostic capabilities and the ever-changing clinical context in any given patient. The rationale for POCUS certification is to ensure a standard of competence, minimize the risk of misinterpretation, and decrease the incidence of incorrect or missed diagnoses. Although the existing evidence does not support a significant risk of missed diagnoses,[11,80] there is always potential for "fixation error" by physicians driving their treatments based on the result of a single scan during a dynamic resuscitation and potentially missing a new diagnosis. Furthermore, even low numbers of reported missed diagnoses do not mean that they do not occur. For these reasons, certification in POCUS may be important, and restricting the use of POCUS to only certified operators may address concerns for achieving a standardized level of competence.[103] Nevertheless, on the other hand it could unwittingly impede the uptake of this valuable technology. The American Medical Association affirms the diversity of applications of ultrasound and indicates that it is within the scope of any appropriately trained physician.[104] While "appropriately trained" may leave room for ambiguity, the authors clarify that the privilege to perform ultrasound should be decided by the hospital in accordance with the standards of the specialty. Similarly, the Canadian Association of Radiologists acknowledge the utility of POCUS performed by appropriately trained physicians and differentiates it from a comprehensive diagnostic ultrasound performed by an imaging specialist.[103] Examples of ultrasound used routinely in anesthesia practice, and not requiring certification, include regional anesthesia and vascular access.

With regard to POCUS certification from an anesthesiology perspective, consideration can be given to the varying experience of other specialties such as critical care, emergency and internal medicine, and cardiology.[3,5,39,45,48,49,66,95,105,106] The diversity in certification requirements highlights the lack of consensus.[5,39,51-53,107] In Canada, the RCPSC has recently approved an acute care point-of-care ultrasonography AFC for emergency medicine trainees.[108] The relevance of this to anesthesia should be assessed with regard to obtaining our own AFC and to

leverage the POCUS experience of specialists in Emergency Medicine for training in our specialty.

Future directions and recommendations

Incorporation of POCUS into the national anesthesiology curriculum

Presently, there is a need in our specialty for developing national consensus positions outlining standards for training, assessment of competence and certification, and remuneration for services rendered. It will be essential to continuously upgrade proficiency requirements as ultrasound technology develops and new uses are found for POCUS. The involvement of POCUS providers in other specialties is essential to ensure a universal language and transferable information. Many medical schools have already begun incorporating ultrasound training into undergraduate medical education and this will accelerate the uptake of POCUS as a standard of practice. Medical students entering residency programs will be familiar with aspects of POCUS and subsequent training will have to dovetail with their previously acquired skills. As a starting point, we suggest that residents be familiar with the core critical care views (Table 3) that help generate a useful differential diagnosis for the hemodynamically compromised patient.

Table 3 Core critical care ultrasound views

Examination	Views
Basic critical care echocardiography	Parasternal long axis
	Parasternal short axis
	Apical four-chamber view
	Sub-xiphoid four-chamber view
	Inferior vena cava-long axis
Lung and pleura	Anterior chest wall
	Anterolateral chest wall
	Posterosuperior chest wall
	Posteroinferior chest wall
Abdominal free fluid	Right upper quadrant view
	Left upper quadrant view
	Suprapubic view
Guidance for vascular access	Short axis of vessel and surrounding structures
	Long axis of vessel with guidewire *in situ*

From: *Arntfield RT, Millington SJ, Ainsworth CD, et al.; Canadian Critical Care Society.* Canadian recommendations for critical care ultrasound training and competency. Can Respir J 2014; 21: 341-5.[3]

These views are incorporated into many assessment protocols[12,48,105,106] and provide an additional benefit of transfer of knowledge from discipline to discipline. Other views we consider to be important for anesthesiologists include the FAST[48] (focused assessment with sonography in trauma) as well as airway,[32-34,36] lung,[27,28,30,109] bladder,[110] gastric,[51-53] and abdominal imaging.[3,47,68,69] Incorporating POCUS into the Anesthesiology National Curriculum will require advocacy to the Royal College of Physicians and Surgeons of Canada and leadership from universities to make this a priority for training.

As anesthesiology residency programs make the transition to a competency-by-design (CBD) paradigm, our specialty is in a position to assume a leadership role in POCUS. We can use our experience with changing to a CBD curriculum to help guide the creation of a "Foundations of Ultrasound" program for our trainees. The University of Ottawa Department of Anesthesia residency-training program may be used as an example. It has incorporated basic POCUS training into the "Boot Camp" portion of the curriculum, using curated online resources and hands-on training sessions with an ultrasound simulator and standardized patients. Subsequently, POCUS will be incorporated longitudinally into the residency program with defined, rotation-specific learning goals that are tracked using a case logbook. The curriculum was developed using evidence from studies evaluating POCUS training strategies[9,46,47,69,107,111-114] and from the medical education[115,116] and psychology literature that suggests incorporation of distributed learning[117,118] (longitudinally delivered content and teaching) and test-enhanced learning[119,120] (use of testing situations to facilitate retrieval). Collaboration and sharing of POCUS curricula used at various Canadian institutions will facilitate the development of an effective, national program to ensure standardized POCUS competency.

Setting up a perioperative ultrasound service

One of the most important advantages of POCUS is its transportability and independence from a specialized physical space, extra personnel, reading room, and other resources associated with *x-ray*, computed tomography, or magnetic resonance imaging. Nevertheless, a "formal" POCUS laboratory could conceivably assist with supervision, education, maintenance of competence, and research. Requirements for a POCUS laboratory are minimal: in addition to the ultrasound machine and appropriate probes, only a computer dedicated to storage of scans for "off line" review, data acquisition, and analysis is required. A perioperative POCUS service, comprised of individuals with appropriate skills, could provide important clinical services similar to an Acute Pain

Service. This could be instrumental for teaching, facilitating research, and developing protocols for standardized care.

Conclusions

Incorporating POCUS into routine anesthesia care offers great potential benefits for our patients. This evolving technology requires a supportive environment that provides structured training and supervision, availability of expert assistance, and access to more comprehensive imaging. Presently, we advocate for the achievement of basic competence in all practicing anesthesiologists and suggest restricting formal certification for the highly trained experts. As with all evolving technologies, POCUS will need to be continually assessed with regard to its impact on anesthesia care and its incorporation into anesthesia practice and training programs.

Conflict of interest None declared.

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