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Review Article

Impact of Point-of-Care Ultrasound on Emergency Airway Management

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ABSTRACT

Point-of-care ultrasound has become an increasingly common bedside adjunct for airway management in the emergency department and intensive care unit, where patients are frequently unstable, unstarved, and difficult to assess by physical examination alone.

This review synthesizes the evidence for four principal applications: sonographic prediction of a difficult airway, ultrasound-guided identification of the cricothyroid membrane for surgical airway access, ultrasound confirmation of endotracheal tube position and depth, and gastric ultrasound for aspiration risk stratification.

Diagnostic accuracy data for tracheal-versus-esophageal tube placement confirmation are the most robust, with pooled sensitivity and specificity consistently above 90% across multiple meta-analyses, including during cardiac arrest when capnography can be unreliable.

Evidence for pre-intubation difficulty prediction and cricothyroid membrane localization is more nuanced, supporting ultrasound as a valuable adjunct to standard assessment and as an anticipatory tool in high-risk patients rather than as a standalone or purely real-time crisis intervention.

We conclude that point-of-care ultrasound has a defensible and expanding role in emergency airway management, while noting that most supporting evidence remains diagnostic-accuracy and simulation-based rather than derived from large outcome trials.

Keywords: *point-of-care ultrasound; emergency airway management; endotracheal tube confirmation; cricothyroid membrane; difficult airway*

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INTRODUCTION

Airway management outside the controlled environment of the operating room carries a different risk profile than elective anesthesia. The patient is frequently unstarved, hemodynamically unstable, or already hypoxemic, and the clinician often has seconds rather than minutes to decide between direct

laryngoscopy, video laryngoscopy, or a surgical airway. Point-of-care ultrasound (POCUS) has moved from a niche skill demonstrated at conferences to a bedside tool that many emergency physicians and intensivists now reach for before, during, and after intubation. It promises three broad things in this setting: a faster read on whether an airway will be difficult, a way to find anatomy that cannot be reliably palpated in an obese or edematous neck, and a confirmation step that does not depend on waveform capnography being immediately available or interpretable [1,2].

This review focuses specifically on the emergency and critical-care airway, not the elective surgical one, because the literature increasingly treats these as distinct use cases with different evidence bases. We look first at pre-intubation assessment, then at ultrasound-guided identification of the cricothyroid membrane for the crash surgical airway, then at post-intubation confirmation of tube position, and finally at adjunctive uses such as gastric content assessment. Throughout, we try to be honest about where the evidence is strong (largely diagnostic accuracy studies) and where it is thinner (patient-centered outcomes such as mortality or first-pass success in randomized trials).

PRE-INTUBATION AIRWAY ASSESSMENT

Traditional bedside predictors of a difficult airway — Mallampati score, thyromental distance, mouth opening — were developed for cooperative, upright, elective surgical patients and translate poorly to a supine, often uncooperative patient in the emergency department or intensive care unit. Ultrasound offers several measurable surrogates instead: the distance from skin to hyoid bone, skin-to-epiglottis distance, the thickness of the anterior neck soft tissue at the level of the vocal cords, and tongue thickness, all of which correlate to varying degrees with difficult laryngoscopy grade [3,4].

A prospective evaluation in intensive care unit patients found that several of these sonographic measures were associated with Cormack-Lehane grade 3-4 views on video laryngoscopy, though no single measurement performed well enough in isolation to replace clinical gestalt [5]. A 2025 systematic review and meta-analysis in *Anaesthesia* pooling upper-airway ultrasound studies against difficult airway outcomes reached a similar conclusion: pooled sensitivity and specificity for individual sonographic parameters were moderate, and the authors argued that ultrasound is best used as one additional data point layered onto standard bedside screening rather than a standalone difficult-airway test [6]. This mirrors what most emergency airway registries have found with other single predictors — no isolated measurement, sonographic or otherwise, reliably rules a difficult airway in or out, and composite risk scores that incorporate ultrasound alongside anatomic exam tend to outperform either approach alone.

Where ultrasound adds something that physical exam cannot is in patients where anatomy is genuinely obscured — massive obesity, cervical collar immobilization after trauma, or distorted neck anatomy from prior surgery or radiation. In these patients a rapid ultrasound sweep of the neck can locate the airway structures that a hand cannot palpate, informing the decision to proceed with an awake technique, call for a second operator, or open a surgical airway tray preemptively [1,7].

LOCATING THE CRICOTHYROID MEMBRANE FOR THE SURGICAL AIRWAY

The "can't intubate, can't oxygenate" scenario is rare but unforgiving, and a large share of documented failures of emergency cricothyrotomy trace back not to technique but to misidentification of the cricothyroid membrane by palpation. Multiple cadaveric and clinical studies have shown that even experienced clinicians frequently misjudge the membrane's location by a centimeter or more, particularly in obese necks, and that palpation accuracy drops further under the stress of a simulated emergency [8,9].

Ultrasound identification of the cricothyroid membrane — typically using a linear probe in a longitudinal or transverse orientation to trace the thyroid cartilage, cricothyroid space, and cricoid ring — has been proposed as a way to mark the membrane preemptively in a patient with an anticipated difficult airway, before the crisis develops, and as a tool novices can use to improve first-attempt success in simulation [10,11]. A comparative simulation study of emergency medicine physicians, residents, and students found that ultrasound-guided identification improved accuracy of membrane localization compared with the traditional landmark technique, particularly among less experienced operators, though time to identification was sometimes longer with ultrasound than with palpation alone [11].

Not every commentator is convinced this translates cleanly into real crash airways. A 2025 appraisal cautioned that the time required to acquire and interpret a clear image may be prohibitive in a true "can't intubate, can't oxygenate" emergency, and argued the strongest use case is prophylactic marking in a patient already identified as high-risk — for example immediately before an awake or difficult intubation attempt — rather than real-time guidance once the crisis is underway [12]. This distinction between elective (anticipatory) and emergent (real-time) use of cricothyroid membrane ultrasound is one of the more practically important nuances in the literature and is easy to lose if the two scenarios are lumped together.

CONFIRMING TUBE PLACEMENT AND DEPTH

Waveform capnography remains the reference standard for confirming tracheal versus esophageal intubation, but capnography is not universally available in every prehospital unit, can be transiently unreliable during cardiac arrest with low pulmonary blood flow, and gives depth information only indirectly. Ultrasound has been studied extensively as either a complement or an alternative.

The basic technique — a transverse probe placement over the thyroid cartilage or suprasternal notch during passage of the tube, watching for a single well-defined tracheal air-mucosa interface versus a "double tract sign" when the tube enters the esophagus — has now been validated across several meta-analyses. Pooled sensitivity and specificity for tracheal versus esophageal intubation detection have consistently exceeded 90% across adult populations, with performance holding up in both emergency department and out-of-hospital settings [13,14,15]. An updated meta-analysis reaffirmed these figures using more recent trial data and additionally reported that real-time dynamic visualization during tube passage performed at least as well as, and in some analyses better than, static post-intubation confirmation [16]. A European multicenter meta-analysis focused specifically on the emergency department setting reported comparably high accuracy and highlighted ultrasound's particular value during cardiac arrest resuscitation, when capnography waveforms can be falsely low or absent due to poor perfusion [17].

Pediatric data lag behind but are accumulating. A 2025 systematic review and meta-analysis of point-of-care ultrasound for confirming endotracheal tube placement in pediatric acute care settings found diagnostic accuracy broadly comparable to adult series, though the authors noted heterogeneity in probe technique and operator experience across the included pediatric studies, and called for standardized training protocols before the technique is adopted as a default in pediatric resuscitation [18].

Beyond the trachea-versus-esophagus question, ultrasound also has a role in confirming appropriate tube depth and in detecting mainstem intubation by assessing for symmetric versus asymmetric lung sliding, and in identifying a pneumothorax that may have resulted from a difficult or traumatic intubation attempt — a complementary bedside lung ultrasound examination that many emergency and critical care POCUS curricula now bundle together with airway ultrasound as a single peri-intubation sonographic package [2,19].

ADJUNCTIVE USES: GASTRIC CONTENT AND ASPIRATION RISK

A less widely appreciated application of point-of-care ultrasound in the emergency airway is gastric assessment. Patients requiring emergency intubation are, almost by definition, unable to reliably report fasting status, and clinical estimation of aspiration risk based on history alone is unreliable in this population. Gastric ultrasound, performed with the patient supine or in a right lateral decubitus position, allows qualitative and semiquantitative assessment of antral contents — empty, clear fluid, or solid/thick fluid — which has been shown in perioperative populations to correlate with aspiration risk and to change airway management decisions such as choice of induction technique and preparedness for rapid suction [20,21].

A study specifically conducted in the emergency medicine department context found that point-of-care gastric ultrasound performed prior to urgent intubation was feasible at the bedside and identified a meaningful proportion of patients with high-risk gastric content who would not have been flagged by history alone, though the study was not powered to demonstrate a reduction in aspiration events [22]. A more recent review framed gastric ultrasound as part of a broader "actionable safety pathway," arguing that a positive full-stomach finding should trigger specific mitigation steps — head-up positioning, preoxygenation strategy, availability of suction, and clinician seniority at the head of the bed — rather than functioning as an isolated data point [23]. This adjunctive role is still emerging relative to airway assessment and tube-confirmation ultrasound, but it illustrates how the same portable probe used to assess the airway is increasingly used to assess the whole physiologic context of the intubation.

BARRIERS TO ADOPTION AND TRAINING

The accuracy figures reported in meta-analyses are largely generated by clinicians with substantial ultrasound experience, and a recurring theme across the literature is that these numbers may not generalize directly to a community emergency department or a rural critical access hospital where point-of-care ultrasound competency is uneven [24,25]. Image acquisition during airway ultrasound specifically requires probe manipulation around a small, curved, and sometimes obscured anatomic target while the operator is simultaneously managing an unstable patient — a very different cognitive load than a focused cardiac or lung ultrasound performed after the immediate crisis has passed.

Simulation-based training appears effective at shortening the learning curve for both cricothyroid membrane identification and tube-confirmation scanning, and several reviews recommend that airway ultrasound be incorporated into standard emergency medicine and critical care ultrasound curricula rather than taught as an optional add-on skill [11,26]. Equipment availability is also improving the calculus: handheld, pocket-sized ultrasound devices with acceptable image quality are now inexpensive enough that placing one in every resuscitation bay is realistic for many departments, which removes what was previously a meaningful logistical barrier to routine

use.

CONCLUSION

Point-of-care ultrasound has earned a defensible place in the emergency airway toolkit, though its strongest evidence sits in different places than a casual read of the literature might suggest. Confirmation of tracheal versus esophageal tube placement is the best-validated application, with consistently high diagnostic accuracy across adult and, increasingly, pediatric populations, and a particular advantage during low-flow states like cardiac arrest when capnography can mislead. Cricothyroid membrane identification is genuinely useful for anticipatory marking in a patient already flagged as a difficult airway, but the evidence for real-time guidance during a true crash cricothyrotomy is thinner and the time cost may be prohibitive in that specific scenario. Pre-intubation difficulty prediction using sonographic measurements is promising as an adjunct to, not a replacement for, standard bedside assessment, and gastric content ultrasound is an emerging tool for risk-stratifying aspiration that has not yet been tested against hard outcomes. None of this is settled science with large randomized trials showing mortality benefit — most of what we have is diagnostic accuracy data and simulation studies — but the consistency of those accuracy findings across multiple independent meta-analyses, combined with the increasing availability of handheld devices, is a reasonable basis for continuing to expand ultrasound training in emergency and critical care airway programs.

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Author Contributions S. Zielinska conceived the review and drafted the initial manuscript. C. Dvorak performed the literature search and contributed the sections on tube-placement confirmation and gastric ultrasound. O. Kowalczyk contributed the sections on pre-intubation assessment and cricothyroid membrane identification and critically revised the manuscript. All authors read and approved the final version.

Ethics Statement This is a literature review and did not involve new human or animal research; no ethics approval was required.

Data Availability No new data were generated for this review. All sources discussed are publicly available in the cited literature.

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