Point-of-Care Ultrasound for Intubation Confirmation of COVID-19 Patients

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The novel coronavirus disease of 2019 (COVID-19) is associated with significant morbidity and mortality, as well as large numbers of patients requiring endotracheal intubation. While much of the literature has focused on the intubation technique, there is scant discussion of intubation confirmation. Herein, we discuss the limitations of traditional confirmatory approaches, summarize the literature supporting a role for point-of-care ultrasound in this application, and propose an algorithm for intubation confirmation among COVID-19 patients. [West J Emerg Med. 2020;21(5)1042-1045.]

Disclaimer: Due to the rapidly evolving nature of this outbreak, and in the interests of rapid dissemination of reliable, actionable information, this paper went through expedited peer review. Additionally, information should be considered current only at the time of publication and may evolve as the science develops.

BACKGROUND

Novel coronavirus disease of 2019 (COVID-19) was first identified in Wuhan, China, beginning in December 2019.[1,2] Since then, the virus has spread rapidly, infecting over 13.3 million people worldwide and resulting in nearly 580,000 deaths.[2] Hypoxemic respiratory failure requiring intubation may occur in up to 19% of all COVID-19 hospitalized patients and 70% of those admitted to the intensive care unit.[3-5]

COVID-19 is rapidly transmissible and, while the most common means of transmission is droplet, airborne transmission may also occur during aerosol-generating procedures such as intubation and subsequent bag-valve ventilation.[6] While much of the transmission conversation has revolved around intubation itself,[7] the discussion of risk associated with post-intubation endotracheal tube (ETT) confirmation is more limited. This commentary will highlight the limitations associated with current intubation confirmation techniques in light of COVID-19 and propose an alternate approach using point-of-care ultrasound (POCUS).

LIMITATIONS OF TRADITIONAL CONFIRMATORY METHODS

Traditional methods of intubation confirmation (eg, auscultation for bilateral breath sounds, condensation in the ETT) are insufficiently accurate in isolation.[8,9] Visualization of ETT passage may be limited by difficult laryngoscopic views and the use of personal protective equipment (PPE). Auscultation can also be challenging in a loud room and may not be possible with some forms of PPE. Moreover, in light of the surface stability of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), auscultation with a stethoscope increases the potential risk for transmission via fomite exposure, while also requiring clinicians to be much closer to the patient which can increase their risk of infection.[10,11]

Other devices, such as end-tidal carbon dioxide (CO_2) detectors and colorimetric capnometry, require at least five breaths for confirmation. This can lead to gastric distension and an increased risk of aspiration if the ETT is incorrectly placed in the esophagus, as well as increased risk of particle aerosolization to providers from the positive pressure ventilations.[8,12] Additionally, capnography may be less reliable in patients where there is a paucity of CO_2 produced (eg, cardiac arrest, pulmonary embolism), with studies suggesting that quantitative capnography may be only 60-65% sensitive during cardiac arrest.[13,14]

When assessing for mainstem (ie, endobronchial) intubation, auscultation is equally problematic, with studies demonstrating

that auscultation alone may misidentify mainstem intubation in 35-60% of patients.[15-17] While radiographs are typically the gold standard for assessing ETT depth, they can be significantly delayed due to the PPE necessary to perform this task and limited departmental resources, which may lead to significant lung barotrauma for unrecognized mainstem intubations in this population with limited oxygen reserve.

ROLE OF POINT-OF-CARE ULTRASOUND FOR INTUBATION CONFIRMATION

POCUS has been increasingly recognized as a valuable tool for intubation confirmation. One approach for this is the transtracheal technique, wherein a clinician places the transducer across the patient's neck post-intubation to visualize the ETT within the trachea or esophagus. This can be facilitated by gently twisting the ETT to create a motion artifact.[18,19] A recent systematic review and meta-analysis found that transtracheal ultrasound was 99% sensitive and 97% specific for confirming ETT location among adult patients.[20] A similar review among pediatric patients found that POCUS was 92-100% sensitive and 100% specific.[21] Studies have also demonstrated that the accuracy remains consistent regardless of ETT size or transducer type.[22,23] Additionally, the learning curve for identifying ETT placement with transtracheal POCUS has been suggested to be relatively short.[24] Importantly, this modality offers the unique benefit that it does not require positive pressure ventilation, thereby minimizing additional exposure to staff.

Other studies have suggested using indirect signs, such as bilateral lung sliding or diaphragmatic elevation for intubation confirmation with a high degree of accuracy.[25] Two studies demonstrated that the combination of lung sliding with transtracheal POCUS further increased the diagnostic accuracy over either in isolation.[26,27]

ROLE OF POINT-OF-CARE ULTRASOUND FOR DETECTING MAINSTEM INTUBATION

Mainstem intubation can be detected through the following three sonographic assessments: lung sliding; diaphragmatic excursion; or the presence of lung pulse. In a mainstem intubation there is no air flow through the contralateral lung, resulting in the absence of the lung sliding (ie, motion artifact visualized between the visceral and parietal layers of the pleura) on that side. Studies of both cadaveric models and emergency department patients have demonstrated that unilateral right lung sliding was 69-92% sensitive and 55.6-100% specific for detecting right mainstem intubation.[28,29] When compared with auscultation, this technique has outperformed auscultation in both adult and pediatric patients.[30,31]

Sonographic assessment of hemidiaphragmatic movement can also be used as a surrogate for ventilation of that lung. When a lung is ventilated by air, the diaphragm will move inferiorly, allowing for direct visualization of lung expansion. Studies have found that this technique is 91-100% sensitive and 50-100% specific, with near-perfect inter-rater reliability.[32,33]

Finally, lung pulse is the visualization of the rhythmic movement of the visceral pleura against the stationary parietal pleura resulting from cardiac pulsations through an airless and motionless left lung due to right mainstem intubation.[34,35] This technique was found to be 93% sensitive and 100% specific for detecting right mainstem intubation.[34] The lung pulse may be particularly valuable for differentiating a mainstem intubation from a pneumothorax, as both would demonstrate unilateral absence of lung sliding.

PROPOSED ALGORITHM

We propose a rapid POCUS algorithm for confirming intubation in COVID-19 patients (Figure). First, transtracheal POCUS can be used to identify endotracheal vs esophageal

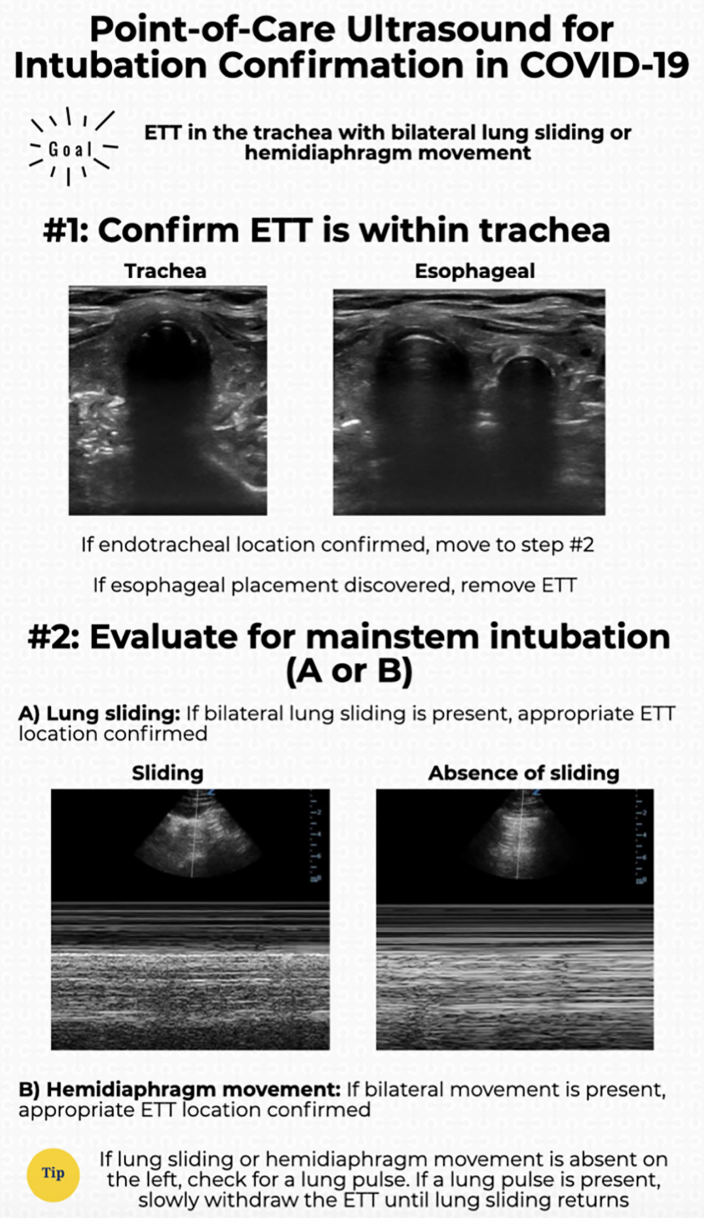

Figure. POCUS algorithm for confirming intubation in COVID-19 patients.

intubation. If there is concern with regard to location, secondary findings (eg, lung sliding) can be used. After confirming the endotracheal location, bilateral lung sliding or diaphragmatic excursion should be used to identify whether a mainstem intubation has occurred. If there is ambiguity regarding this, lung pulse can be used to differentiate unilateral lung sliding from a pneumothorax vs a mainstem intubation. If a mainstem intubation is suggested, the clinician should slowly withdraw the ETT while visualizing the contralateral lung for the re-appearance of lung sliding. This algorithm has not been prospectively validated and future studies should assess the accuracy and safety of this approach.

CONCLUSION

Post-intubation ETT confirmation of COVID-19 patients presents a significant risk of exposure to providers and may be more limited by PPE. We propose the integration of POCUS into the intubation confirmation pathway and present a novel algorithm. Future studies should assess the impact of this on provider safety and the diagnostic accuracy of the protocol compared with current methods.

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