Timely weaning from mechanical ventilation of patients in intensive care units (ICUs) is intriguing and difficult work. Unnecessary delay in weaning from ventilator support increases the rate of complications such as pneumonia or airway trauma, as well as costs.¹,² The major factor in successful weaning is resolution of the precipitating illness. Other factors include comorbid illnesses, cause of acute respiratory failure, protocol, and the method of weaning. Current views suggest that nurses can be the key players in reducing the duration of mechanical ventilation for patients and can lead the extubation part of ventilatory weaning.³ Nurses’ involvement in decision making about ventilator weaning relies on appropriate knowledge and skills in managing ventilation. The method of weaning is an important variable because it affects the potential to intervene. Accordingly, extensive efforts have been made to identify predictors of successful extubation or weaning.

Feature

Extubation With or Without Spontaneous Breathing Trial

JING WANG, MD
YINGMIN MA, MD, PhD
QIUHONG FANG, MD, PhD

PURPOSE—To evaluate whether spontaneous breathing trials (SBTs) are necessary when extubating critical care patients.

METHODS—A prospective, randomized, double-blind study was performed in adult patients supported by mechanical ventilation for at least 48 hours in the general intensive care unit of a teaching hospital. Patients ready for weaning were randomly assigned to either the SBT group (extubation with an SBT) or the no-SBT group (extubation without an SBT). Patients in the SBT group who tolerated SBT underwent immediate extubation. Patients in the no-SBT group who met the weaning readiness criteria underwent extubation without an SBT. The primary outcome measure was a successful extubation or the ability to maintain spontaneous breathing for 48 hours after extubation.

RESULTS—A total of 139 adult patients were enrolled. No significant difference in the demographic, respiratory, and hemodynamic characteristics was indicated between the groups at the end of weaning readiness assessment. Successful extubation was achieved in 56 of 61 patients (91.8%) in the SBT group and 54 of 60 patients (90.0%) in the no-SBT group. In the SBT and no-SBT groups, 5 (8.2%) and 6 (10.0%) patients, respectively, needed reintubation; 7 (11.5%) and 9 (15.0%) patients, respectively, required noninvasive ventilation after extubation. In-hospital mortality did not differ significantly between the groups.

CONCLUSION—Intensive care patients can be extubated successfully without an SBT. (Critical Care Nurse. 2013;33[6]:50-56)
Major weaning studies were conducted by using spontaneous breathing trials (SBTs) through T-piece and pressure support (PS) ventilation. In these studies, readiness to wean was assessed by an initial 2-hour T-piece trial. Patients who tolerated this trial were extubated, whereas those whose trial was unsuccessful were randomized to different weaning methods. Previous data revealed a shortened discontinuing period when following a standard protocol that includes an SBT trial in weaning patients from ventilation. Common practice currently recommends an SBT for 30 min to 120 min before extubation. However, the trial may be unsuccessful in some patients before extubation because of the discomfort and increased labor of breathing caused by the endotracheal tube. Consequently, low levels of positive pressure ventilatory support are often applied during SBTs. Several studies showed the same extubation results between short (30-minute) and long (120-minute) SBTs. Although work of breathing was not evaluated in these studies, use of the shortened SBT, which relieves the patient from endotracheal tube discomfort sooner and hypothetically reduces the work of breathing, may improve patients’ tolerance of SBTs.

The potential for reducing the period of SBT and the effect of said reduction on a patient’s spontaneous breathing ability after extubation remain unclear. The effects of complete elimination of the SBT procedure during extubation should be investigated. Some studies recommend SBTs, whereas others suggest that SBTs are inaccurate and that approximately 15% of extubation failures are unidentified in SBTs. The reintubation rates of initial SBTs ranged from 10% to 20%. Failure rates for SBTs of 26% to 42% have been reported. Studies have been conducted to identify predictors of successful extubation or weaning. The present study evaluated the clinical outcome of extubation with or without an SBT. We hypothesized that an SBT is not an essential process during weaning from ventilation in ICU patients.

**Materials and Methods**

**Patients**

The present study was conducted in an 8-bed adult general ICU in a 1000-bed primary teaching hospital. All patients enrolled in this study had been receiving mechanical ventilation via an endotracheal tube for more than 48 hours during the study period. The investigation was approved by the hospital’s ethics committee. Written informed consent was obtained from the next of kin of each patient. The patients were ventilated in PS mode during the entire weaning period. The levels of inspiratory PS and positive-end expiratory pressure were progressively reduced depending on a patient’s clinical assessment and blood gas values.

The patients had to satisfy the following readiness criteria: significant improvement or resolution of the underlying cause of acute respiratory failure; full wakefulness; need for bronchial toilet less than twice within the 4-hour period preceding the assessment; stable hemodynamics without further need for vasoactive agents; ratio of PaO₂ to fraction of inspired oxygen (FiO₂) greater than 200 at a positive end-expiratory pressure of 4.0 cm H₂O, with a maximum FiO₂ of 0.40; core temperature less than 38.0°C; systolic blood pressure greater than 90 mm Hg; and respiratory rate/tidal volume ratio less than 105 breaths/min per liter. The ratio was calculated after 1 minute of spontaneous breathing. During the SBT, the maximum inspiratory PS was 12 cm H₂O, and no mandatory machine breaths were supplied from the ventilator.

**Study Protocol**

We investigated the weaning process with and without an SBT. All patients were continuously assessed according to the readiness criteria and were screened for enrollment once a day (between 10 AM and noon). As soon as they were ready for weaning, the patients...
were randomly assigned to either the SBT group or the no-SBT group. Randomization was conducted in a blinded fashion by using opaque and sealed envelopes. All patients breathed through the ventilator circuit with flow triggering (2 L/min), positive end-expiratory pressure of 4.0 cm H$_2$O, $F_iO_2$ of 0.4, and PS before enrollment. The patients in the SBT group underwent a 1-hour SBT with inspiratory PS of 7 cm H$_2$O and other settings remaining constant ($F_iO_2$ of 0.4, positive end-expiratory pressure of 4.0 cm H$_2$O, and trigger sensitivity of 2 L/min). Patients who exhibited poor tolerance to SBT were immediately administered full ventilation support and continuously assessed for the subsequent weaning. Poor tolerance was defined by the following failure criteria: a decrease in oxygen saturation to less than 90%; a respiratory rate greater than 35/min for more than 5 minutes in the presence of diaphoresis or thoracoabdominal paradox; and a sustained increase in heart rate (>140/min) or a significant change in systolic blood pressure (>180 or <90 mm Hg). Patients who tolerated the SBT underwent immediate extubation and received supplemental oxygen via a facemask.

Patients in the no-SBT group who met the readiness criteria immediately underwent extubation without an SBT and received supplemental oxygen via a facemask. Noninvasive ventilatory support was introduced after extubation under the following conditions: hypoxemia ($S_aO_2 <90\%$ for $>15$ minutes) while receiving supplemental oxygen, respiratory acidosis (arterial pH $<7.35$ with $Paco_2 >45$ mm Hg), and respiratory rate greater than 25/min for 1 hour. The mode of ventilation was biphasic positive airway pressure. When such support was inadequate (hypoxemia, hypercapnea, or respiratory distress), the patient was reintubated and mechanical ventilation was resumed.

The SBT and extubation were performed by 2 physicians who are members of the research team. Decisions regarding reintubation were made by the physicians who were blinded to the treatment groups. Extubation failure was defined as reintubation within 48 hours. The reasons for reintubation were prospectively recorded.

**Statistical Analysis**

Results are expressed as mean (SD). Mean values of selected demographic variables and physiologic parameters of patients who underwent SBT were compared with those of patients who underwent extubation directly via Student $t$ tests. Differences in proportions between the 2 groups were determined by a $\chi^2$ test.

**Results**

**Characteristics of Patients**

A total of 121 patients satisfied the inclusion criteria for extubation and were randomized (SBT group, $n = 61$; no-SBT group, $n = 60$). Table 1 shows the baseline characteristics for patients in the 2 treatment groups. No significant difference in sex, age, Acute Physiology and Chronic Health Evaluation II score at ICU admission,
duration of mechanical ventilation, size of endotracheal tube, and reason for mechanical ventilation was apparent between the treatment groups. No significant difference in respiratory measurements, hemodynamic parameters, level of albumin in the blood, and level of hemoglobin at the end of weaning readiness assessment was indicated between the groups (Table 2). In the non-SBT group, the level of PS was 11.6 (1.1) cm H₂O at the time of extubation. In the SBT group, the level of PS was 12.1 (1.4) cm H₂O before the patient entered the SBT phase. The Figure presents the treatment course and the outcomes.

Reintubation

Reintubation was required in 11 patients after noninvasive ventilation: 6 of 60 (10.0%) in the no-SBT group and 5 of 61 (8.2%) in the SBT group (P = .76). Reasons for reintubation included inability to clear secretions (n = 6), new sepsis (n = 2), and respiratory distress (due to acute renal failure, n = 2; due to new hemorrhagic shock, n = 1). A total of 16 patients required noninvasive ventilation after extubation: 9 of 60 (15.0%) in the no-SBT group and 7 of 61 (11.5%) in the SBT group (P = .87). A total of 12 patients died while in the hospital after extubation: 7 of 60 (11.7%) in the no-SBT group and 5 of 61 (8.2%) in the SBT group (P = .78).

Discussion

In this study, we assessed the outcomes of extubation with and without an SBT. The results did not indicate whether the patients in whom the SBT was unsuccessful could discontinue ventilation without an SBT in future extubation attempts. However, 54 patients (90%) were successfully extubated without an SBT, and 56 patients (91.8%) were successfully extubated with an SBT. No significant differences in reintubation and requirement for noninvasive ventilation support after extubation were found between the 2 groups. These results suggest that SBT is not required before extubation.

Tolerance of an SBT in the discontinuation of mechanical ventilation has been examined. Results showed successful extubation with an SBT (with PS ventilation, Table 2 Patient parameters measured before extubation (no-trial group) and at the start of the spontaneous breathing trial (trial group)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No trial (n = 60)</th>
<th>Trial (n = 61)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio of respiratory rate to tidal volume, breaths per minute per L</td>
<td>68.6 (22.2)</td>
<td>64.1 (24.3)</td>
<td>.59</td>
</tr>
<tr>
<td>Paco₂, mm Hg</td>
<td>38.8 (4.1)</td>
<td>39.5 (5.1)</td>
<td>.17</td>
</tr>
<tr>
<td>Paco₂, mm Hg</td>
<td>101.7 (23.5)</td>
<td>97.8 (22.4)</td>
<td>.81</td>
</tr>
<tr>
<td>Ratio of Pao₂ to fraction of inspired oxygen</td>
<td>277.7 (72.8)</td>
<td>262.8 (72.8)</td>
<td>.67</td>
</tr>
<tr>
<td>Heart rate, beats per minute</td>
<td>90.8 (13.3)</td>
<td>99.4 (17.8)</td>
<td>.16</td>
</tr>
<tr>
<td>Systolic arterial blood pressure, mm Hg</td>
<td>138.8 (16.3)</td>
<td>135.0 (19.8)</td>
<td>.40</td>
</tr>
<tr>
<td>Body temperature, °C</td>
<td>37.0 (0.6)</td>
<td>37.2 (0.6)</td>
<td>.84</td>
</tr>
<tr>
<td>Albumin, g/L</td>
<td>34.4 (4.9)</td>
<td>32.6 (4.3)</td>
<td>.44</td>
</tr>
<tr>
<td>Hemoglobin, g/L</td>
<td>90.9 (21.1)</td>
<td>87.3 (13.8)</td>
<td>.15</td>
</tr>
</tbody>
</table>

*All values in second and third column are mean (SD).
continuous positive airway pressure, and T-tube strategy) and shortened mechanical ventilation by protocol-directed weaning with an SBT. One possible reason for SBT failure in some patients is the increased ventilatory muscle work caused by the endotracheal tube. To improve SBT tolerance, shortened SBT duration (30 minutes) is recommended, which has shown extubation outcomes similar to the outcomes for longer SBT duration (120 minutes) when releasing patients from mechanical ventilation sooner.\(^1\) Cohen et al\(^1\) recently assessed the effect of SBT with automatic tube compensation, a ventilatory mode designed to overcome the imposed work of breathing due to artificial airways. Cohen et al observed a trend exhibiting higher SBT tolerance among patients and less need for noninvasive ventilation support after extubation compared with an SBT with continuous positive airway pressure. Esteban et al\(^3\) compared 2-hour trials of unassisted breathing with a PS of 7 cm H\(_2\)O versus a T-piece trial. Failure to tolerate weaning was observed in a smaller proportion of patients in the PS group (14%) than in the T-piece trial group (22%). These results suggest that PS decreased breathing load and minimized work of breathing during SBT, which may improve SBT tolerance and improve the extubation outcome. In another study,\(^4\) researchers demonstrated a significant increase in endocrine stress response, as assessed by plasma levels of cortisol, insulin, and glucose, as well as by urinary levels of vanillylmandelic acid, during an SBT. The magnitude of the response was significantly larger at the end of a breathing trial with a T-tube than with PS ventilation. The levels of vanillylmandelic acid returned to normal in the T-tube group but remained elevated in the T-tube group 48 hours after extubation. All patients requiring reintubation were from the T-tube group. Increased endocrine stress response may have elevated oxygen consumption in the body during the trial. Although the change in endocrine stress response could not be assessed in the present study, the patients’ ability to maintain spontaneous breathing successfully after extubation without an SBT suggests that excluding the SBT avoids increased ventilatory muscle overload during extubation.

Indication for long-term ventilator discontinuation is unclear for patients who are unable to exhibit SBT tolerance, which is generally considered for permanent ventilator discontinuation. A considerable proportion of patients in whom T-tube SBT is unsuccessful can be extubated successfully after a further trial with PS.\(^2\) However, whether patients in whom the SBT is unsuccessful can be successfully extubated without the SBT has not been determined. The need for an SBT with or without a supporting procedure (shortening SBT duration or using automatic tube compensation) to predict spontaneous breathing ability before extubation has not been ascertained. Whether SBT failure can be used to predict the need for ventilator dependence cannot be formally assessed because patients in whom the SBT is unsuccessful remain on ventilation support.

Extrubation without an SBT was successful compared with extubation with an SBT, which is the standard protocol in discontinuing ventilation support. Data for this single-center cohort of patients suggest that the effect of and need for an SBT in weaning patients off of mechanical ventilation requires further research in a general ICU population.

Studies exploring interprofessional responsibility for decision making related to mechanical ventilation and weaning in Australia and New Zealand revealed that physicians and nurses actively collaborated in the management of ventilation and weaning, generally in the absence of protocols.\(^5\) Therefore, physicians and nurses must discuss the weaning process.

Financial Disclosures
None reported.

Letters
Now that you’ve read the article, create or contribute to an online discussion about this topic using eLetters. Just visit www.ccnonline.org and select the article you want to comment on. In the full-text or PDF view of the article, click “Responses” in the middle column and then “Submit a response.”


References
Extubation With or Without Spontaneous Breathing Trial

Facts

- Timely weaning from mechanical ventilation of patients in intensive care units is difficult work. Unnecessary delay in weaning from ventilator support increases the rate of complications such as pneumonia or airway trauma, as well as costs.
- The major factor in successful weaning is resolution of the precipitating illness. Other factors include comorbid illnesses, cause of acute respiratory failure, protocol, and the method of weaning.
- Nurses can be the key players in reducing the duration of mechanical ventilation for patients and can lead the extubation part of ventilatory weaning. Nurses’ involvement in decision making about ventilator weaning relies on appropriate knowledge and skills in managing ventilation.
- We investigated the weaning process with and without a spontaneous breathing trial (SBT). As soon as patients were ready for weaning, they were randomly assigned to either the SBT group or the no-SBT group.
- The patients in the SBT group underwent a 1-hour SBT with inspiratory pressure support of 7 cm H₂O and other settings remaining constant (FIO₂ of 0.4, positive end-expiratory pressure of 4.0 cm H₂O, and trigger sensitivity of 2 L/min). Patients who exhibited poor tolerance to SBT were immediately administered full ventilation support and continuously assessed for the subsequent weaning. Patients who tolerated the SBT underwent immediate extubation and received supplemental oxygen via a facemask.
- Patients in the no-SBT group who met the readiness criteria immediately underwent extubation without an SBT and received supplemental oxygen via facemask.
- A total of 121 patients satisfied the inclusion criteria for extubation and were randomized (SBT group, n = 61; no-SBT group, n = 60). No significant difference in respiratory measurements, hemodynamic parameters, level of albumin in the blood, and level of hemoglobin at the end of weaning readiness assessment was indicated between the groups.
- No significant differences in reintubation and requirement for noninvasive ventilation support after extubation were found between the 2 groups. These results suggest that SBT is not required before extubation.
- Extubation without an SBT was successful compared with extubation with an SBT, which is the standard protocol in discontinuing ventilation support. Data for this single-center cohort of patients suggest that the effect of and need for an SBT in weaning patients off of mechanical ventilation require further research in a general intensive care unit population.
