Do You Believe What You See or What You Hear?

Ultrasound versus *Stethoscope for Perioperative Clinicians*

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MANY perioperative clinicians wear a stethoscope and frequently use it for auscultation to, among other things, confirm endotracheal intubation or to rule out esophageal or unintended bronchial intubation. As a matter of routine, auscultation has been used for decades immediately after intubation or whenever correct placement of the endotracheal tube is in doubt in the maintenance of endotracheal intubation. However, accumulating evidence indicates the superiority of other novel techniques to identify esophageal intubation[1,2] when compared with the venerable practice of auscultation. Now, other forms of malposition, specifically endobronchial intubation, appear to be more readily and accurately detected *via* techniques besides auscultation. Perhaps the stethoscope is closer to a costume piece than ever before.

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In this issue of ANESTHESIOLOGY, Ramsingh *et al.*[3] demonstrate the superiority of point-of-care ultrasound over auscultation of breath sounds to differentiate tracheal and bronchial intubation. The study is a prospective, randomized, double-blinded, crossover trial, and was well designed and conducted. The authors found that point-of-care ultrasound is a reliable technique to directly reveal tracheal intubation by detecting tracheal dilation and detects bronchial intubation by demonstrating absent contralateral pleural lung sliding on the unintubated side.

Ramsingh *et al.*[3] reproduced the low sensitivity (66%) and specificity (59%) of auscultation to diagnose endobronchial intubation, similar to previous reports of auscultation to differentiate tracheal *versus* bronchial intubation.[4–6] Even in a nonstressful environment, for instance in this study,[3] experienced clinicians are, at best, able to detect no more than two thirds of definite, deliberate bronchial intubations. The detection rate for unplanned endobronchial intubation, especially under stressful conditions (*e.g.*, trauma) and/or by less experienced clinicians, is probably even lower.

Every technology and technique has its time. Some last longer than others, but many are replaced. Auscultation has been practiced for endotracheal tube positioning for decades, mainly due to lack of better techniques. We tabulated the advantages and disadvantages of various techniques of endotracheal tube position detection to put point-of-care ultrasound in context (table1). Point-of-care ultrasound has all the cost and speed advantages of auscultation, but vastly superior sensitivity and specificity. The cost of a point-of-care ultrasound device is reasonable and dropping fast. Having already displaced stethoscopy for cardiac examination, ultrasound seems poised to take out another province of auscultation. The remaining two techniques, fiberoscopy and radiography, cannot compete due to cost, requirements for skilled (additional) operators or interpretation, and potential risk exposure.

Point-of-care ultrasound is superior to auscultation to detect bronchial intubation. However, the sensitivity (93%) and specificity (96%) of differentiating tracheal *versus* bronchial intubation with this technique are only close to (but do not reach) 100%. Perhaps the gold standard method, chest x-ray, is still needed if misplacement of endotracheal tube cannot be ruled out. However, Ramsingh *et al.*[3] did not present the sensitivity and specificity that could be obtained by combining the two assessments: visualizing tracheal dilation and nonsymmetric lung pleural sliding. If tracheal dilation and nonsymmetric lung pleural sliding are mutually exclusive in adults, then observing tracheal dilation indicates that nonsymmetric lung pleural sliding should not be observed, and *vice versa*. Therefore, combining these two assessments would further increase the accuracy of differentiating tracheal *versus* bronchial intubation. Point-of-care ultrasound also demonstrates the distance between cricoid cartilage

Image: A. Johnson.

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Accepted for publication November 4, 2015. From the Department of Anesthesiology, Graduate School of Medicine, Chiba University, Chiba, Japan (S.I.); Departments of Anesthesiology, Surgery, and Biomedical Informatics (W.S.S.); and Department of Anesthesiology (Y.J.), Vanderbilt University Medical Center, Nashville, Tennessee.

 Anesthesiology 2016; 124:989-91

<zdoi;10.1097/ALN.0000000000001074>

Table 1. Comparison of the Techniques Commonly in Use to Differentiate Tracheal *vs.* Bronchial Intubation

Techniques	Sensitivity (%)	Specificity (%)	Invasive or Harmful Exposure	Immediacy	Cost per Use	Comments
Auscultation	60–66[3-6]	59–93[3-6]	No	Present	No	Low sensitivity, low specificity
Fiberoscopy	91.7[7]	98.6[7]	Yes	Present	Over $50[8]	Harmful and not cost-effective
Ultrasound	93[3]	96[3]	No	Present	No	Highly accurate and cost-effective, no delay in diagnosis
Chest x-ray*	100	100	Yes	Absent	$100 (the national median costs)[9]	It is considered as the gold standard.[4,10] Highly accurate; x-ray is harmful; not cost-effective; delayed diagnosis

*The 100% values of sensitivity and specificity were authors' best estimates of ideal performance in expert hands. Radiographic confirmation is susceptible to poor communication between clinicians, in addition to other weaknesses.

(glottis) and the endotracheal tube cuff, so clinicians can both confirm the cuff in the trachea and also estimate the distance between the cuff and the carina. The tracheal length of adult humans, defined from glottis to carina, is 9.2 ± 1.5 cm (mean ± SD),[10] and knowing the distance between glottis and the cuff helps clinicians assess the likelihood of bronchial intubation. Therefore, combining tracheal dilation, assessment of pleural sliding on both sides, and assessment of cuff location relative to the glottis (and hence, carina) should achieve sensitivity and specificity comparable to those obtained with chest x-ray recommended as a standard.[4,11] This assertion is readily testable and should be done since the authors have the primary data.[3]

Like any new technique, using point-of-care ultrasound to detect the tube misplacement is not without challenge. First, the learning curve is unknown, as mentioned by Ramsingh *et al.*, although their operators all had reasonably brief minimum practice periods. From other domains, it is encouraging to know that only 5 min of training allows trainees to detect esophageal intubation in cadavers using ultrasound, with a sensitivity of 97%.[12] Second, whether the degree of cuff inflation affects the detection of tracheal dilation observed by ultrasound has not been tested. Some clinicians inflate the cuff only until a relatively low-pressure leak around it has been occluded and no more. In theory, such a cuff conforms relatively closely to the trachea and may produce no dilation. Since there is no standard pressure or volume for endotracheal tube cuff inflation, a low-inflated cuff may be difficult to visualize. This remains to be explored before the sensitivity and specificity of tracheal dilation can be assumed in all hands. Third, the study was conducted on adults.[3] It is unknown if the findings are reproducible in pediatric populations. For example, tracheal dilation requires an inflated cuff. Although uncuffed endotracheal tubes are falling out of fashion, they still have adherents. Certainly, an uncuffed tube does not create tracheal dilation. Fourth, ultrasound only indirectly detects bronchial intubation or tracheal intubation. It does not directly show the location of the cuff or tip of the tube. Lack of observable tracheal dilation could occur if the cuff is below the sternal notch or in the esophagus but not necessarily in a main stem bronchus. Therefore, it requires another method to detect bronchial or esophageal intubation by visualizing lung pleural sliding. To visualize the lung sliding, the sonographer has to change the mode of ultrasound. This requires additional effort.

In other published work, it has been proposed that ultrasound can be used dynamically in direct conjunction with the airway procedures for maximum benefit in airway management.[13] This is because one can directly visualize the tube passing to the trachea or esophagus while it is being inserted. The previous investigators[13] were concerned that the accuracy of detecting bronchial intubation with point-of-care ultrasound postintubation is not as high as that obtained by dynamically examining the airway during

intubation. In contrast, Ramsingh *et al.* found the accuracy of detecting bronchial intubation is high even when the assessment was conducted after the intubation was completed.

The studies of Ramsingh *et al.*[3] and others[12,14] open new areas to explore other potential methods with which the accuracy to detect misplacement of endotracheal tube could be further optimized as enumerated below. 1) To inflate the cuff with liquid instead of air. It was described previously that filling the cuff with fluid helps in revealing the cuff position by ultrasonagraphy.[15] This method is proven valuable even in pediatric population.[16] 2) To make the cuff with echogenic material. Such material enhances the image of the cuff and makes the cuff more visible relative to the tracheal region not interfaced with cuff. Such alterations could make the detection of cuff location much easier, and the sonographer can visualize the cuff and tracheal rings around the cuff, which confirms tracheal intubation, not esophageal or bronchial intubation. In other words, one-stop shopping.

The findings[3] of Ramsingh *et al.* further undermine the perioperative role of the stethoscope (except perhaps as a fomite): accuracy using auscultation to detect intentional or unintentional bronchial intubation is low. Alternatively, point-of-care ultrasound produces the accuracy close to that obtained with chest x-ray, but using a device that is becoming prevalent and potentially ubiquitous in the perioperative environment. We expect that continuous improvement of image quality and clinical experience with point-of-care ultrasound will further prompt its application in detecting misplacement of endotracheal tubes and beyond and enable us to provide better patient care.

Competing Interests

The authors are not supported by, nor maintain any financial interest in, any commercial activity that may be associated with the topic of this article.

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