Extubation Outcome after Spontaneous Breathing Trials with T-Tube or Pressure Support Ventilation

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A 2-h T-tube trial of spontaneous breathing was used in selecting patients ready for extubation and discontinuation of mechanical ventilation. However, some doubt remains as to whether it is the most appropriate method of performing a spontaneous breathing trial. We carried out a prospective, randomized, multicenter study involving patients who had received mechanical ventilation for more than 48 h and who were considered by their physicians to be ready for weaning according to clinical criteria and standard weaning parameters. Patients were randomly assigned to undergo a 2-h trial of spontaneous breathing in one of two ways: with a T-tube system or with pressure support ventilation of 7 cm H_2O. If a patient had signs of poor tolerance at any time during the trial, mechanical ventilation was reinstituted. Patients without these features at the end of the trial were extubated. Of the 246 patients assigned to the T-tube group, 192 successfully completed the trial and were extubated; 36 of them required reintubation. Of the 238 patients in the group receiving pressure support ventilation, 205 were extubated and 38 of them required reintubation. The percentage of patients who remained extubated after 48 h was not different between the two groups (63% T-tube, 70% pressure support ventilation, $p = 0.14$). The percentage of patients failing the trial was significantly higher when the T-tube was used (22 versus 14%, $p = 0.03$). Clinical evolution during the trial was not different in patients reintubated and successfully extubated. ICU mortality among reintubated patients was significantly higher than in successfully extubated patients (27 versus 2.6%, $p < 0.001$). Spontaneous breathing trials with pressure support or T-tube are suitable methods for successful discontinuation of ventilator support in patients without problems to resume spontaneous breathing.

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Once a patient recovers from the illness leading to the application of mechanical ventilation, discontinuation of ventilator support and extubation must be attempted. It is therefore essential to be able to distinguish patients who are ready to sustain immediate spontaneous ventilation from those who need a gradual transition from mechanical ventilation to spontaneous ventilation.

Predictive criteria of weaning may help to evaluate the suitability of disconnecting a patient from the ventilator, but some of the criteria, especially the classic criteria (vital capacity, maximal inspiratory pressure, minute ventilation, etc.), are frequently inaccurate (1–4). Rapid shallow breathing, as reflected by the breathing frequency to tidal volume (f/V_T) ratio, seems to be the most useful parameter because of its simplicity and reliability (4).

Recent studies (1, 5, 6) have shown us that a T-tube trial of spontaneous breathing lasting 2 h is a useful test in selecting patients who are ready for extubation. Such a trial is associated with a rate of extubation failures, i.e., the percentage of patients who must be reintubated, ranging from 15 to 19%. Despite these studies, some doubt remains as to whether it is the most appropriate method.

The increase in the work of breathing caused by the presence of an endotracheal tube may be an excessive load for some patients breathing through the T-tube circuit, and poor tolerance of the trial can result from this. Pressure support ventilation is useful to counteract the extra work imposed by breathing through an endotracheal tube. In general, the level of pressure support necessary to decrease the work of breathing to that after extubation is 7 to 8 cm H_2O (7–9).

Successful extubation rates after trials of spontaneous breathing rely on the percentage of patients failing the trial and the percentage of patients needing reintubation after successful trials of spontaneous breathing and extubation. The added stress provided by T-tube trials could increase trial failure rates. On the other hand, the reduction of the work of breathing provided by the pressure support could lead to extubation of patients who are only marginally able to sustain spontaneous breathing, and so a higher reintubation rate would be expected. If the above hypothesis is true, the rate of successful extubation after trials of spontaneous breathing with T-tube or pressure support would be similar.

The aim of this study was to determine the optimal approach to performing spontaneous breathing trials before extubation. We have compared the percentage of patients who remained extubated for 48 h after discontinuation of mechanical ventilation and extubation in two groups of ventilated patients who were randomly assigned to undergo a trial of spontaneous breathing with either T-tube or pressure support of 7 cm H_2O. Secondary objectives were to identify which patients would be more likely to require reintubation within 48 h and to analyze the effect of reintubation on mortality.

METHODS

Patients

The study was conducted between October 1994 and June 1995 in 27 medical-surgical intensive care units in tertiary care hospitals (23 in Spain, two in Argentina, one in Brazil, and one in Venezuela). The study population consisted of 512 patients; however, 28 patients were excluded from the analysis because of missing data. The remaining 484 patients (343 men and 141 women), with a median age of 64 yr (25th–75th percentiles: 51 to 72), received mechanical ventilation for more than 48 h before the spontaneous breathing trial was performed (median: 6 d; 25th–75th percentiles: 4 to 10). The reasons for the initiation of ventilator support were the following: neurologic or neuromuscular disorders in five patients, coma in 60, chronic obstructive pulmonary disease with acute respiratory failure in 100, and acute respiratory failure in 318. The acute respiratory failure was a result of surgery in 92 patients, pneumonia in 55, multiple trauma in 35, acute respiratory distress syndrome in 11, heart failure in 46, sepsis in 44, and other causes in 35. One patient had missing data on why ventilator support was initiated. On admission to the intensive care unit, the patients had a median score of 36 (25th–75th percentiles: 27 to 47) on the Simplified Acute Physiology Score (SAPS II) (10). Until the first attempt was made to discontinue ventilator support, all patients received volume-targeted assist-control ventilation. All patients had endotracheal tubes of at least 8 mm in diameter, except for three women (two in the T-tube group and one in the pressure support group) who had tubes of 7.5 mm.

To be enrolled in the study, the patients had to have an improvement or resolution of the underlying cause of acute respiratory failure: adequate gas exchange, as indicated by a partial pressure of arterial oxygen (Pa_{O_2}) higher than 60 mm Hg breathing a fraction of inspired oxygen ($F_{I_{O_2}}$) $\leq$ 0.40 with a positive end-expiratory pressure of $\leq$ 5 cm H_2O; a Glasgow Coma Score higher than 13; a core temperature below 38° C; a hemoglobin level above 10 g/dl; and no further need for vasoactive or sedative agents. In addition, the attending physician had to agree that the patient was in stable condition and ready to be weaned from the ventilator. Patients with a tracheostomy were excluded. The study was approved by the Ethics Committees of the hospitals.

Protocol

After patients were enrolled in the study, volume-targeted assist-control ventilation was stopped and each patient breathed spontaneously for 3 min through a T-tube circuit, with the $F_{I_{O_2}}$ set at the same level as that used during mechanical ventilation. Tidal volume and respiratory frequency were measured with a spirometer during this period. Maximal inspiratory pressure was measured, and the most negative value of three efforts was selected. Patients underwent a trial of spontaneous breathing lasting as long as 2 h when they met at least two of the following criteria: maximal inspiratory pressure less than 20 cm H_2O, tidal volume greater than 5 ml/kg body weight, and a respiratory frequency of less than 35 breaths/min. If a patient did not meet these criteria when first tested, he or she was evaluated daily until the criteria were fulfilled. Patients were randomly assigned using a random-number table to undergo the trial of spontaneous breathing in one of two ways: with a T-tube circuit or with pressure support ventilation of 7 cm H_2O. The patients were allocated to the two groups in a blinded fashion with the use of opaque, sealed, numbered envelopes, which were opened only when a patient fulfilled all of the inclusion criteria. Randomization was performed by permuted blocks according to the study center.

Respiratory frequency, heart rate, systolic blood pressure, and arterial oxygen saturation measured by pulse oximetry were recorded every 15 min during the trial of spontaneous breathing. The primary physician terminated the trial if a patient had any of the following signs of poor tolerance: a respiratory frequency of more than 35 breaths/min, arterial oxygen saturation below 90%, heart rate above 140 beats/min or a sustained increase or decrease in the heart rate of more than 20%, systolic blood pressure above 200 or below 80 mm Hg, agitation, diaphoresis, or anxiety. If a patient had signs of poor tolerance at any time during the trial, mechanical ventilation was reinstituted. Patients who had none of these features at the end of the trial were immediately extubated. After extubation, the patients received supplemental oxygen by face mask. Successful extubation was considered if extubation was performed after the 2-h trial of spontaneous breathing, and reintubation was not required within 48 h of extubation.

In patients requiring reintubation within 48 h, the motive for reintubation was recorded as: (*1*) upper airway obstruction in cases of episode of acute respiratory distress with stridor; (*2*) respiratory failure in cases of hypoxemia, hypercapnia, or increased work of breathing. All patients were followed until death or hospital discharge.

Statistical Analysis

We have previously reported that 62% of ventilated patients can be successfully extubated after a 2-h trial of spontaneous breathing performed with a T-tube (6). We calculated that 220 patients were needed in each group to detect a 20% difference, the threshold we consider of clinical relevance, in the percentage of successfully extu-

TABLE 1

CHARACTERISTICS OF THE STUDY POPULATION AT BASELINE ACCORDING TO METHODS USED TO PERFORM THE SPONTANEOUS BREATHING TRIAL

Characteristic	T-Tube Group (*n* = 246)	Pressure Support Group (*n* = 238)	p Value
Sex			
Male, n (%)	168 (68)	175 (74)	0.24
Female, n (%)	78 (32)	63 (26)	
Median age, yr (25th–75th percentiles)	64 (53–71)	64 (50, 72)	0.47
Median SAPS II score (25th–75th percentiles)	36 (29–47)	36 (26–46)	0.10
Median time of ventilator support before trial of spontaneous breathing, d (25th–75th percentiles)	6 (4–9)	6 (4–12)	0.23
Reason for mechanical ventilation*			
Neuromuscular disease, n (%)	1 (0.4)	4 (1.7)	0.18
Coma, n (%)	37 (15.0)	23 (9.7)	
COPD, n (%)	50 (20.3)	50 (21.1)	
Acute lung injury, n (%)	158 (64.2)	160 (67.5)	
Cause of acute respiratory failure			
Postoperative state, n (%)	45 (28.5)	47 (29.4)	0.96
Pneumonia, n (%)	30 (19.0)	25 (15.6)	
Multiple trauma, n (%)	18 (11.4)	17 (10.6)	
ARDS, n (%)	6 (3.8)	5 (3.1)	
Heart failure, n (%)	22 (13.9)	24 (15.0)	
Sepsis, n (%)	19 (12.0)	25 (15.6)	
Other, n (%)	18 (11.4)	17 (10.6)	

* Data on this variable were not available for one patient in the Pressure Support Group.

bated patients (from the expected 62 to 75%) at a power of 80% with a two-tailed type I error of 0.05.

Data are presented as medians with the 25th–75th percentile ranges or percentages as appropriate. All categorical variables were analyzed by chi-square tests, except when small size required the use of Fisher's exact test. Comparison of continuous variables among T-tube and pressure support groups was performed using Student's *t* test for variables, with normal distribution and the Mann-Whitney U test for variables with nonnormal distribution. Comparisons of continuous variables among the following three groups: (*1*) patients who failed a spontaneous breathing trial (Trial Failure Group), (*2*) patients reintubated (Reintubation Group), (*3*) patients successfully extubated (Successful Extubation Group) were made using one-way analysis of variance for continuous variables with normal distribution and the Kruskall-Wallis test for variables with nonnormal distribution. The incremental area under the curve was used as a summary statistic for the measurements for each patient (11) to compare the respiratory frequency, heart rate, systolic blood pressure, and oxygen saturation in the trial failure, and reintubation and successful extubation groups for the 2-h spontaneous breathing trial.

For overall risk of death, an unconditional logistic regression analysis was undertaken to control for confounding variables and to identify independent risk factors in patients who tolerated the spontaneous breathing trial. The following variables were entered into the maximal model: age, SAPS II score at admission to the intensive care unit, days receiving mechanical ventilation prior to weaning, reason for the initiation of mechanical ventilation, and extubation outcome (reintubation or not).

RESULTS

Of the 484 patients, 246 patients were assigned to undergo spontaneous breathing trials with T-tube circuits and 238 were assigned to pressure support ventilation of 7 cm H_2O. The two groups were similar with respect to the patient characteristics, the indications for mechanical ventilation, and respiratory functional parameters measured before the trial of spontaneous breathing was performed (Tables 1 and 2).

The 192 patients (78%) in the T-tube group successfully completed a 2-h trial of spontaneous breathing and were immediately extubated; 36 of them (18.7%) required intubation within 48 h. The remaining 54 patients had signs of poor tolerance during the trial of spontaneous breathing, which lasted a median of 30 min (25th–75th percentiles: 15 to 60) and were reconnected to the ventilator (Figure 1).

The 205 patients (86%) in the pressure support group were

TABLE 2

RESPIRATORY PARAMETERS MEASURED DURING THE FIRST THREE MINUTES AFTER DISCONTINUATION OF VENTILATOR SUPPORT AND PRIOR TO RANDOMIZATION

Respiratory Parameters	T-Tube Group (*n* = 246) Median (25th–75th Percentiles)	Pressure Support Group (*n* = 238) Median (25th–75th Percentiles)	p Value
Ratio of Pa_{O_2} to $F_{I_{O_2}}$*	270 (225–329)	260 (225–325)	0.23
Tidal volume, ml	426 (350–540)	450 (358–555)	0.07
Respiratory frequency, breaths/min	23 (18–28)	24 (19–27)	0.46
f/V_T ratio†	51 (35–73)	52 (38–70)	0.48
Maximal inspiratory pressure, cm H_2O	−27 (−20–−35)	−25 (−22–−35)	0.42

* Arterial P_{O_2} was measured while patients were receiving mechanical ventilation.
† The f/V_T ratio is respiratory frequency divided by tidal volume expressed in liters/breaths/min.

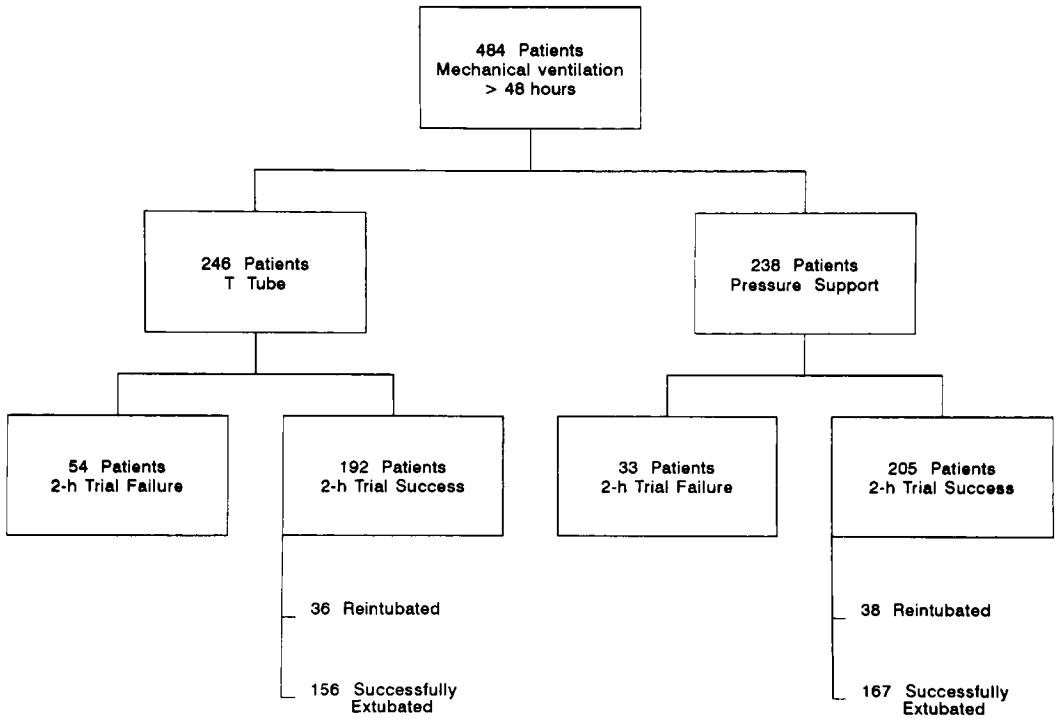

Figure 1. Distribution of the studied population according to the method used to perform spontaneous breathing trial and the outcome of the trial.

extubated after a successful 2-h trial of spontaneous breathing, and 38 of them (18.5%) required intubation within 48 h. The remaining 33 patients were reconnected to the ventilator because of poor tolerance to the trial after a median duration of 45 min (25th–75th percentiles: 15 to 75) (Figure 1). The duration of the spontaneous breathing trial in patients who failed was not different according to the method used (30 min in the T-tube group versus 45 min in the pressure support group, $p = 0.15$).

The percentage of patients who remained extubated 48 h after a spontaneous breathing trial was not different when comparing T-tube and pressure support (63 versus 70%, $p = 0.14$). These results mean an absolute increase of 7% (95% confidence interval, 2 to 15) in the percentage of successfully extubated patients and a relative increase of 10% (95% confidence interval, 9 to 11) when spontaneous breathing trials were performed with pressure support instead of with T-tube. In other words, the number of patients needed to treat with pressure support to successfully extubate one more patient than with T-tube is 15.

There were no significant differences in the percentage of patients successfully extubated when comparing patients requiring mechanical ventilation prior to trial for less than 8 d and patients requiring more than 8 d (68 versus 57% in the T-tube group, $p = 0.12$; 74 versus 65% in the pressure support group, $p = 0.13$). The percentage of patients failing the trial of spontaneous breathing was significantly greater when the T-tube was used (22 versus 14%, $p = 0.03$). The reintubation rate was not different between the groups (18.7% with T-tube and 18.5% with pressure support, $p = 0.94$). The reintubation rate causing the initiation of mechanical ventilation was not different when the T-tube and the pressure support groups were pooled together (22% in the coma group, 24% in the chronic obstructive pulmonary disease with acute respiratory failure group, and 17% in the acute lung injury group, $p = 0.28$). Tracheostomy was performed in 13 of the 36 reintubated patients in the T-tube group and 14 of the 38 reintubated patients in the pressure support group.

In patients who tolerated the trial of spontaneous breathing there were no differences between T-tube and pressure support groups regarding ICU mortality (8.8 versus 5.8%, $p = 0.25$), in-hospital mortality (15.1 versus 15.6%, $p = 0.90$), median length of stay in the intensive care unit (10 d versus 12 d, $p = 0.33$), and median length of stay in hospital (24 d versus 28 d, $p = 0.33$).

Age, SAPS II score on admission to the intensive care unit, days receiving mechanical ventilation prior to spontaneous breathing trial, Pa_{O_2}/FI_{O_2} ratio, respiratory frequency, tidal volume, f/V_T ratio, and maximal inspiratory pressure are shown and compared according to weaning outcome in Table 3.

Changes in respiratory frequency, heart rate, systolic blood pressure, and oxygen saturation during the spontaneous breathing trial are shown in Figure 2. When the trial failure group was compared with each of the other two groups, that group had significantly higher incremental areas under the curve for respiratory frequency, heart rate, and systolic blood pressure, and significantly lower incremental area for oxygen saturation. However, patients who were reintubated were not different from those who were successfully extubated.

Eighty-one percent of the patients were reintubated because of respiratory failure, and the remaining patients needed reintubation because of signs of upper airway obstruction. Fifteen percent of the reintubated patients had some complications associated with the technique: cardiac arrest successfully resuscitated in two patients, esophageal intubation in one patient, right bronchial intubation in one patient, gastric aspiration in one patient, supraventricular tachycardia in one patient, esophageal intubation with aspiration and pneumonia in one patient, and development of pneumonia within 72 h in four patients.

TABLE 3

COMPARISON OF THE STUDY POPULATION ACCORDING TO THE OUTCOME OF THE SPONTANEOUS BREATHING TRIAL

	Successfully Extubated (*n* = 323)	Reintubated (*n* = 74)	Trial Failure (*n* = 87)	
	Median (25th–75th Percentiles)	Median (25th–75th Percentiles)	Median (25th–75th Percentiles)	p Value
Age, yr	63 (48–70)	67 (60–74)	66 (54–73)	0.005*
SAPS II score	36 (26–45)	36 (29–51)	38 (31–50)	0.07
Duration of ventilator support before trial of spontaneous breathing, d	6 (4–10)	6 (4–10)	8 (5–12)	0.02†
Ratio of Pa_{O_2} to $F_{I_{O_2}}$	269 (228–337)	266 (233–314)	257 (193–310)	0.03‡
Respiratory frequency, breaths/min	22 (18–26)	24 (19–27)	27 (22–31)	< 0.001†
Tidal volume, ml	450 (380–582)	415 (350–550)	380 (310–480)	< 0.001†
f/V_T ratio	47 (34–66)	50 (35–73)	68 (51–87)	< 0.001†
Maximal inspiratory pressure, cm H_2O	−25 (−20–−36)	−25 (−25–−35)	−28 (−25–−37)	0.48

* Significant difference for the comparison of successfully extubated with reintubated patients.
† Significant difference for the comparison of trial failure group with each of the other two groups.
‡ Significant difference for the comparison of successfully extubated and trial failure groups.

ICU mortality among patients requiring reintubation was significantly higher than mortality in successfully extubated patients (27.0 versus 2.6%, $p < 0.001$). Logistic regression analysis was undertaken to control for the effect of confounding variables and identify independent risk factors of death in patients who tolerated spontaneous breathing trials and were extubated. Only reintubation within 48 h was independently associated with an increased risk of mortality (RR, 11.16; 95% confidence interval, 4.64 to 26.85). Patients requiring reintubation because of respiratory failure had a mortality rate of 30% (20 of 66), whereas mortality was 7% (one of 14) in patients needing reintubation because of upper airway obstruction.

Fifty-four patients in the T-tube group and 33 patients in the pressure support group failed the 2-h trial. Of the patients in the

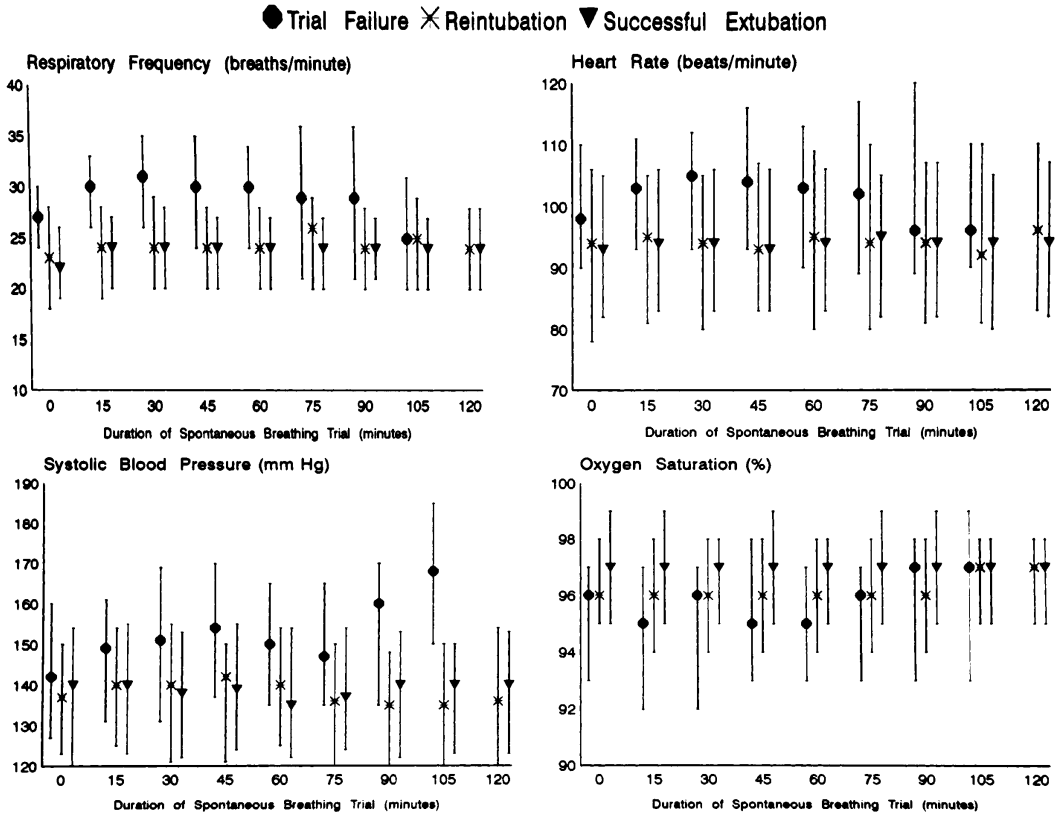

Figure 2. Median (25th–75th percentiles) respiratory frequency (*upper left*), heart rate (*upper right*), systolic blood pressure (*lower left*), and oxygen saturation (*lower right*) in successfully extubated patients, reintubated patients, and patients failing the trial of spontaneous breathing, according to the length of time from the start of the 2-h trial; $p < 0.01$ for the comparison of the incremental area under the curve between the trial failure group and each of the other two groups for all the four measured clinical variables.

T-tube group, 41 were ultimately successfully extubated, seven were tracheostomized without previous extubation, three were reintubated and subsequently tracheostomized, and three died without being extubated. Of the patients in the pressure support group, 23 were ultimately successfully extubated, three were reintubated and one of them subsequently tracheostomized, one was tracheostomized without previous extubation, and six died without being extubated. Mortality rate among patients failing the trial of spontaneous breathing was 20% in the T-tube group and 27% in the pressure support group.

DISCUSSION

Our study has three major findings. One, the percentage of patients successfully extubated after spontaneous breathing trials was 10% higher with pressure support of 7 cm H_2O than with T-tube. Two, neither respiratory functional parameters measured in the first three minutes of spontaneous breathing nor clinical characteristics of patients nor changes in the clinical variables assessed during the 2-h trial allowed us to predict the necessity of reintubation within 48 h after extubation. Three, reintubation was associated with a dramatic increase in mortality.

Several predictive weaning criteria can be used to identify patients able to resume and sustain spontaneous breathing and those who are likely to fail a weaning trial. However, most of them have shown good sensitivity (ranging from 0.60 to 1.0) but poor specificity (ranging from 0.10 to 0.80) (1–4). The rapid shallow breathing index (f/V_T ratio) appears to be the most accurate in predicting weaning outcome, in addition to being easy to measure (4). In many patients, despite favorable weaning parameters obtained shortly after disconnection, spontaneous breathing gradually becomes less effective as time passes. To detect such occurrence of weaning failure, it is useful to perform a brief test to evaluate the ability to breathe spontaneously. The optimal approach to performing such a test is not yet established. Recent studies have shown that almost 75% of patients ventilated can be extubated after a 2-h trial of spontaneous breathing, and reintubation within 48 h is needed in 15 to 19% of extubated patients (5, 6). All these studies have performed breathing trials using a T-tube circuit. The endotracheal tube can impose substantial resistive work, but it is not clear whether this work is superior to the work imposed by the natural upper airway, including the glottis and the trachea. Work of breathing in healthy people breathing through an endotracheal tube can increase by 27 and 240% depending on the internal diameter of the tube and flow rate (7, 12–14). On the other hand, it has been reported in critically ill patients that the work of breathing significantly increases in the postextubation period as compared with that while breathing spontaneously through an endotracheal tube (9, 15).

Several studies have shown that pressure support compensates for the additional work imposed by the endotracheal tube and the demand valve of the ventilator. This task can be accomplished with a level of pressure support of 7 cm H_2O, although the compensatory level ranges from 3 to 14 cm H_2O (7, 9, 15). Another important feature of pressure support ventilation is that it improves the efficacy of spontaneous breathing and reduces external respiratory work and oxygen consumption by respiratory muscles during weaning (15–18). However, there are no studies showing that these advantages make pressure support more efficacious than the T-tube when it is used before extubation in patients able to sustain spontaneous ventilation.

Two recent studies have compared different methods of weaning in a population of patients difficult to wean (patients who failed to tolerate an initial 2-h breathing trial) and have shown that there are no differences in length of time to successful extubation when comparing T-tube and pressure support (5, 6). In the study by Esteban and coworkers (6) the duration of weaning was 4 d (median) for pressure support ventilation and 3 d (median) for intermittent trials of spontaneous breathing through a T-tube circuit. After adjustment for other covariates, the rate of successful weaning with intermittent trials of spontaneous breathing with a T-tube was not significantly different from that with pressure support ventilation rate ratio, 1.66; 95% confidence interval, 0.87 to 3.16; $p = 0.13$). In the study by Brochard and coworkers (5) the mean duration of weaning in patients who completed the weaning protocol was significantly shorter with pressure support ventilation than with T-tube and synchronized intermittent mandatory ventilation pooled together (5.7 ± 3.7 d versus 9.3 ± 8.2 d, $p < 0.05$); although comparison of weaning duration between patients weaned with pressure support versus T-tube is absent from their article, one can check that weaning duration was not different by performing the comparison of mean duration of weaning in patients using T-tube and patients using pressure support ventilation.

We have now compared T-tube and pressure support in a population of patients able to maintain spontaneous breathing after discontinuation of ventilatory support. Our results show that a significantly higher percentage of patients in the pressure support group successfully underwent spontaneous breathing trials; however, this effect had not been of sufficient magnitude to be translated into a clinically relevant effect on the successful extubation rate, on the understanding that we only consider as clinically relevant a difference in the successful weaning rate higher than 20% and our results actually show a difference of 10%. The finding that spontaneous breathing trials with pressure support lead to higher trial-success rates but not to higher risk for reintubation, suggest that some patients fail spontaneous breathing trials with the T-tube because of the respiratory load imposed by the T-tube system, but they can be successfully extubated when this overload is eliminated by the pressure support. Further studies with higher sample size are needed to demonstrate that the marginal effect of pressure support on the trial-success rate found by us becomes apparent on the percentage of patients successfully extubated. On the other hand, although no financial analyses have been performed, our results also suggest that, in the current environment when essentially all ventilators have pressure support, the T-tube approach would be more expensive since this requires a humidification system as well as the connectors.

In a prospective study of patients being weaned from mechanical ventilation, Tobin and coworkers (19) found that rapid shallow breathing developed immediately upon discontinuing ventilator support in patients who failed the weaning trial. Such patients showed an increase in respiratory frequency from 21.0 ± 2.0 breaths/min during ventilatory support to 32.3 ± 2.3 breaths/min during the first 15 min of spontaneous breathing after discontinuation of ventilator support. In patients who underwent a successful weaning trial and were extubated, there was no change in breathing between ventilator support and spontaneous breathing immediately after discontinuation of the ventilator. In our study, clinical evolution during spontaneous breathing trials, evaluated in terms of respiratory frequency and heart rate and systolic blood pressure and oxygen saturation was clearly different among patients who failed the trial and patients who underwent the 2-h trials successfully (Figure 2). Immediately after discontinuation of ventilator support, patients failing a spontaneous breathing trial showed respiratory frequencies, heart rates, and systolic blood pressures significantly higher than patients who tolerated the whole 2-h period, and oxygen saturations significantly

lower. However, there was not a significant difference between patients requiring intubation within 48 h of extubation and successfully weaned patients. Although these parameters were not predictive of extubation failure, it is possible that a more precise breath-by-breath analysis of respiratory pattern could detect subtle differences not reflected in the measurements taken at 15-min intervals.

Neither respiratory functional parameters measured before a trial of spontaneous breathing nor clinical evolution during the trial have allowed us to predict patients who will ultimately require reintubation within 48 h. It is possible that respiratory failure requiring reintubation is determined by factors appearing after removal of the endotracheal tube such as subsequent cardiac failure (20), restless sleep (21), use of sedative agents, volume and tenacity of respiratory secretions, respiratory muscle weakness secondary to sepsis or muscle relaxant (22), the patient's psychological status, etc. Studies focusing on these aspects could cast light on the factors leading to the need for reintubation. This is the key issue in attempting to decrease reintubation rates.

Mortality in our study could seem low for a population composed of ventilated patients, but it is necessary to take into account that our study involved only ventilated patients with a favorable pretrial clinical course. Again, mortality among reintubated patients was significantly higher than mortality in successfully weaned patients (27.0 versus 2.6%, $p < 0.001$). This increase in mortality in reintubated patients was independent of age, SAPS II score at the time of intensive care unit admission, days receiving mechanical ventilation prior to weaning, and reason for the initiation of mechanical ventilation. All of this must be considered very cautiously because the association we have found between mortality and reintubation does not necessarily imply causality among them. It is possible that, in many patients reintubation was the result of high mortality clinical events. If this were the case, mortality in the reintubated patients would always be higher. As a matter of fact, patients reintubated because of respiratory failure showed a mortality of 30%, whereas mortality was only 7% in patients reintubated because of upper airway obstruction.

The results available from this study confirm the finding previously reported by the Spanish Lung Failure Collaborative Group, that ventilator support can be successfully discontinued in two thirds of ventilated patients after a 2-h trial of spontaneous breathing (6). The present study has shown that both pressure support of 7 cm H_2O and T-tube are suitable methods for spontaneous breathing trials before extubation in ventilated patients without difficulty in resuming spontaneous breathing. Presumably the above is also applicable to patients weaned with the technique of a once-daily trial of spontaneous breathing (6).

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