

Commentary

The cuff-leak test: what are we measuring?

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See *Research* by Priniakakis *et al.*, page 119

Abstract

Stridor is one of the most frequent causes of early extubation failure. The cuff-leak test may help to identify patients at risk to develop post-extubation laryngeal edema. However the discrimination power of the cuff-leak test is highly variable and can be used, at best, to detect patients at risk to develop edema but should not be used to postpone extubation as tracheal extubation can still be successful in many patients with a positive test. In this editorial, the author discusses the factors influencing the leak and hence its predictive value.

Keywords extubation failure, laryngeal edema, stridor

Tracheal extubation of patients is still a major challenge, with the possibility of post-extubation stridor and then re-intubation if the patient is unable to sustain the increase in respiratory work. Stridor is responsible for 15–38% of extubation failures [1–3] and for close to 38% of early extubation failures [3]. Recognition of stridor is important because these patients can benefit from close monitoring and from specific therapies including non-invasive respiratory assistance, aerosolized adrenaline (epinephrine), and steroids (even though the efficacy of steroids remains under debate). Ideally, patients at risk of developing laryngeal edema should be identified as early as possible, and the cuff-leak test has been proposed for this purpose. The principle of this test is quite simple and is based on the fact that the air leak around a tracheal tube with a cuff deflated will be inversely related to the degree of laryngeal obstruction generated by laryngeal edema.

The cuff-leak test was developed initially in children with croup [4]; extubation was likely to be successful if an air leak could be heard when the baby coughed during positive pressure ventilation. The test was further refined to allow quantitative measurements, using the difference between the expired tidal volume with the cuff inflated and with the cuff deflated: the higher the leak, the lower the likelihood that post-extubation stridor will occur. The discrimination power of the test is highly variable (Table 1), depending on the population investigated, the incidence of post-extubation

stridor (ranging from 4% to 38%), the method of determination of cuff leak (absolute value versus value relative to tidal volume measured with an inflated cuff, number of measurements of tidal volumes averaged, and so on). But perhaps more importantly, the cut-off value should be adapted to the situation; the cut-off that is usually given in most studies assumes an equivalent impact of false positive and false negative values. However, in clinical practice, both may not have equivalent weight. In some cases, a policy of minimizing the risk of false negatives and thus accepting a lower specificity may be preferred. This policy minimizes the risk of extubation failure and may be preferred in patients in whom tracheal intubation is difficult. On the other hand, a policy minimizing the risk of false positives, and thus less sensitive, may be preferred if one wishes to minimize the risk of unnecessary prolonged intubation. In any case, a low cuff-leak should never be used to preclude extubation because the specificity of the test is still low [5], even when the policy favoring minimizing false negatives is chosen so that the test can be used mainly to characterize patients at risk of developing post-extubation stridor.

In this issue, Priniakakis and colleagues [6] shed some new light on the factors that might affect the leak, and hence the evaluation of the cuff-leak test. First, they separate the inspiratory and expiratory components of the leak. Usually, the leak is calculated by measuring five or more tidal volumes

Table 1**Characteristics of studies that used the cuff-leak test to predict extubation failure**

Author	Number of patients	Type of patients	Cut-off value	Sensitivity/specificity	Stridor/reintubation, N (% of positive tests)
Fisher [8]	62	Upper airway obstruction	n.a.	100/85	n.a.
Sandhu [9]	110	Trauma	11.7%	n.a./98	14 (n.a.)
Miller [10]	110	At risk	110 ml	83/99	6 (n.a.)
Engoren [7]	524	Post operative	110 ml	0/96	2 (0)
De Backer [5]	76	Mixed	15.5%	75/72	10 (80)
Jaber [11]	112	Mixed	110 ml (or 12%)	85/95	13 (n.a.)
Maury [12]	115	Medical	n.a.	100/98	4 (100)

n.a., not applicable.

after deflation of the cuff. Of course, the inspired tidal volume effectively reaching the alveoli will also decrease so that the tidal volume measured with the cuff deflated is influenced by both inspiratory and expiratory leaks.

Prinianakis and colleagues [6] developed a method that limits the influence of the inspiratory leak. After an inspiratory pause, the cuff is deflated and the subsequent expired tidal volume is measured. This maneuver is repeated five times and the five values are averaged. The two methods were compared in 15 patients and the expiratory leak was consistently lower than the total leak. As the ratio between expiratory and total leak was constant (around one-third to one-quarter of the total leak) whatever the value of the leak, this suggests that factors affecting expiratory leak would similarly affect inspiratory leak, and thus total leak.

In the second part of the study, the authors used a lung model to evaluate the factors influencing the expiratory leak (and thus probably similarly the inspiratory leak). They obstructed the lumen between the endotracheal tube and the common tube of the model to obtain calibrated low and high leaks. Thereafter, they sequentially evaluated the impact of resistance, compliance, and flow. Factors affecting the leak were similar, independently of the size of the endotracheal tube. The total leak was not affected by the breathing pattern, with similar values in normal, restrictive, and obstructive patterns. As expected, factors influencing predominantly the inspiratory phase influenced total leak but not expiratory leak. Total leak was inversely related with inspiratory flow and with compliance. Airway resistance, which mostly affects expiration, affected total and expiratory leak similarly, with higher leaks at high resistances.

What are the clinical implications of these findings? First, should the measurement of the expiratory leak alone replace the measurement of the total leak? Probably not. The design

of this study was not to compare the performance of both tests but rather to evaluate the factors influencing the leak. As these patients were deeply sedated and even muscle relaxants were used, extubation occurred quite a long time after the test so that the ability of the test to predict extubation failure could not be assessed. It is even likely that the inspiratory component might have a major role in the validity of the test. Inspiration occurs at high pressure, which favors leakage of gas around the tracheal tube. As the problem of the test is mainly its lack of specificity, suggesting that in some patients an absence of leak can be observed even when there is no airway obstruction, it is likely that using the expiratory leak would be even less discriminatory because this occurs at low pressure. Second, the findings reported by Prinianakis and colleagues [6] might explain, at least in part, some of the differences between studies. Series in post-operative patients showed that the capacity of the cuff-leak test to predict extubation failure was much lower than in populations of critically ill patients ventilated for at least 48 hours [5,7]. This might be explained by the influence of decreased compliance or increased airflow resistance, which are more likely to occur in these patients. Because these factors increase the amount of leak, an absent leak is even more suggestive of airway obstruction.

In conclusion, the cuff-leak test can be used to identify patients at high risk of developing post-extubation stridor, who often require re-intubation. The use of this test in non-selected populations is of limited value but it might be more efficient in selected patients, even though an absent leak should never postpone extubation given the non-negligible rate of false positive tests. The data presented by Prinianakis and colleagues [6] help us understand the major roles of compliance, airway resistance, and flow in the interpretation of the cuff-leak test.

Competing interests

The author(s) declare that they have no competing interests.

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