The Cuff Leak Test: Does It "Leak" Any Information?

Post-extubation stridor and upper-airway obstruction are multifactorial in etiology and can occur as a result of laryngotracheal edema, intubation trauma, excessive cuff pressure with mucosal ulceration, and prolonged intubation with secondary inflammation and granuloma formation.[1] Cuff leak tests (CLTs) were introduced in an attempt to predict post-extubation upper-airway obstruction and reduce the incidence of extubation failure. Qualitative CLTs were performed by deflating the endotracheal tube (ETT) cuff, blocking the ETT opening, and listening for an audible leak around the ETT while patients were spontaneously breathing.[2] In an effort to increase the accuracy of CLTs in detecting post-extubation stridor, methods of quantifying a cuff leak were introduced.

Miller and Cole[3] described the cuff-leak test with the ventilator set in assist-control mode at a tidal volume (V_T) of 10–12 mL/kg. An inspiratory V_T and 6 subsequent expiratory V_T values were recorded after oropharyngeal suctioning and ETT cuff deflation. The cuff leak was measured as the difference between the preset inspiratory V_T and the average of the 3 lowest of the subsequent 6 expiratory V_T values. The threshold cuff-leak volume was determined by visual inspection of the receiver-operating characteristic plot. A leak of < 110 mL was considered a positive result of the CLT and indicated that patients were at risk for post-extubation stridor secondary to laryngeal edema.[3]

This quantitative cuff leak has been expressed as an absolute volume or as a percentage of the inspired V_T. When the cuff leak volume is < 110–130 mL[3,4] or < 10–15.5%[5,6] of the delivered V_T, the risk for post-extubation stridor is significantly elevated. Other attempts have focused on quantifying a cuff leak volume in spontaneously breathing patients receiving CPAP.[7] The leak volume was calculated as the difference between the expiratory V_T with inflated cuff and the expiratory V_T with deflated cuff.

Even with quantifiable cuff leak volumes, studies reported a low sensitivity and a low positive predictive value of cuff leak volumes in detecting post-extubation stridor.[3–5,8] This was attributed to several factors, including the lack of standardization of the ratio of ETT size to the laryngeal diameter (a large ETT will result in a smaller cuff leak volume for the same laryngeal diameter), and the possible contribution of the exhaled limb of the breathing circuit and the ventilator to an increased airway resistance and therefore an increase in cuff leak volume.

In an effort to eliminate the ETT size as a confounding variable, Gros et al, in this issue of RESPIRATORY CARE, evaluated the use of intra-individual variation of the cuff-leak test (ΔCLT), as a predictor of post-extubation stridor.[9] They performed the CLT (as proposed by Miller and Cole) immediately after intubation (T0) and before extubation (T1) to evaluate the differences in cuff leak: $\Delta CLT = CLT1 - CLT0$. A positive CLT was defined as $\Delta CLT < 0$ mL, according to the receiver-operating characteristic curve.

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Unfortunately, this did not improve the accuracy of the standard pre-extubation cuff-leak test in predicting post-extubation stridor. As the authors state in their discussion, other confounding variables have been introduced by measuring ΔCLT, including the change in pulmonary compliance between the T0 and T1 measurements and the different conditions under which T0 and T1 were conducted, with patients sedated and paralyzed during T0 while awake and actively participating during T1.

So how do we interpret the findings of this and other studies on cuff leak test? Most studies on cuff leak volume document a high specificity and a high negative predictive value (Table), which means that patients with a cuff leak volume above a certain threshold (ΔCLT above 0 mL, cuff leak volume $> 15\%$ of V_T or > 140 mL) have a low probability of developing post-extubation stridor. Incorporating the CLT into the clinical decision making tree may avoid unnecessary delays in extubating patients for fear of post-extubation stridor, once other extubation criteria are met.

Since CLT has a low sensitivity and a low positive predictive value, patients with a positive CLT may or may not develop post-extubation stridor. Even though Gros et al[9] reported a sensitivity of 86% in their study results, the wide confidence intervals (95% CI 42–100%), and the results of other studies point to an overall low sensitivity of cuff leak volumes in detecting post-extubation stridor. While there is currently no evidence that delaying extubation of patients with a positive CLT improves outcomes,

Table. Definitions of Cuff Leak Test Sensitivity, Specificity, and Predictive Values

Sensitivity	Patients with a positive cuff leak test (cuff leak volume < 130 mL) or change in cuff-leak test volume (ΔCLT) < 0 mL who developed post-extubation stridor, divided by all patients with post-extubation stridor
Specificity	Patients with a negative cuff leak test (cuff leak volume > 130 mL) or ΔCLT > 0 mL who did not develop post-extubation stridor, divided by all patients with no post-extubation stridor
Positive predictive value	Patients with a positive cuff leak test (cuff leak volume < 130 mL) or ΔCLT < 0 mL who developed post-extubation stridor, divided by all patients with a positive cuff leak test (cuff leak volume < 130 mL) or ΔCLT < 0 mL
Negative predictive value	Patients with a negative cuff leak test (cuff leak volume > 130 mL) or ΔCLT > 0 who did not develop post-extubation stridor, divided by all patients with a negative cuff leak test (cuff leak volume > 130 mL) or ΔCLT > 0 mL

the following considerations can help to reduce the incidence of extubation failure and improve the success rate of reintubation attempts

- Careful evaluation of other extubation parameters, especially that laryngeal pathology is one of many causes of extubation failure. The incidence of reintubation within 48–72 hours of ETT removal is in the range of 12.5% in the critical care population.[1]
- Fiberoptic evaluation of the airway to confirm or exclude laryngeal edema, especially in patients with recent large fluid shifts, prone positioning with dependent facial edema, and external facial swelling.
- A preformulated plan for securing the airway in case reintubation becomes necessary. This includes the availability of clinicians with airway management expertise, and immediate access to various intubation and ventilation equipment (fiberoptic equipment, laryngeal mask airways, emergency cricothyroidotomy)
- Use of steroids to reduce laryngeal edema[10]
- Use of airway exchange catheters, which can provide temporary oxygenation until definitive measures to secure the airway are taken, in case of extubation failure, and can also act as a conduit for reintubation[11]

Gros et al are to be congratulated for their attempts to improve the accuracy of the CLT in detecting post-extubation stridor by using patients as their own controls. The elimination of one confounding variable in their study (relationship of tube size to laryngeal diameter) was shadowed by the introduction of 2 other confounders: the change in pulmonary compliance, and the different conditions under which the CLT was performed (sedated/paralyzed vs awake). The incidence of post-extubation stridor in their study (6.7%) is in line with the results of most trials in the medical and surgical population, and is a reminder that being prepared for management of post-extubation stridor (and other causes of extubation failure) may be more important than trying to predict its occurrence.

Maged Y Argalious MD MBA
Postanesthesia Care Unit
Anesthesiology Institute
The Cleveland Clinic
Lerner College of Medicine
Cleveland, Ohio

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Correspondence: Maged Y Argalious MD MBA, Postanesthesia Care Unit, Anesthesiology Institute, The Cleveland Clinic, 9500 Euclid Avenue, G-3, Cleveland OH 44195. E-mail: argalim@ccf.org.

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