Perioperative point of care ultrasound in ambulatory anesthesia: thinking beyond nerve blocks

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Purpose of review
Ultrasound has become readily available in the perioperative area. In this review, we aim to bring forth some uses of ultrasound beyond that in regional anesthesia.

Recent findings
Critical care and emergency physicians have embraced ultrasound in their respective fields. We as anesthesiologists and practitioners of acute care medicine are not immune to this penetration. There is been a lot of recent literature on the various uses of perioperative point of care ultrasound. Our review summarizes the recent data and provides the reader with an overall idea of the uses of ultrasound in the perioperative arena.

Summary
Focus towards improving patient outcomes is the goal of all physicians and point of care ultrasound is one modality that can help us manage some common conditions in the perioperative period. Perioperative point of care ultrasound training may soon become a prerequisite for an anesthesiology residency.

Keywords
airway ultrasound, focused cardiac ultrasound, gastric ultrasound, goal directed echocardiography, lung ultrasound, perioperative point of care ultrasound, point of care ultrasound, risk evaluation sonography

INTRODUCTION

The area of ambulatory surgery/anesthesia is one of rapid growth and evolution. It is estimated that over 60% of all elective procedures performed in the United States occurs in the ambulatory setting, with suggestions that this may increase to 70% in the near future [1]. With this growth, the practice of ambulatory anesthesia is penetrating more anesthesiologists and thus allows this area to be exposed to emerging technologies and practice strategies in perioperative care. Point of care ultrasound (POCUS) is one such modality that has a great potential to expand in an ambulatory anesthesia setting.

Ultrasound has proven to serve a vital role in the rapid assessment of the patient's cardiac, pulmonary, vascular, airway, and gastrointestinal status.

Critical care has fully incorporated ultrasound in its curriculum and providers are routinely using it as an extension of their physical exam [2]. More recently, the development of comprehensive perioperative POCUS (P-POCUS) curriculum termed Focused perioperative Risk Evaluation Sonography Involving Gastro-abdominal Hemodynamic and Transthoracic ultrasound (F.O.R.E.S.I.G.H.T.) has been suggested to positively impact perioperative care [3]. In addition, a multisubspecialty task force reviewed the current applications of P-POCUS and reported a 'call to action' on this topic to be embraced by anesthesiologists [4▪▪]. It is time that we start developing a curriculum and training anesthesiologist in point of care ultrasound [5▪,6]. The present review article seeks to bring forth the utility of perioperative POCUS (P-POCUS) with a particular focus on recent topics relevant for anesthesiologists in the ambulatory surgery center. We briefly review the goal directed approach with POCUS followed by the new

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KEY POINTS

- Perioperative point of care ultrasound is gaining acceptance in acute care medicine.
- Major components of the perioperative point of care ultrasound exam are cardiothoracic ultrasound, airway ultrasound, and gastric ultrasound.
- The learning curve for point of care ultrasound is steep.
- As an anesthesiologist, one must be facile with perioperative point of care ultrasound.

and emerging applications of POCUS. Topic not covered in this review is the use of ultrasound for regional anesthesia including neuroaxial anesthesia.

PERIOPERATIVE POINT OF CARE ULTRASOUND VERSUS GENERAL ULTRASOUND

P-POCUS is defined as the use of portable ultrasonography at the patient's bedside for diagnostic and therapeutic purposes [7]. Physician performing a P-POCUS is the one working in the trenches. This physician performs all image acquisition and interpretation at the bedside and then uses that information to diagnose, manage, and even direct future therapies. This saves time waiting for the consultant cardiologist or radiologist. The important difference here is the acuity and time constraint. P-POCUS is not intended to be a comprehensive exam but can be depending on the skill of the operator. P-POCUS is intended to have a narrower scope of practice when compared to an ultrasound exam. The scope mainly depends on the skill set of the physician and the availability of time and equipment. POCUS is already being performed in critical care and emergency settings where it can have a broader scope of practice [2,8].

INDICATION FOR P-POCUS IN THE AMBULATORY SETTING

Ultrasound has been used for therapeutic and diagnostic purposes. In the ambulatory setting, one can utilize many of the applications of ultrasound. Table 1 enumerates conditions that can be routinely managed with P-POCUS skills. Some conditions will likely have an overlap. P-POCUS can also be used to arrive at a diagnosis Table 1.

Table 1. Conditions that can be managed with P-POCUS

Preoperative	Post operative
Gastric content	Acute respiratory failure
Intravenous access	Pneumonia
Airway pathology	Acute hemodynamic instability
Difficult airway	Undifferentiated shock

P-POCUS, perioperative point of care ultrasound.

THE ARTICLE FURTHER DESCRIBES KEY COMPONENTS OF P-POCUS

Goal directed pocus in the perioperative area

The idea of goal directed management is to focus on the task at hand, for example hypotensive shock and come up with a quick diagnosis and management plan. Goal-directed exams use limited number of standard images to rapidly assess the anatomy/function of the organ of focus.

Goal-directed echocardiography

The utility of echocardiography in an acute setting is to help with the diagnosis of hemodynamic instability or shock. Figure 1 and Table 2 show the broad causes of hemodynamic failure. Examinations such as the focus assessed transthoracic echocardiography (FATE) [9] and perioperative anesthesiology ultrasonographic evaluation (PAUSE) [10▪▪] have been developed by anesthesiologists to facilitate care of these acute care scenarios. These examinations are designed to evaluate a patient in a few minutes and is often combined with lung ultrasound (LUS). A goal-directed echocardiography (GDE) comprises of four main views of the heart (Fig. 2) with a view of the IVC and helps in identifying life-threatening conditions shown in Table 3.

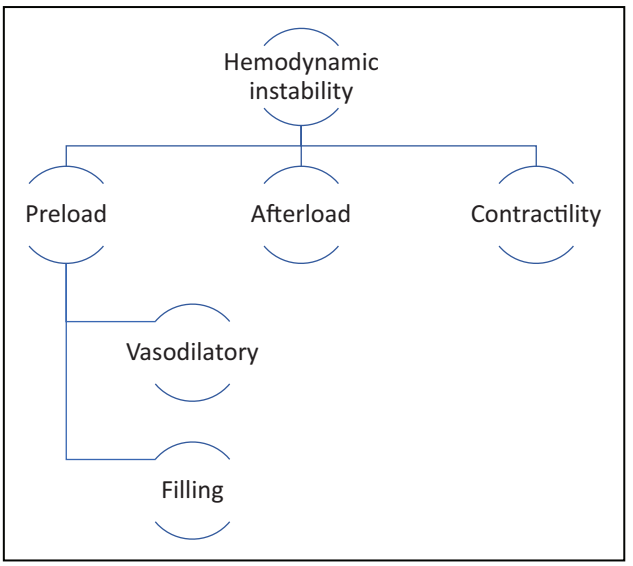

FIGURE 1. Causes of hemodynamic failure.

Table 2. Differential diagnosis for hemodynamic failure

Filling	Vasodilatory	Afterload	Contractility
Tamponade	Sepsis	Pulmonary embolus	Myocardial ischemia
Pneumothorax		Pulmonary hypertension	LV systolic dysfunction
Hypovolemia		LVOT obstruction	
		Severe aortic stenosis	

LVOT, left ventricular outlet tract.

Table 3. Conditions that can be identified by goal directed echocardiography

Severe valvular pathology
Left ventricular failure
Massive pulmonary embolus
Cardiac tamponade

This exam might also help identify condition that could complicate treating the primary process.

GDE can be utilized as a part of peri-arrest or cardiac arrest algorithm in the ambulatory surgery setting. A subcostal exam done during the pauses in chest compression has shown to change diagnosis and alter management in a significant number of patients in the prehospital setting [11]. This exam can differentiate a patient with a true pulseless electrical activity (PEA) from asystole. The prognosis for return of spontaneous circulation with observed contractility in patients classified as PEA is improved when compared to no myocardial activity. Complete lack of ventricular contractility during CPR is a strong predictor that the resuscitation effort will not be successful [12▪▪].

Beyond a GDE, a TTE can be utilized as an adjunct to a physical exam [13]. Focused transthoracic echo has shown to decrease mortality in high-risk cardiac patients undergoing surgery for hip fracture [14].

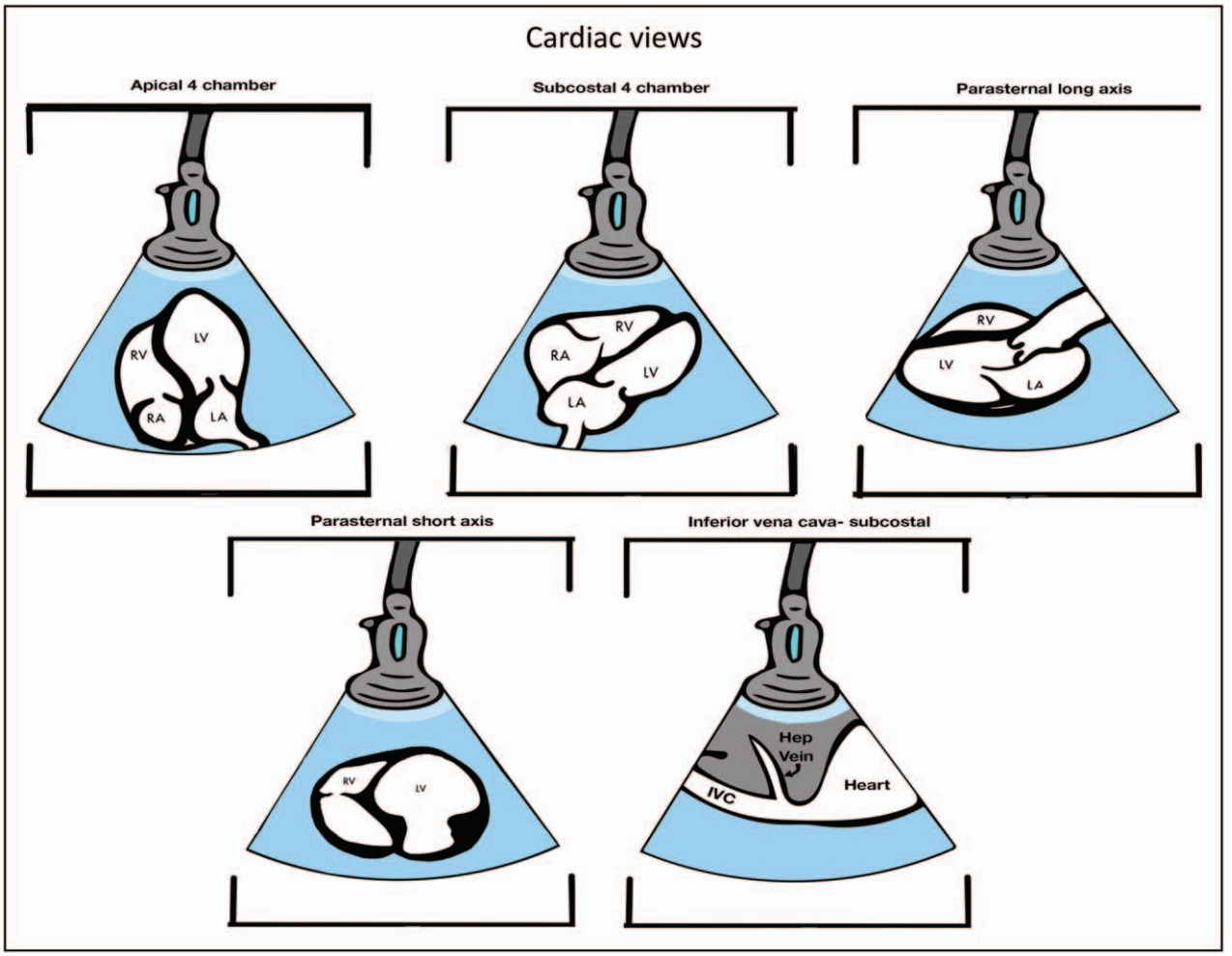

FIGURE 2. Cardiac views.

POCUS can be used to form a differential for acute respiratory failure in the postoperative period [15]. The key lies in following standardized protocol. Conditions that can be diagnosed are shown in Table 2 [16].

Lung ultrasound

LUS is a relatively late entry in the field of ultrasound imaging. Lungs were considered to be a hindrance to performing a transthoracic echocardiogram. Currently LUS allows a physician to rapidly assess and manage a patient in acute respiratory failure. When LUS is combined with GDE one can differentiate different causes of cardiopulmonary compromise. When compared to chest roentgenograms (CXR), LUS has proven to be faster and superior in diagnosing pneumothorax, pleural effusion, and alveolar interstitial diseases [16,17]. Lung ultrasonography can differentiate acute decompensated heart failure, pneumonia, acute respiratory distress syndrome, pneumothorax, pulmonary embolus, and diaphragmatic dysfunction [18,19,20▪▪,21▪,22,23,24▪,25–28]. The addition of LUS to a chest computed tomography (CT) improves diagnostic accuracy and efficiency [27]. Pulmonary edema as a cause acute respiratory failure is not uncommon. LUS along with GDE can help with accurately differentiating cardiogenic from noncardiogenic edema [26]. Some authors have suggested using LUS for intraoperative workup of desaturation on pulse oximetry and detection of perioperative atelectasis [22,29]. A number of different protocol have been postulated to aid with the examination of the lungs.

ULTRASOUND FOR AIRWAY MANAGEMENT

The utility of P-POCUS for airway evaluation has also recently been demonstrated to identify difficult laryngoscopy, appropriate location of the endotracheal tube, and facilitate cricothyrotomy/tracheostomy procedures. Figure 3 demonstrates the normal sonoanatomy of the vocal cords.

Difficult laryngoscopy and endotracheal tube localization

Point of care ultrasound has demonstrated to improve the airway examination.

Reddy *et al.* [30] found that the anterior neck soft tissue thickness at the level of the vocal cords is a potential predictor of difficult airway. Visualization of the hyoid bone, decreased temporomandibular joint (TMJ) mobility, measurement of the hyomental distance with neck extension, and the measurement of anterior soft tissue thickness at the thyrohyoid membrane all have been used to predict difficult airways [31▪▪].

Recent studies have also shown the utility of ultrasound for verification of successful endotracheal intubation, reporting sensitivity, and specificity of 100% for the detection of successful endotracheal intubation versus esophageal [32]. Perhaps more relevant for the perioperative setting is detection of tracheal versus endobronchial intubation. A recent P-POCUS examination abbreviated Pulmonary tree and Lung expansion Ultrasound Study (P.L.U.S.), which included assessment for tracheal dilation with the endotracheal tube cuff inflation and bilateral

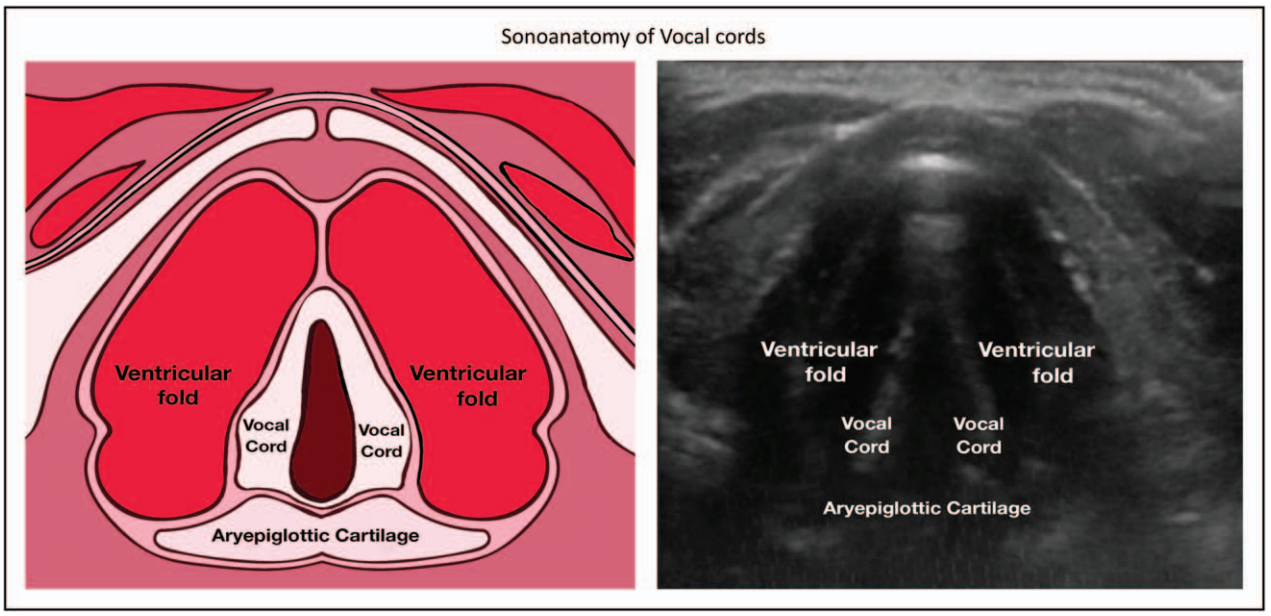

FIGURE 3. Sonoanatomy of vocal cords.

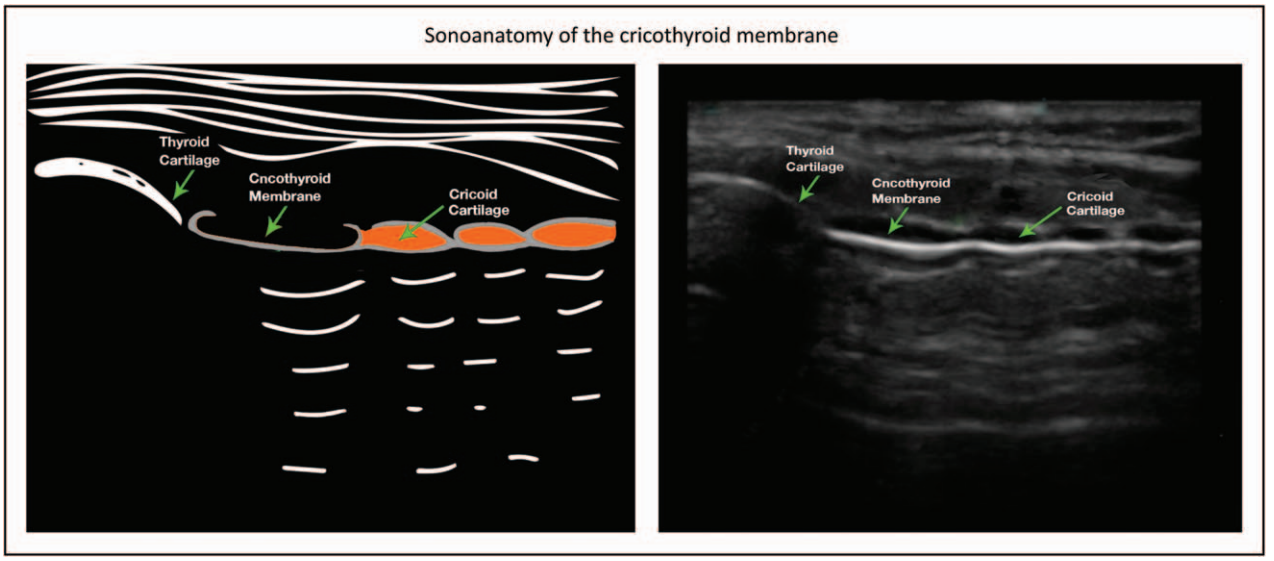

FIGURE 4. Sonoanatomy of the cricothyroid membrane.

pleural lung sliding, demonstrated a high degree of sensitivity and specificity (> 93%) to detect endobronchial versus tracheal intubations [33]. Upper airway ultrasound can also be used to predict the size of a double lumen tube [34▪▪].

Cricothyrotomy/tracheostomy

Surface landmarks for identification are not reliable in majority for the identification of cricothyroid membrane, especially in obese and female patients [35–37]. Bedside ultrasound is a reliable modality for rapid identification of anatomy for emergent cricothyrotomy [34▪▪,38]. Similarly, ultrasound has demonstrated improved success in accessing the trachea with more than 90% first pass attempt [39]. Real-time ultrasound has been used for percutaneous tracheostomies with improved accuracy for midline placement of the needle and probable decrease in the complication rates related to the procedure [40,41]. Figure 4 demonstrates the normal sonoanatomy of the cricothyroid membrane.

ABDOMINAL/GASTRIC ULTRASOUND

The utility of P-POCUS to evaluate for gastric content has been one of the most published P-POCUS topics in recent years [42,43,44▪▪]. A recent grading

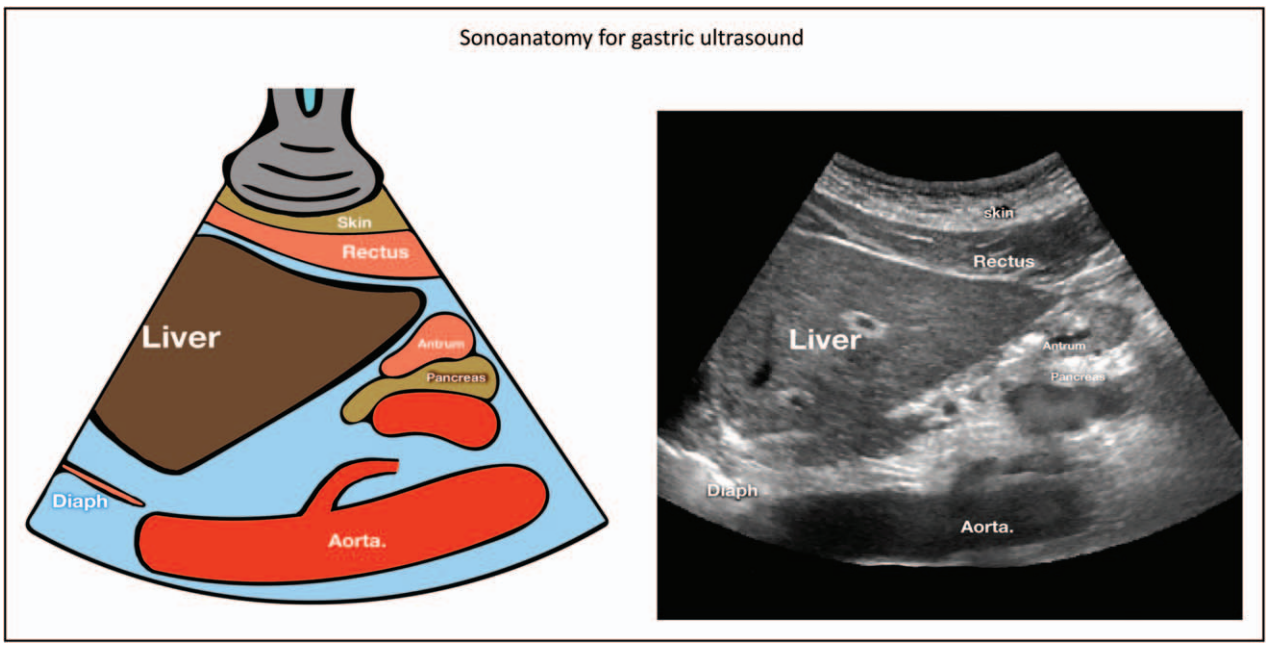

FIGURE 5. Sonoanatomy for gastric ultrasound.

system based exclusively on qualitative sonographic assessment of the gastric antrum has shown strong correlation with predicted gastric volume [43]. It has been suggested that gastric ultrasound could play a vital role in quantifying gastric content and eventually be used not only in an emergent setting but also for elective cases [45▪▪]. A potential value of this modality in a variety of perioperative populations and setting has been suggested. There are multiple tools to educate and report gastric P-POCUS exam findings [44▪▪]. Figure 5 shows the sonoanatomy of the gastric antrum.

In addition, perioperative abdominal ultrasound has demonstrated utility in other applications as well. Commonly used in the emergency room, the Focused Assessment with Sonography for Trauma (FAST) exam is the most commonly performed POCUS examination in the United States and is designed to evaluate for intra-abdominal fluid extravasation (IAFE). Regarding the perioperative setting, Haskins *et al.* [46] demonstrated the utility of applying the FAST exam for evaluating for IAFE in patients who had undergone hip arthroscopy and subsequently correlating the presence of IAFE to increased pain scores in the recovery area.

Finally, the utility of POCUS to facilitate the placement of orogastric tubes has been demonstrated. Chenaitia *et al.* [47] found that ultrasound has 98.3% sensitivity and 100% specificity for OGT placement in the emergency room setting. Currently, this has not been explored in the perioperative setting.

Ultrasound can also be utilized to evaluate a patient with low urine output. Evaluating a full versus an empty bladder is one of the easiest ultrasound examination to perform. The decision to catheterize the patient or not can be guided with a bladder ultrasound [48]. Recently a lot has been written on the use of ultrasound for neuroaxial blockade [49,50,51▪]. This article will not be covering this topic.

CONCLUSION

Advances in technology have allowed the ambulatory surgery environment to play a larger role for anesthesiologist than ever before. The centers are caring for patients with higher acuity undergoing more complex procedures. With this transition, it is intuitive that the bedside patient evaluation techniques advance in tandem. P-POCUS is a key advancement in bedside evaluation that allows the provider to rapidly diagnose acute disorder and facilitate therapeutic strategies. The time has come for anesthesiologists to embrace this modality to further advance perioperative care.

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Conflicts of interest

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