



SEMIQUANTITATIVE COUGH STRENGTH SCORE FOR PREDICTING REINTUBATION AFTER PLANNED EXTUBATION

By Jun Duan, MD, Lintong Zhou, MD, Meiling Xiao, RN, Jinhua Liu, RN, and Xiangmei Yang, RN

Background Semiquantitative cough strength score (SCSS, graded 0-5) and cough peak flow (CPF) have been used to predict extubation outcome in patients in whom extubation is planned; however, the correlation of the 2 assessments is unclear.

Methods In the intensive care unit of a university-affiliated hospital, 186 patients who were ready for extubation after a successful spontaneous breathing trial were enrolled in the study. Both SCSS and CPF were assessed before extubation. Reintubation was recorded 72 hours after extubation.

Results Reintubation rate was 15.1% within 72 hours after planned extubation. Patients in whom extubation was successful had higher SCSSs than did reintubated patients (mean [SD], 3.2 [1.6] vs 2.2 [1.6], $P=.002$) and CPF (74.3 [40.0] vs 51.7 [29.4] L/min, $P=.005$). The SCSS showed a positive correlation with CPF ($r=0.69$, $P<.001$). Mean CPFs were 38.36 L/min, 39.51 L/min, 44.67 L/min, 57.54 L/min, 78.96 L/min, and 113.69 L/min in patients with SCSSs of 0, 1, 2, 3, 4, and 5, respectively. The discriminatory power for reintubation, evidenced by area under the receiver operating characteristic curve, was similar: 0.677 for SCSS and 0.678 for CPF ($P=.97$). As SCSS increased (from 0 to 1 to 2 to 3 to 4 to 5), the reintubation rate decreased (from 29.4% to 25.0% to 19.4% to 16.1% to 13.2% to 4.1%).

Conclusions SCSS was convenient to measure at the bedside. It was positively correlated with CPF and had the same accuracy for predicting reintubation after planned extubation. (*American Journal of Critical Care*. 2015;24:e86-e90)

Extubation is the last step of weaning from mechanical ventilation when a patient has passed a spontaneous breathing trial (SBT).¹ Unfortunately, the prevalence of reintubation is 15% in patients who undergo planned extubation.² In high-risk patients, the reintubation rate exceeds 30%.³ Even worse, mortality rates are much higher in reintubated patients (50%) than in successfully extubated patients (5%).⁴ Thus, it is essential to improve the management of weaning and extubation by identifying patients at high risk of reintubation.

Cough peak flow (CPF), measured before extubation, is a predictor of reintubation.⁵⁻⁹ It has moderate to high sensitivity and specificity for distinguishing whether or not the extubation will be successful. However, measurement of CPF in intubated patients requires a spirometer and associated connectors and filters, which may not be available in many intensive care units.

Khamiees and colleagues⁹ had proposed use of a semiquantitative cough strength score (SCSS), graded from 0 (weak) to 5 (strong), to predict reintubation after planned extubation. They found that the patients with a lower SCSS had a greater risk of reintubation. However, the SCSS is a ranking. Whether it is as accurate as CPF for predicting reintubation is unclear. Thus, we designed this study to compare the accuracy of SCSS and CPF in predicting reintubation.

Materials and Methods

We enrolled all patients who were ready to be weaned off mechanical ventilation after a successful SBT and excluded those patients who were less than 18 years old or had experienced less than 24 hours of mechanical ventilation. Patients who had undergone tracheotomy before extubation also were excluded. This study was approved by the investigational review board at the First Affiliated Hospital of Chongqing Medical University. Written informed consent was obtained from the patients or their next of kin.

Patients undergoing mechanical ventilation were managed by our hospital protocol.¹⁰ Strategies

About the Authors

Jun Duan and **Lintong Zhou** are physicians and **Meiling Xiao**, **Jinhua Liu**, and **Xiangmei Yang** are nurses in the Department of Respiratory Medicine at the First Affiliated Hospital of Chongqing Medical University, Chongqing, China.

Corresponding author: Dr Jun Duan, Department of Respiratory Medicine, the First Affiliated Hospital of Chongqing Medical University, Youyi Road 1, Yuzhong District, Chongqing 400016, China (e-mail: duanjun412589@163.com).

for preventing ventilator-associated pneumonia (eg, elevation of the head of the bed, hand hygiene, oral hygiene) were used in every patient. A Ramsay score of 3 to 4 was maintained by administering midazolam and propofol when patients became agitated, patient-ventilator asynchrony occurred, or other clinical conditions occurred in which the patients needed to relax. Sedation was interrupted every morning; if the patient remained calm, the sedation was stopped, if not, the sedation was continued. Every morning, patients were evaluated for readiness to be weaned off mechanical ventilation. If they had completed an SBT, the endotracheal tube was removed. Before extubation, we positioned the patients at 30° to 45°, measured the SCSS first, and then measured the CPF according to the protocol as follows.

To measure SCSS, we coached the patient to cough with as much effort as possible when we disconnected the ventilator. The cough strength was scored from 0 to 5 as follows: 0 = no cough on command, 1 = audible movement of air through the endotracheal tube but no audible cough, 2 = weakly (barely) audible cough, 3 = clearly audible cough, 4 = stronger cough and 5 = multiple sequential strong coughs.⁹

To measure CPF, we used a spirometer (Chestgraph HI-101; CHEST MI, Inc), a bacterial filter, and a special connector to connect the spirometer and the endotracheal tube. Before measurement, secretions were removed by suctioning and patients were oxygenated with pure oxygen for 2 minutes. Then we disconnected the ventilator, connected the spirometer to the endotracheal tube, and instructed the patient to cough with as much effort as possible. The highest CPF was chosen from 3 measurements.

Reintubation was deemed necessary by the attending physicians if the patients showed tachypnea,

All patients ready to be weaned from mechanical ventilation after a successful spontaneous breathing trial were enrolled.

Table 1
Clinical characteristics of the patients

Variable	Extubation success (n = 158)	Reintubation (n = 28)	P
Age, mean (SD), y	68.3 (16.0)	73.6 (14.0)	.10
Male/female, No. of patients	109/49	16/12	.28
APACHE II score at intubation, mean (SD)	23.4 (6.7)	25.3 (5.6)	.18
Causes for intubation, No. of patients			
AECOPD	80	13	.84
Pneumonia	44	10	.50
Acute respiratory distress syndrome	17	3	>.99
Postoperative respiratory failure	6	0	.59
Others	11	2	>.99
Days of mechanical ventilation before extubation, mean (SD)	7.4 (10.5)	8.6 (5.3)	.58

Abbreviations: AECOPD, acute exacerbation of chronic obstructive pulmonary disease; APACHE, Acute Physiology and Chronic Health Evaluation.

Table 2
Data collected when the patients passed a spontaneous breathing trial indicating readiness for extubation^a

Variable	Extubation success (n = 158)	Reintubation (n = 28)	P
Respiratory rate, breaths/min	23 (5)	23 (4)	.96
Tidal volume, mL	444 (135)	383 (110)	.02
Minute ventilation, L	9.8 (2.8)	8.8 (2.7)	.08
Respiratory rate/tidal volume	60 (24)	64 (21)	.33
Heart rate, beats/min	95 (15)	99 (18)	.18
Systolic blood pressure, mm Hg	127 (18)	122 (20)	.21
Diastolic blood pressure, mm Hg	75 (11)	70 (10)	.02
pH	7.44 (0.48)	7.42 (0.07)	.15
Paco ₂ , mm Hg	45 (12)	48 (15)	.18
Pao ₂ , mm Hg	92 (25)	97 (31)	.38
Fraction of inspired oxygen (FiO ₂)	0.41 (0.05)	0.42 (0.05)	.08
Pao ₂ /FiO ₂	233 (79)	232 (73)	.93
Cough peak flow, L/min	74.3 (40.0)	51.7 (29.4)	.005
Semiquantitative cough strength score	3.2 (1.6)	2.2 (1.6)	.002

^a Values in second and third column are expressed as mean (SD).

hypoxemia, hypercapnia, hemodynamic instability, diminished consciousness, diaphoresis, or clinical signs of respiratory muscle fatigue. At the same time, reintubation was recorded within 72 hours after extubation.

Receiver operating characteristic (ROC) curves (SPSS 17.0, SPSS) were used to analyze the diagnostic accuracy of SCSS and CPF. The area under

the ROC curve for SCSS and that for CPF were compared with each other by using the Hanley and McNeil method.¹¹ CPF between different SCSS groups was statistically analyzed by using 1-way analysis of variance. The Pearson correlation coefficient was used to assess the correlation between SCSS and CPF. The maximum Youden index was chosen as the optimal cutoff value.¹² A *P* value less than .05 was considered significant.

Results

We enrolled 186 patients from January 2011 to January 2014. The reintubation rate was 15.1% within 72 hours after planned extubation. The clinical characteristics of the patients are summarized in Table 1; Table 2 shows the data collected before extubation when the patient passed an SBT. The successfully extubated patients had higher tidal volumes (mean [SD], 444 [135] vs 383 [110] mL, *P* = .02), higher diastolic blood pressure (75 [11] vs 70 [10] mm Hg, *P* = .02), higher CPF (74.3 [40.0] vs 51.7 [29.4] L/min, *P* = .005), and higher SCSS (3.2 [1.6] vs 2.2 [1.6], *P* = .002).

The Figure and Table 3 show that the diagnostic accuracy of SCSS was no different from the diagnostic accuracy for CPF (area under curve: 0.677 vs 0.678, *P* = .97). The optimal cutoff value was 3 for SCSS and 62.4 L/min for CPF.

The SCSS increased continuously as CPF increased (Table 4). Moreover, the SCSS showed a strongly positive correlation with CPF (*r* = 0.69, *P* < .001).

Table 5 shows that the reintubation rate increased as the SCSS decreased. Patients with SCSSs of 4, 3, 2, 1, and 0, respectively, were 3.2, 4.0, 4.7, 6.1, and 7.2 times as likely to be reintubated as were patients with an SCSS of 5 within 72 hours after planned extubation.

Discussion

Reintubation was associated with a 5-fold increase in the relative odds of death and a 2-fold increase in stay in the intensive care unit, hospital stay, and institutional costs.¹³ Identifying the clinical characteristics that are predictors of reintubation is important for caregivers. As demonstrated by Smina and colleagues,⁵ CPF is an independent predictor of reintubation. They reported that patients with unsuccessful extubation had significantly lower CPFs than did patients with successful extubation (64.2 L/min vs 81.9 L/min). Smina et al obtained an optimal threshold value of 60 L/min with an area under the curve of 0.70 in predicting extubation failure at 72 hours after initial extubation. In our study, we obtained an optimal cutoff point of

62.4 L/min, which was similar to the cutoff reported by Smina et al. It also had similar accuracy (area under curve = 0.678) in predicting reintubation at 72 hours following initial extubation (Table 3).

SCSS was originally introduced by Khamiees and colleagues⁹ in 2001. Their study included 91 patients with 100 extubations. They reported that patients with weak (grade 0-2) coughs were 4 times as likely to have unsuccessful extubation, compared with patients with moderate to strong (grade 3-5) coughs (risk ratio, 4.0; 95% CI, 1.8-8.9) at 72 hours after extubation. Similarly, we also demonstrated that reintubation was highly associated with cough strength. As our sample was larger than the sample in the study by Khamiees et al, we reported the reintubation rate and relative risk in each SCSS group. With patients who had an SCSS of 5 used as the reference, patients with SCSSs from 4 to 0 were 3.2 to 7.2 times more at risk for reintubation (Table 5). Even worse, the reintubation rate reached as high as 29% in patients with an SCSS of 0. Thus, we suggest that decision making should be cautious in patients with weak cough strength. Even if extubation is done, these patients should have enhanced airway management such as adequate humidification, chest physical therapy, use of expectorant drugs, and so on.

To our knowledge, ours is the first study to compare the correlation between SCSS and CPF. The CPF is a quantitative measurement of cough strength. It is highly associated with reintubation after planned extubation.⁵⁻⁹ In our study, the sensitivity and specificity of SCSS for predicting reintubation were similar to those for CPF (Table 3). Further, we demonstrated that the SCSS had a strong positive correlation with CPF (Table 4). However, measurement of CPF in intubated patients requires a spirometer, a bacterial filter to avoid cross-contamination, and a special connector to connect the spirometer to the endotracheal tube. These items may be unavailable in many intensive care units, which limits the general use of CPF. The SCSS, on the other hand, is a semiquantitative scale (graded 0-5) and does not require any device. Thus it is easy and convenient

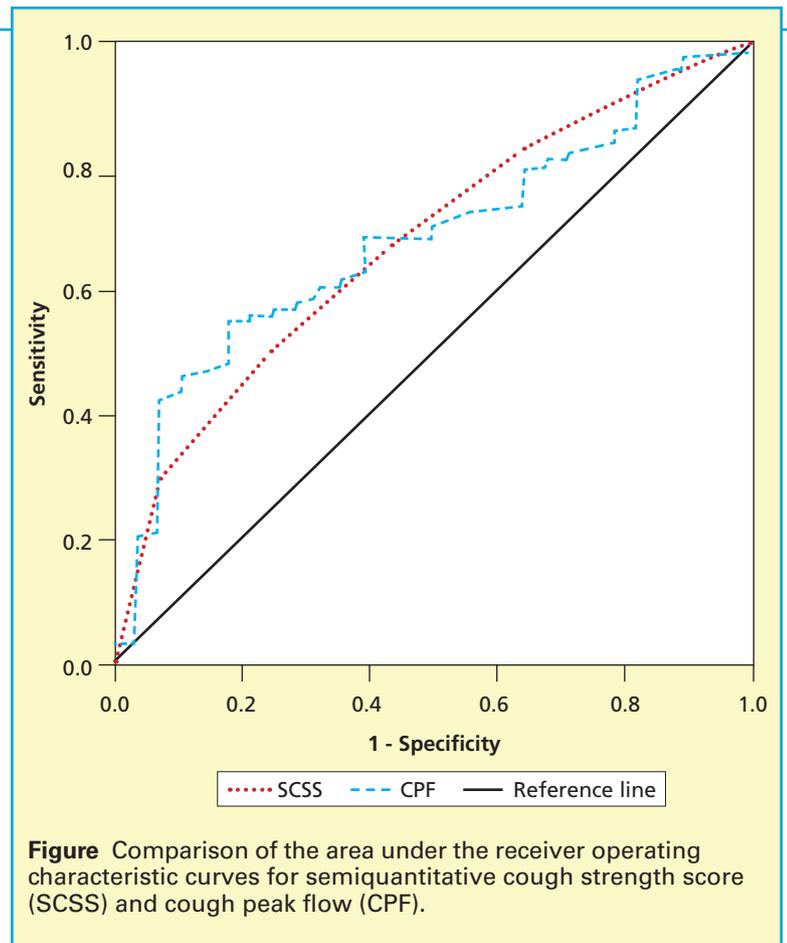


Figure Comparison of the area under the receiver operating characteristic curves for semiquantitative cough strength score (SCSS) and cough peak flow (CPF).

for caregivers to use the SCSS to assess cough strength.

Our study has several limitations. The SCSS is a semiquantitative measurement. Its accuracy depends on the clinicians' experience. Thus, strict and frequent training is necessary before this technique can be used. The sample was relatively small when we divided it into 6 groups according to the SCSS, which may have biased our findings, so future studies should enroll more patients to enhance the studies' power.

Conclusions

SCSS is conveniently measured by clinicians, shows a high correlation with CPF, and has good

Table 3
Comparison of semiquantitative cough strength score (SCSS) and cough peak flow (CPF) by receiver operating characteristic curves

Variable	Optimal cutoff value	Sensitivity, %	Specificity, %	LR+	LR-	Area under curve, mean (SE)	P
SCSS	3	75.0	50.6	1.52	0.49	0.677 (0.051)	.97
CPF	62.4 L/min	82.1	55.1	1.83	0.32	0.678 (0.050)	

Abbreviations: LR+, likelihood ratio of positive test; LR-, likelihood ratio of negative test.

Table 4
Relationship between semiquantitative cough strength score (SCSS) and cough peak flow (CPF)^a

SCSS	CPF, L/min
0	38.36 (11.57)
1	39.51 (11.34)
2	44.67 (18.70)
3	57.54 (20.98)
4	78.96 (32.62)
5	113.69 (35.68)

^a Comparison of CPF between different SCSS groups used 1-way analysis of variance ($P < .001$).

Table 5
Relative risk of reintubation in patients with different semiquantitative cough strength scores (SCSSs)

SCSS	Total No.	No. (%)	Relative risk (95% CI)
5	49	2 (4)	1.0 (Reference)
4	38	5 (13)	3.2 (0.7-15.7)
3	31	5 (16)	4.0 (0.8-19.1)
2	31	6 (19)	4.7 (1.0-22.0)
1	20	5 (25)	6.1 (1.3-29.0)
0	17	5 (29)	7.2 (1.5-33.8)

sensitivity and specificity for predicting reintubation after planned extubation. A noninvasive measurement, SCSS is as accurate as CPF for predicting reintubation after planned extubation.

ACKNOWLEDGMENTS

We thank all the physicians, respiratory therapists, and nurses who took care of the patients.

FINANCIAL DISCLOSURES

This study was supported by State Key Clinical Specialty Construction Project Funding.

REFERENCES

1. MacIntyre NR, Cook DJ, Ely EW Jr, et al, American College of Chest Physicians, American Association for Respiratory Care, American College of Critical Care Medicine. Evidence-based guidelines for weaning and discontinuing ventilatory support: a collective task force facilitated by the American College of Chest Physicians; the American Association for Respiratory Care; and the American College of Critical Care Medicine. *Chest*. 2001;120:375S-395S.
2. Krinsley JS, Reddy PK, Iqbal A. What is the optimal rate of failed extubation? *Crit Care*. 2012; 16:111.
3. Thille AW, Richard JC, Brochard L. The decision to extubate in the intensive care unit. *Am J Respir Crit Care Med*. 2013; 187:1294-1302.
4. Thille AW, Harrois A, Schortgen F, Brun-Buisson C, Brochard L. Outcomes of extubation failure in medical intensive care unit patients. *Crit Care Med*. 2011;39:2612-2618.
5. Smina M, Salam A, Khamiees M, Gada P, Amoateng-Adjepong Y, Manthous CA. Cough peak flows and extubation outcomes. *Chest*. 2003;124:262-268.
6. Beuret P, Roux C, Auclair A, Nouridine K, Kaaki M, Carton MJ. Interest of an objective evaluation of cough during weaning from mechanical ventilation. *Intensive Care Med*. 2009; 35:1090-1093.
7. Salam A, Tilluckdharry L, Amoateng-Adjepong Y, Manthous CA. Neurologic status, cough, secretions and extubation outcomes. *Intensive Care Med*. 2004;30:1334-1339.
8. Su WL, Chen YH, Chen CW, et al. Involuntary cough strength and extubation outcomes for patients in an ICU. *Chest*. 2010;137:777-782.
9. Khamiees M, Raju P, DeGirolamo A, Amoateng-Adjepong Y, Manthous CA. Predictors of extubation outcome in patients who have successfully completed a spontaneous breathing trial. *Chest*. 2001;120:1262-1270.
10. Duan J, Guo S, Han X, et al. Dual-mode weaning strategy for difficult-weaning tracheotomy patients: a feasibility study. *Anesth Analg*. 2012;115:597-604.
11. Hanley JA, McNeil BJ. A method of comparing the areas under receiver operating characteristic curves derived from the same cases. *Radiology*. 1983;148:839-843.
12. Youden WJ. Index for rating diagnostic tests. *Cancer*. 1950; 3:32-35.
13. Menon N, Joffe AM, Deem S, et al. Occurrence and complications of tracheal reintubation in critically ill adults. *Respir Care*. 2012;57:1555-1563.

To purchase electronic or print reprints, contact American Association of Critical-Care Nurses, 101 Columbia, Aliso Viejo, CA 92656. Phone, (800) 899-1712 or (949) 362-2050 (ext 532); fax, (949) 362-2049; e-mail, reprints@aacn.org.