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Swallowing Disorders as a Predictor of Unsuccessful Extubation: A Clinical Evaluation

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Background Unsuccessful extubation may be due to swallowing dysfunction that causes airway obstruction and impairs patients' ability to cough and expectorate.
Objective To determine whether swallowing assessment before extubation is helpful in predicting unsuccessful extubation due to airway secretions.
Methods This prospective study included all patients intubated orotracheally for more than 6 days. Before extubation, 3 tests designed to assess (1) cervical, oral, labial, and lingual motility; (2) gag reflex; and (3) swallowing were used at the bedside. Causes of reintubation were identified, and their relationship to patients' swallowing function before extubation was evaluated.
Results Sixty-two patients were enrolled. Data on 55 patients reintubated for swallowing dysfunction were analyzed. Nine patients were reintubated because of obstruction related to upper airway secretions. Evaluation before extubation enabled prediction of 7 of those 9 unsuccessful extubations. Among the 23 patients with central nervous system disease, 3 of 4 unsuccessful extubations were predicted. According to a multivariate logistic regression model, motility and swallowing were independent predictors of unsuccessful extubation (area under receiver-operating-characteristic curve, 80%). The gag reflex was the only significant predictor of the ability to cough (area under curve, 73%) and excessive pulmonary secretion (area under curve, 67%). Swallowing was an independent predictor of the need for suctioning (area under curve, 78%).
Conclusions Using simple bedside tests to evaluate swallowing before extubation is helpful when deciding whether to extubate patients who have been intubated for more than 6 days. Involvement of nurses in these decisions would improve patients' management. (*American Journal of Critical Care.* 2008;17:504-510)

Patients in whom extubation is unsuccessful stay significantly longer in intensive care units (ICUs) and have a higher mortality rate than do patients who are extubated successfully.[1,2] Tracheal reintubation can become necessary in several situations, including mechanical ventilation, airway protection, airway obstruction, pulmonary cleansing, and high-level continuous positive airway pressure.[3] In most of these situations, reintubation is associated with life-threatening complications and a poor prognosis.

These many and varied causes of reintubation necessitate a battery of tests for each indication. Results of functional respiratory tests are often used as weaning parameters (ie, to assess ability to maintain spontaneous breathing without ventilatory assistance). However, such measurements are not accurate enough to enable prediction of unsuccessful extubation (ie, the inability to tolerate removal of the translaryngeal tube).[4,5] Previous reports[6-10] on these tests indicate that some respiratory measurements are independent predictors of extubation outcomes. These measurements include peak expiratory flow (as an evaluation of cough strength), score on the Glasgow Coma Scale, secretion volume, the cuff leak test, the ratio of Pa_{O_2} to fraction of inspired oxygen, maximum negative inspiratory pressure, and the ratio of respiratory rate to tidal volume. However, the reliability of such measurements remains debatable because the measurements may vary, depending on the study population and the methods of evaluation.[11] This concern is particularly important for patients with central nervous system (CNS) diseases; in these patients, swallowing disabilities may result because of either their neurological disease or their impaired mental status.[12]

Unsuccessful extubation can be caused by upper airway obstruction with consequent narrowing of the respiratory space or by inability to manage respiratory secretions. Swallowing dysfunction that leads to aspiration is common, especially after prolonged intubation, and accounts for up to 15% of unsuccessful extubation cases.[6] The incidence of swallowing dysfunction is underestimated, mainly among patients whose intubation lasts longer than 48 hours.[13-15] Moreover, no guidelines are available to predict extubation outcome in brain-injured patients.[2] Swallowing is usually evaluated after extubation and requires specialized intervention and transportation of patients. We therefore devised a scale for bedside evaluation of swallowing function before extubation. Our aim in the study reported here was to determine whether this scale is useful to predict unsuccessful extubation related to airway secretions.

Swallowing dysfunction accounts for up to 15% of extubation failure.

Patients and Methods

This research was done in accordance with the appropriate institutional review body and was carried out in conformity with the ethical standards set forth in the Helsinki Declaration of 1975. All patients were treated according to our standard clinical practice, so their specific informed consent was not required.

Patients

All successive patients admitted to the medical or surgical ICU at l'Hôpital Lariboisière-Fernand Widal, Paris, France, and intubated by the orotracheal route for more than 6 days were prospectively enrolled when extubation was planned. Patients with nasotracheal intubation, previous swallowing disorders, ear-nose-throat surgery, or chronic persistent vegetative status were not included. During the study period, all patients were intubated with a low-pressure, high-volume tube cuff. Cuffs were routinely checked, and pressure was kept at 25 to 30 cm H_2O. Treatments, weaning protocols, and decisions to extubate or reintubate were left to the discretion of the attending physicians.

Swallowing function was based on cervical, oral, labial, and lingual motility; gag reflex; and swallowing.

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Table 1
Bedside evaluation of swallowing function before extubation

Function	Score	
Motility[a]		
Holding the head up	Not able	1 ☐
	Able	2 ☐
Opening the mouth	Not able	1 ☐
	Able	2 ☐
Pursing the lips	Not able	1 ☐
	Able	2 ☐
Gritting the teeth	Not able	1 ☐
	Able	2 ☐
Sticking the tongue out over the lower teeth	Not able	1 ☐
	Able	2 ☐
		Total (5-10)
Gag reflex[b]		
Right side	None	1 ☐
	Weak	2 ☐
	Normal	3 ☐
Left side	None	1 ☐
	Weak	2 ☐
	Normal	3 ☐
		Total (2-6)
Swallowing[c]	Incomplete	0 ☐
	Complete	1 ☐
		Total (0-1)

[a] Motility was scored 2 if a motor response to a request or the ability to move was observed by the therapist, and 1 if no movement was observed.

[b] The left and right sides were scored separately, by triggering each lateral oropharyngeal side with the finger. A 10-mL syringe positioned between the molars was used to protect therapists from biting.

[c] The complete motor scheme of swallowing was assessed, including pharyngolaryngotracheal axis elevation, the anterior movement of the larynx and hyoid bone, and the sound of pressure propelling the bolus down the esophagus.

All patients met institutionally sanctioned weaning criteria.[16] Extubation was performed by trained nurses and physiotherapists. (In France, physical and respiratory therapies are performed by the same therapist.) Before extubation, subglottal suctioning was performed.

Using a bedside preextubation evaluation, 78% of extubation failures were predicted.

Interventions

Before extubation, the different components of swallowing functions were evaluated at the bedside by using a scale to assess (1) cervical, oral, labial, and lingual motility; (2) the gag reflex; and (3) swallowing (Table 1 and Figure 1). These tests do not require any specific equipment. A 10-mL syringe was positioned between the patient's molars to prevent biting when the operator introduced a finger into the patient's mouth to test the gag reflex.

In both the medical and surgical ICUs, evaluations were performed by 4 experienced physiotherapists, with the patient's tube cuff inflated. When the cuffs were deflated, however, tube mobility was excessive and an excessive coughing reflex occurred that impaired the evaluation process despite suctioning of pharyngeal secretions. The physicians were not told the results of the swallowing tests.

The ability to cough and swallow, secretion volume, and the need for suctioning were evaluated immediately (within 10 minutes) and at 24 and 48 hours after extubation (Figure 2). Cough was scored as normal or abnormal according to the efficiency with which secretions were ejected. The ability to perform a complete swallow without coughing was scored as possible or impossible. Increases in laryngeal secretions after extubation were evaluated by using suctioning and respiratory therapy.

Justification of the Evaluation Tests

The choice of evaluation criteria (Table 1) was based on the physiology of swallowing in its buccolingual and oropharyngeal stages.[17,18] Each item was related to a simple order that was easy for the therapist to mimic. The testing of spontaneous cervical motility allowed even confused patients to be scored. Although the score on the Glasgow Coma Scale was not precisely determined at the time of extubation, all the patients had a sufficient level of consciousness to allow examination of their motor functions. Ability to hold the head up is usually considered before extubation is decided, because this ability indicates that sedative and neuromuscular blocking agents have worn off completely. Weakness of muscles in the front of the neck may cause swallowing dysfunction related to hyoid bone instability and nonphysiological positioning of the head and neck. Therefore, the palpable muscles in the front of the neck, which appeared either spontaneously or after adequate postural stimulation, were tested (a score of 1 of 5 on manual muscle testing was required).[19]

Ability to open the mouth indicated normal tonicity. Ability to purse the lips indicated facial nerve integrity. Ability to grit the teeth, which is part of the swallowing process, was necessary to give a fixation point for the suprahyoid muscles. Their contraction allows the pharyngolaryngeal tracheal axis to tighten and the hyoid bone and larynx to elevate. Swallowing is usually difficult when the mouth is open. Ability to stick out the tongue over the lower teeth indicated that the tongue was strong enough to push the bolus being swallowed backward down the esophagus.

Data Collection and Analysis

The physiological variables measured at admission were used to calculate the Simplified Acute Physiology Score II.[20] Extubation was considered unsuccessful if reintubation was required within 48 hours after extubation. The causes of unsuccessful extubation were identified, and their relationship to swallowing function before extubation was evaluated. Some patients were reintubated for reasons other than swallowing problems or airway protection. Thus, the only patients included in the analysis were patients who were successfully extubated and patients in whom extubation was unsuccessful because of upper airway secretions.

Statistical Analysis

Results were expressed as medians (10th-90th percentiles). Comparisons were performed by using the Mann-Whitney test (because of the nonnormal distribution of variables) or the Fisher exact test. The value of each test in predicting successful extubation was assessed by using multivariate logistic regression. When a quantitative parameter (or a

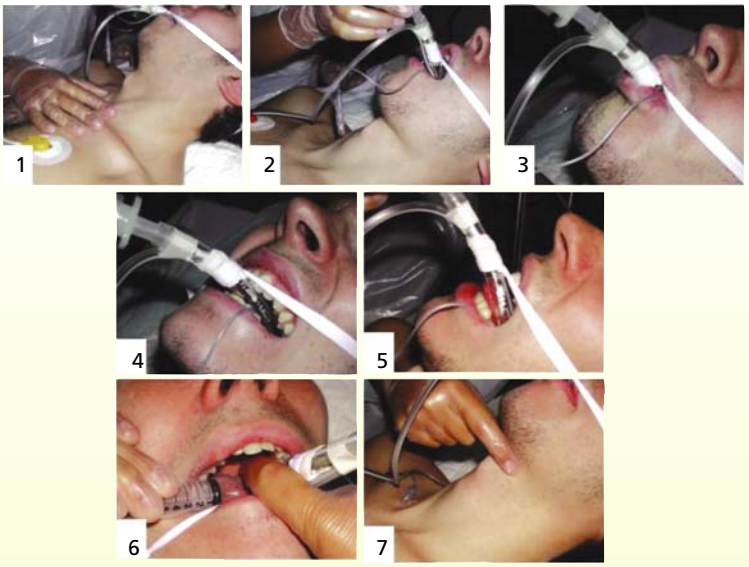

Figure 1 Steps in the clinical evaluation of swallowing disorders. Assessment of the patient's ability to hold the head up (1), open the mouth (2), purse the lips (3), grit the teeth (4), and stick the tongue out over the lower teeth (5), and determination of the gag reflex score (6) and the swallowing score (7).

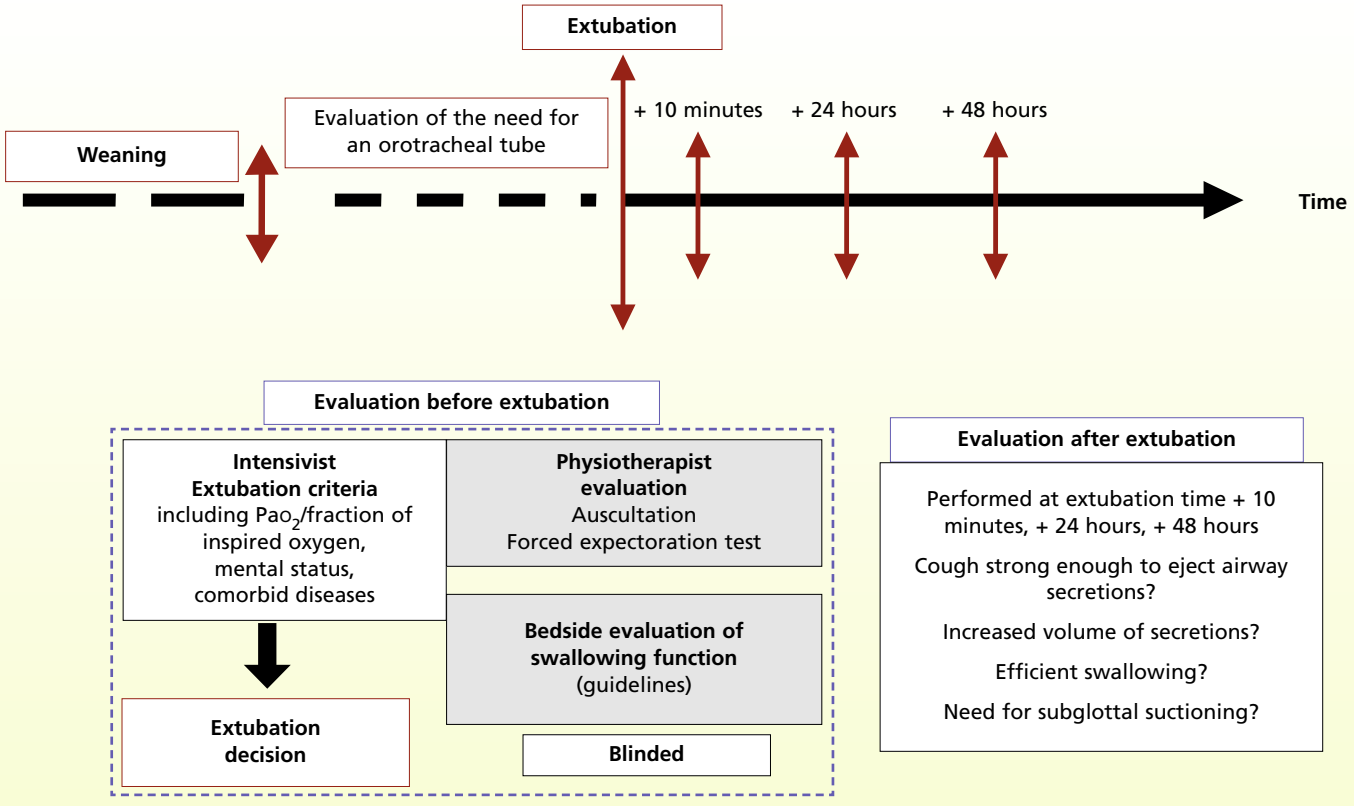

Figure 2 Time and methods of data collection and evaluation.

Table 2
Patients' demographic characteristics

Characteristic	Value
No. of patients enrolled	62
No. of patients included in the analysis	55
Age, median (10th-90th percentile), y	51 (26-79)
Sex, No. of patients	
Male	38
Female	17
Intubation time, median (10th-90th percentile), d	13 (7-27)
Simplified Acute Physiology Score II, median (10th-90th percentile)	50 (28-73)
Primary disorders, No. (%) of patients	
Central nervous system diseases	23 (42)[a]
Acute respiratory failure	14 (26)
Shock	7 (13)
Heart failure	6 (11)
Acute poisoning	5 (9)

[a] Including 10 with head trauma and 7 with brain ischemia.

Table 3
Value of evaluation before extubation to predict unsuccessful extubation due to excessive bronchial secretions: successful vs unsuccessful extubation

Characteristic	Extubation		*P*
	Successful (n = 46)	Unsuccessful (n = 9)	
Age, median (10th-90th percentile), y	46 (25-79)	56 (36-75)	.30
Sex, No. of patients			.70
Male	30	8	
Female	16	1	
Intensive care unit, No. of patients			.90
Surgical	24	5	
Medical	22	4	
Central nervous system diseases, %	41	44	.90
Intubation duration, median (10th-90th percentile), d	12 (7-26)	13 (7-23)	.80
Simplified Acute Physiology Score II, median (10th-90th percentile)	47 (24-69)	60 (45-81)	.005
Death in intensive care unit, %	0	33	<.001
Evaluation before extubation			
Motility scores (scale, 5-10), median (10th-90th percentile)	10 (9-10)	9 (6-10)	.003
Gag reflex scores (scale, 2-6), median (10th-90th percentile)	5 (2-6)	5 (1-5)	.30
Swallowing process, No. of patients			.005
Complete	34	2	
Incomplete	12	7	

score combining several parameters) was identified as a predictor of an event, the sensitivity and specificity of the predictor for different considered cutoff points were determined. Then the true-positive rate (ie, sensitivity) was plotted against the false-positive rate (1 - specificity) for the different possible cutoff points of the parameter. This kind of graph is called a receiver-operating-characteristic (ROC) curve. Accuracy of prediction was indicated by the area under the ROC curve. An area of 1 represented a perfect test; an area of 0.5 represented a worthless test. Areas larger than 0.9, 0.8, 0.7, or 0.6 were considered excellent, good, fair, or poor, respectively. ROC curves show the trade-off between sensitivity and specificity: any increase in sensitivity results in a decrease in specificity. Values in predicting unsuccessful extubation were estimated by calculating the values of sensitivity and specificity for the different cutoff points that maximize the "sensitivity plus specificity" sum. Similar methods were used to identify potential predictors of cough, swallowing, greater volumes of secretions, and the need for suctioning. All tests were 2-sided, with a 5% significance level.

Results

A total of 62 patients were enrolled during 15 months, and 55 patients were included in the analysis (Table 2). Patients admitted to the surgical and medical ICUs differed in median age (40 years, 10th-90th percentile, 23-64 vs 63 years, 10th-90th percentile, 39-84; $P < .001$) and median days of intubation (16, 10th-90th percentile, 9-35 vs 10, 10th-90th percentile, 7-23; $P = .002$). Seven patients were reintubated within 24 hours of extubation for reasons other than swallowing dysfunction or airway protection, including septic shock (n = 2), laryngeal edema (n = 1), bronchospasm (n = 1), respiratory problems (n = 1), heart problems (n = 1), and kidney failure (n = 1).

A total of 46 patients were successfully extubated; the remaining 9 patients (16%) were reintubated for upper airway obstruction related to secretions (Table 3). No other patients were reintubated once 48 hours had elapsed after extubation. When the bedside evaluation was done before extubation, 7 of 9 (78%) unsuccessful extubations were predicted. Of the 23 patients with Central Nervous System (CNS) diseases, 19 were successfully extubated; the other 4 were reintubated. Among the patients with CNS disorders, 3 of the 4 (75%) unsuccessful extubations were predicted.

On the basis of the logistic regression model coefficients, cervical motility and swallowing were independent predictors of unsuccessful extubation (area under ROC curve, 80%; sensitivity, 0.56; specificity, 0.98; Figure 3). The gag reflex was the

only significant predictor of the ability to cough (area under ROC curve, 73%; sensitivity, 0.59; specificity, 0.73) and of the presence of excessive pulmonary secretions (area under ROC curve, 67%; sensitivity, 0.36; specificity, 0.93). Swallowing was an independent predictor of the need for suctioning (area under ROC curve, 78%; sensitivity, 0.43; specificity, 0.89). No test was predictive of swallowing disorders.

Discussion

In this preliminary investigation, swallowing function before extubation was predictive of successful extubation in patients intubated for more than 6 days. Of the 3 tests used, the tests for cervical motility and swallowing were independent predictors of reintubation.

To our knowledge, this study is the first assessment of the reliability of standard criteria for physiotherapeutic extubation. Although our evaluation before extubation seemed easy to perform, one limitation of this study was that we did not evaluate interoperator reliability. Among the criteria of our bedside guidelines, we chose to evaluate the gag reflex, because it may be impaired by orotracheal intubation and the sensitivity level of the corresponding oropharyngeal side may increase. The gag reflex may be absent in several CNS disorders, in cranial nerve impairments, or in elderly persons.[21,22] The presence of this reflex does not ensure protection against aspiration.[23]

We were able to predict a patient's ability to cough and to eject bronchial secretions, but no reliable criteria were predictive of swallowing disorders. However, we think that the 9 patients who were reintubated for upper airway obstruction related to excessive secretions had a primary swallowing problem, because their scores on the Glasgow Coma Scale were greater than 9 on extubation and their cough did not weaken. Indeed, we could not even distinguish major swallowing disorders from silent aspiration. Mechanisms for swallowing impairment and for the ability to cough and eliminate bronchial secretions are different.[12,17,24] Bedside clinical evaluations done just after extubation always yield underestimates of the incidence of swallowing disorders when fiber-optic measuring devices are used.[21,23,25]

To date, no study has been done to evaluate swallowing before extubation. Swallowing mechanisms are complex and may be impaired in many situations, including CNS diseases.[13] In patients with CNS diseases, the success of extubation is difficult to predict.[2] With our evaluation, 3 of 4 reintubations could be predicted in the patients with CNS diseases, thus highlighting the value of our bedside evaluation for testing the maintenance of airway patency, even independent of a voluntary command.

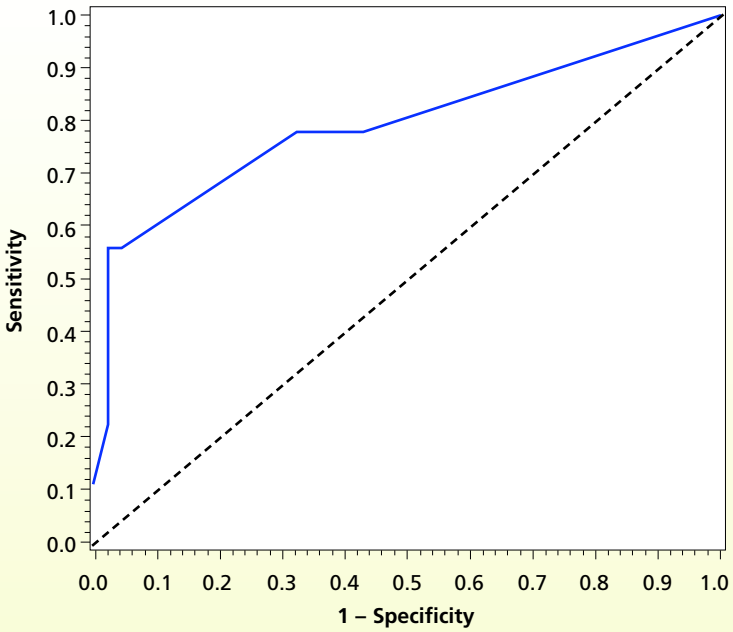

Figure 3 Receiver-operating-characteristic curve based on the regression logistic model with the 2 variables (ie, cervical motility and swallowing) that were independent predictors of unsuccessful extubation.

For the purpose of this study, the evaluation tests were performed only by physiotherapists. However, we think that nurses in critical care could perform these assessments, just as they do tests to determine whether patients are ready for weaning from mechanical ventilation.[16] Thus, our bedside evaluation guidelines for assessing swallowing function before extubation could be implemented by several members of the ICU multi-disciplinary team.

Swallowing evaluation before extubation, using simple bedside tests, is useful to predict extubation failure.

Conclusion

Our results indicate the usefulness of evaluating swallowing disorders before extubation and of predicting unsuccessful extubations by using simple bedside tests. Simultaneous evaluation by physicians and physiotherapists may be helpful for extubation decisions in patients intubated for long periods. However, our findings should be confirmed in further studies of larger cohorts by extensive repetition of the current procedures.

FINANCIAL DISCLOSURES
None reported.

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