Intensive Care Med (2001) 27: 1649–1654
DOI 10.1007/s001340101035

J. A. Farias
A. Retta
I. Alía
F. Olazarri
A. Esteban
A. Golubicki
D. Allende
O. Maliarchuk
C. Peltzer
M. E. Ratto
R. Zalazar
M. Garea
E. G. Moreno

A comparison of two methods to perform a breathing trial before extubation in pediatric intensive care patients

Received: 21 December 2000
Final revision received: 3 June 2001
Accepted: 4 June 2001
Published online: 10 August 2001

Supported in part by the Argentinian Society of Critical Care Medicine (SATI)
Presented in part at the ATS 2000 Internacional Conference, May 5–10, Toronto, Abstract 80

J. A. Farias (✉) · A. Retta · F. Olazarri · A. Golubicki · R. Zalazar · M. Garea · E. G. Moreno
Unidad de Cuidados Intensivos Pediátricos,
Hospital de Niños Ricardo Gutiérrez,
Gallo 1330, 1425 Buenos Aires, Argentina
E-mail: jufarias@intramed.net.ar
Phone: +54-11-49640100
Fax: +54-11-49640798

I. Alía · A. Esteban
Unidad de Cuidados Intensivos,
Hospital Universitario de Getafe, Madrid, Spain

D. Allende · O. Maliarchuk
Unidad de Cuidados Intensivos Pediátricos,
Hospital Interzonal, Neuquén, Argentina

C. Peltzer · M. E. Ratto
Unidad de Cuidados Intensivos Pediátricos,
Hospital de Niños Sor María Ludovica,
La Plata, Buenos Aires, Argentina

Abstract *Objective*: To compare the percentage of infants and children successfully extubated after a trial of breathing performed with either pressure support or T-piece.
Design: Prospective and randomized study.
Setting: Three medical-surgical pediatric intensive care units (PICUs).
Patients: Two hundred fifty-seven consecutive infants and children who received mechanical ventilation for at least 48 h and were deemed ready to undergo a breathing trial by their primary physician.
Interventions: Patients were randomly assigned to undergo a trial of breathing in one of two ways: pressure support of 10 cmH_2O or T-piece. Bedside measurements of respiratory function were obtained immediately before discontinuation of mechanical ventilation and within the first 5 min of breathing through a T-piece. The primary physicians were unaware of those measurements, and the decision to extubate a patient at the end of the breathing trial was made by them.
Measurements and main results: Of the 125 patients in the pressure support group, 99 (79.2 %) completed the breathing trial and were extubated, but 15 of them (15.1 %) required reintubation within 48 h. Of the 132 patients in the T-piece group, 102 (77.5 %) completed the breathing trial and were extubated, but 13 of them (12.7 %) required reintubation within 48 h. The percentage of patients who remained extubated for 48 h after the breathing trial did not differ in the pressure support and T-piece groups (67.2 % versus 67.4 %, $p = 0.97$).
Conclusions: In infants and children mechanically ventilated, successful extubation was achieved equally effectively after a first breathing trial performed with pressure support of 10 cmH_2O or a T-piece.

Keywords Weaning · Mechanical ventilation · Children · Weaning indices · Pressure support ventilation · T-piece

Introduction

Mechanical ventilation is frequently used to support critically ill children and, although lifesaving, it is associated with numerous serious complications [1]. Therefore, every effort should be made to discontinue ventilator support at the earliest possible time and to extubate the patient. Determining the optimal time for extubation is based on a clinical evaluation of the patient's ability to sustain spontaneous breathing when mechanical ventilation is discontinued. We have recently reported that ventilator support can be discontinued in three-quarters of ventilated children after a trial of breathing through a T-piece lasting 2 h [2].

Pressure support, continuous positive airway pressure (CPAP) and T-piece are the most common methods used to test the readiness for liberation from mechanical ventilation. The advantage of pressure support over the T-piece and the CPAP is that pressure support may compensate the additional work of breathing caused by the endotracheal tube and the ventilatory circuit [3, 4]. The level of pressure support necessary to counteract the imposed work of breathing varies considerably from patient to patient. Brochard et al. [3] reported, in 11 adult patients, that the level of pressure support that reduced the work of breathing to its postextubation value varied from 3.4 to 14.4 cmH_2O. In a study on 15 patients (11 adult and 4 pediatric) intubated with endotracheal tubes sized between 6.0 and 9.0 mm, Banner et al. [4] found that pressure support levels ranging from 5 to 22 cmH_2O were necessary to decrease the imposed work of breathing to zero. The effect of pressure support on breathing pattern and work of breathing in children was first investigated by Tokioka et al. [5]. These authors studied six children, aged from 3 to 5 years and intubated with endotracheal tubes between 4.5 and 6.0 mm in internal diameter, and found that the work of breathing decreased by 48 % with pressure support of 5 cmH_2O and by 73 % with pressure support of 10 cmH_2O. Jarreau et al. [6] studied six intubated preterm infants and found that patient-triggered ventilation with peak inspiratory pressure of 10 cmH_2O reduced the work of breathing by 40 % compared with its level in intermittent mandatory ventilation, and that peak inspiratory pressure of 15 cmH_2O did not produce a greater decrease in work of breathing than the one observed with 10 cmH_2O.

Pressure support might be more efficacious than T-piece in breathing trials performed before extubation in children because of its ability to reduce the work of breathing. With this in mind, we conducted a prospective and randomized study to compare the percentage of infants and children who remained extubated for 48 h after discontinuation of mechanical ventilation in two groups of ventilated patients who were assigned to undergo breathing trials with either T-piece or pressure support ventilation. Neither the level of pressure support that is required to compensate for the work of breathing imposed by narrow endotracheal tubes nor the level of pressure support at which the endotracheal tube can be removed have been reported in infants, we therefore arbitrarily chose a level of 10 cmH_2O for this study.

Methods

Patients

The study was conducted between May 1997 and November 1998 in three medical-surgical pediatric intensive care units (PICUs) located at three tertiary-care hospitals. All infants and children admitted to the PICUs who received mechanical ventilation for at least 48 h and were judged by the primary physician as ready to undergo a breathing trial were eligible for the study. Patients were enrolled if they met all of the following conditions: (1) age between 1 month and 15 years; (2) improvement or resolution of the underlying cause of acute respiratory failure; (3) adequate gas exchange as indicated by a partial pressure of arterial oxygen (PaO_2) higher than 60 mmHg while breathing with a fractional inspired oxygen (FIO_2) of 0.40 or less and a positive end-expiratory pressure (PEEP) of 5 cmH_2O or less; (4) a core temperature below 38.5 °C; (5) alert mental status after removal of sedatives agents; (6) a hemoglobin level above 10 g/dl; (7) no further need for vasoactive agents. Patients with tracheostomy ($n = 5$) or audible air leak around the endotracheal tube ($n = 12$) were excluded from the study.

Protocol

When a patient was enrolled in the study, mechanical ventilation was stopped and the patient breathed through a T-piece with the FIO_2 set at the same level as used during mechanical ventilation. The absence of an audible air leak was confirmed by two investigators (staff respiratory therapists) by using a stethoscope placed over the patient's neck.

The following measurements were taken within the first 5 min of breathing through the T-piece: respiratory rate, exhaled minute volume and maximal inspiratory pressure (P_{Imax}). Exhaled minute volume was measured with a Wright Infant Spirometer (Ferraris Medical, London, UK) over 1 min. Tidal volume was calculated by dividing exhaled minute volume by respiratory frequency and was indexed to body weight. P_{Imax} was measured by occluding the airway using a one-way valve and the most negative value of three efforts was selected. Frequency-to-tidal volume ratio (f/V_T ratio) was calculated by dividing respiratory rate by tidal volume indexed to body weight. The respiratory therapists caring for the patients collected the above data and all of the physicians in the PICUs were unaware of the results of each patient's respiratory measurements.

Through the use of a random number table, patients were randomly assigned to undergo a trial of breathing with either pressure support ventilation of 10 cmH_2O or a T-piece lasting up to 2 h. Patients were allocated to the two groups in a blinded fashion through the use of opaque, sealed, numbered envelopes, which were opened only when a patient fulfilled all the inclusion criteria. Randomization was done through the permuted block method according to study center. In patients of the pressure support group a positive end-expiratory pressure up to 5 cmH_2O could be applied.

Table 1 Characteristics of the study population at baseline according to the method used to perform the weaning trial. Values are median (25th percentile, 75th percentile) (*ARDS* acute respiratory distress syndrome)

Characteristic	Pressure support (n = 125)	T-piece (n = 132)	p value
Males/females *(n)*	52/73	52/80	0.81
Age (months)	12 (5, 49)	10 (3, 31)	0.15
Body weight (kg)	8.8 (6, 16)	7.5 (4.9, 12.1)	0.03
PRISM score on PICU admission	13 (10, 17)	12 (9, 16)	0.07
Duration of ventilator support before weaning trial (days)	6 (4, 10)	6 (4, 11)	0.97
Reason for the initiation of mechanical ventilation, *n* (%)			
Neuromuscular disease	2 (2)	1 (1)	0.85
Coma	15 (12)	19 (14)	
Acute on chronic pulmonary disease	16 (13)	15 (11)	
Acute respiratory failure	92 (73)	97 (73)	
Cause of acute respiratory failure, *n* (%)			
Pneumonia/bronchiolitis	42 (45)	41 (42)	0.78
Postoperative state	19 (21)	22 (23)	
Heart failure	7 (8)	10 (10)	
Septic shock	9 (10)	10 (10)	
ARDS	3 (3)	6 (6)	
Pulmonary contusion	6 (6)	2 (2)	
Other	6 (6)	6 (6)	
Endotracheal tube size	4.5 (4, 5)	4 (3.5, 4.5)	0.57

The primary physicians terminated the trial if a patient had any of the following signs of poor tolerance: (1) respiratory frequency higher than the value corresponding to the percentile 90 for a given age [7, 8]; (2) signs of increased respiratory work: use of accessory respiratory muscles, intercostal-suprasternal-supraclavicular retraction, a paradoxical breathing pattern; (3) diaphoresis and anxiety; (4) heart rate higher than the value corresponding to the percentile 90 for a given age [7]; (5) change in mental status (agitation or somnolence); (6) blood pressure lower than those values corresponding to the percentile third for a given age [9]; (7) oxygen saturation lower than 90% while measured by pulse oximetry; (8) partial pressure of arterial carbon dioxide higher than 50 mmHg or an increase of more than 10 mmHg; (9) arterial pH lower than 7.30. If a patient had any of the above signs at any time during the breathing trial, mechanical ventilation was reinstituted. From this point forward, the methods for mechanical ventilation and/or weaning were freely chosen by the primary physician and neither was specified by protocol. Patients who had no signs of poor tolerance at the end of the breathing trial were immediately extubated and received supplemental oxygen by face mask.

Weaning was considered successful if extubation was performed after the breathing trial and reintubation was not required within 48 h of extubation. The primary physicians decided the need for reintubation according to clinical examination, blood gases or both. The reason for reintubation was prospectively recorded as: (1) upper airway obstruction; (2) hypoxemia (oxygen saturation below 90% measured by pulse oximetry or partial pressure of oxygen lower than 60 mmHg while breathing with a $FIO_2 \geq 0.5$); (3) respiratory acidosis (arterial pH < 7.30); (4) atelectasis; (5) decreased level of consciousness; (6) clinical signs of increased respiratory work. If another cause was responsible, it was listed.

All patients were followed-up until discharge from the hospital or death. The institutional ethics committees of the hospitals approved the study and parents provided informed consent.

Statistical analysis

We have previously reported that 75% of ventilated pediatric patients can be successfully extubated after a 2-h trial of spontaneous breathing performed with a T-piece [2]. We calculated that 113 patients were needed in each group to detect a 20% difference in the percentage of successfully extubated patients (from the expected 75% to 90%) at a power of 80% with a two-tailed type I error of 0.05.

Data are shown as medians with 25th–75th percentile range or percentages as appropriate. All categorical variables were analyzed with the chi-square test, except where small size required the use of Fisher's exact test. Comparison of continuous variables among the two groups was made with Student's t test for variables with normal distribution, and the Mann-Whitney U test for variables with abnormal distribution.

Results

Two hundred fifty-seven patients were enrolled in the study. At the time of enrollment, patients were being ventilated in assist-control ventilation (n = 118), synchronized intermittent mandatory ventilation (SIMV) (n = 80) or SIMV plus pressure support (n = 59) with any of the following ventilators: Dräger Evita (Dräger, Germany), Dräger Evita 4 (Dräger, Germany), Newport Wave E200 (Newport Medical Instruments, Newport Beach, Calif.). Of those patients, 125 were assigned to a breathing trial with pressure support ventilation of 10 cmH_2O, and 132 were assigned to a breathing trial with a T-piece. Demographic data of patients in the two studied groups are presented in Table 1. The two groups were similar with respect to the indications for mechanical ventilation but patients in the T-piece group were smaller and younger than patients in the pressure

Table 2 Respiratory functional indices measured during the first 5 min while breathing through a T-piece after discontinuation of mechanical ventilation. Values are median (25th percentile, 75th percentile)

Respiratory functional indices	Pressure support (n = 125)	T-piece (n = 132)	p value
PaO_2/FIO_2 ratio	278 (227, 351)	283 (215, 367)	0.92
Respiratory frequency (breaths/min)	37 (24, 49)	40 (28, 52)	0.11
Tidal volume (ml/kg)	6.5 (5, 8.1)	5.9 (4.8, 7.6)	0.09
f/V_T ratio (breaths/min per ml per kg)	6 (4, 9)	7 (4, 10)	0.06
Maximal inspiratory pressure (cmH_2O)	–25 (–30, –40)	–30 (–30, –40)	0.14

Table 3 Rates of successful extubation, reintubation within 48 h and breathing trial failure according to the reason for the initiation of mechanical ventilation

	Successful extubation		Reintubation		Trial failure	
	PSV	T-piece	PSV	T-piece	PSV	T-piece
Acute respiratory failure, n (%)	61 (65)	63 (68)	13 (15)	12 (12)	18 (20)	22 (20)
Acute on chronic pulmonary disease, n (%)	10 (64)	9 (58)	0 (0)	1 (8)	6 (36)	5 (33)
Coma, n (%)	12 (86)	16 (81)	1 (7)	0 (0)	2 (7)	3 (19)

Table 4 Mortality and lengths of stay in the two study groups. Values are median (25th percentile, 75th percentile)

	Pressure support (n = 125)	T-piece (n = 132)	p value
Length of stay in the PICU (days)	11 (7, 18)	12 (7, 20)	0.66
Length of stay in the hospital (days)	21 (16, 34)	22 (16, 34)	0.67
In-unit mortality, n (%)	16 (13)	15 (11)	0.87
In-hospital mortality, n (%)	21 (17)	20 (15)	0.85

support group. Respiratory functional parameters measured while breathing through a T-piece before randomization to the two study groups are shown in Table 2. Patients of the T-piece group had a trend toward higher f/V_T ratio indexed to body weight but such a difference was not clinically relevant.

Of the 125 patients in the pressure support group, 26 (20.8 %) patients were reconnected to the ventilator because of poor tolerance of the breathing trial after a median duration of 30 min (25th and 75th percentiles: 30 and 90 min, respectively). The remaining 99 (79.2 %) patients successfully completed the breathing trial and were immediately extubated, but 15 of them (15.1 %) were reintubated within 48 h. Of the 132 patients in the T-piece group, 30 (22.7 %) patients were reconnected to the ventilator because of poor tolerance to the breathing trial after a median duration of 30 min (25th and 75th percentiles: 20 and 45 min, respectively). The remaining 102 (77.3 %) patients successfully completed the breathing trial and were immediately extubated, but 13 of the them (12.7 %) were reintubated within 48 h.

The percentage of patients who remained extubated 48 h after the breathing trial did not differ in the pressure support and the T-piece groups (67.2 % versus 67.4 %, respectively, $p = 0.97$). In the pressure support and T-piece groups, neither the reintubation rates (15.1 % versus 12.7 %, respectively, $p = 0.62$) nor the trial failure rates (20.8 % versus 22.7 %, respectively, $p = 0.81$) were different.

The percentages of patients successfully extubated, reintubated within 48 h or failing the breathing trial according to the indication for mechanical ventilation are presented in Table 3. Among all 28 patients who required reintubation, it was necessary in 5 (17.8 %) patients solely because of signs of upper airway obstruction, and in the remaining 23 patients because of one or more of the following conditions: signs of increased respiratory work in 18 patients, decreased level of consciousness in 14, hypoxemia in 6, respiratory acidosis in 5 and atelectasis in 2 patients.

There were no statistically significant differences among the two study groups with respect to the PICU and hospital lengths of stay and with respect to in-unit mortality or in-hospital mortality (Table 4). Table 5 shows the mortality rates according to the outcome of the breathing trial in patients of the T-piece and the pressure support groups. Both the in-unit mortality and the in-hospital mortality were significantly higher among patients who required reintubation when compared with successfully extubated patients (in-unit mortality: 39.3 % versus 2.9 %, $p < 0.001$; in-hospital mortality: 46.4 % versus 6.3 %, $p < 0.001$). The in-unit mortality rate among patients who failed the breathing trial was 26.8 %.

Table 5 Mortality in the two study groups according to the outcome of the breathing trial

	Pressure support (n = 125)	T-piece (n = 132)	p value
Successful extubation			
In-unit mortality, n (%)	3 (3.6)	2 (2.2)	0.94
In-hospital mortality, n (%)	7 (8.3)	4 (4.5)	0.30
Reintubation			
In-unit mortality, n (%)	6 (40)	5 (38.4)	0.93
In-hospital mortality, n (%)	6 (40)	7 (53.8)	0.46
Reinstitution of mechanical ventilation			
In-unit mortality, n (%)	7 (26.9)	8 (26.6)	0.98
In-hospital mortality, n (%)	8 (30.7)	9 (30.0)	0.95

Discussion

Our study produced two main findings. First, the pressure support ventilation of 10 cmH_2O is as effective as the T-piece for performing a breathing trial before extubation. Second, the reintubation after 48 h of extubation is associated with a significant increase in mortality rate.

We have demonstrated, in a population of children, that neither success in breathing trial nor the reintubation within 48 h of extubation are different when a breathing trial is performed with pressure support of 10 cmH_2O or T-piece. At the moment this study was planned, no reports existed in the literature evaluating what level of pressure support reduced the work of breathing in intubated infants to that after extubation, so we arbitrarily chose a level of 10 cmH_2O. It might be possible that this level of pressure support both compensated for the resistive work imposed by the endotracheal tube and the ventilatory circuit and also reduced the total work of breathing. In such a case, the clinical tolerance during the breathing trial would had been better in the group of pressure support as compared with that of T-piece and, consequently, the percentage of patients passing the breathing trial would have been higher in the pressure support group. In our study population, both the percentage of patients that successfully completed the breathing trial and the percentage of patients that were reintubated within 48 h were virtually the same in the pressure support and the T-piece groups, so it is unlikely that a pressure support level of 10 cmH_2O underestimated the patient's ability to sustain spontaneous breathing.

Takeuchi et al. [10] have recently reported, in seven infants aged 1–11 months and intubated with endotracheal tubes between 3.5 and 4.5 mm in internal diameter, that the work of breathing at a pressure control level of 4 cmH_2O was similar to that after extubation. Brochard et al. [3] showed, in adult patients, that the level of pressure support necessary to compensate for the additional work of breathing caused by the endotracheal tube is higher in patients with chronic lung disease (12.0 ± 1.1 cmH_2O) than in those free of intrinsic lung disease (5.7 ± 2.2 cmH_2O). Since the infants in the study by Takeuchi et al. [10] had near-normal lung mechanics and gas exchange, the extrapolation to our study population that a level of pressure support of 4 cmH_2O mimics the work of breathing observed after extubation may be inadequate, because around 10 % of our patients had chronic pulmonary disease and 70 % were recovering from an acute episode of respiratory failure.

Using the T-piece for breathing trials instead of pressure support is more expensive because the former requires a humidification system as well as connectors. Contrarily, a major problem when using pressure support in small children is air leakage from the uncuffed endotracheal tubes. Positive inspiratory pressure persists if an air leak is present and massive air leakage may lead to autotriggering. Fortunately, air leak from the tube is not frequent with less than 10 cmH_2O of airway pressure.

Extubation failure, defined as reintubation and reinstitution of mechanical ventilation, has been reported to occur at rates of 11–29 % in infants and children [2, 11, 12, 13, 14, 15, 16]. Several studies have reported that adult patients requiring reintubation have a significantly higher mortality than patients who are successfully extubated [17, 18, 19]. This is the first study reporting that reintubation is also a poor prognostic factor in infants and children. There are several reasons that might explain why the need for reintubation is associated with an adverse outcome. One of these reasons is the relatively invasive nature of the procedure of intubation per se, but this seems unlikely because it has been reported that mortality is not greater among patients developing complications at the time of reintubation than in patients without complications during the procedure [19]. A second possible reason is that reintubation is not a direct etiologic contributor to poor outcome but rather an independent marker of severity of illness. A third reason is that, between the time of extubation and reintubation, patients may have developed a new problem, unrelated to the disease that initially precipitated their need for mechanical ventilation. The appearance of such a problem means a new course of ventilatory assistance and, accordingly, the mortality rate of reintubated patients in the studies of Epstein et al. [17] and Esteban et al. [18, 19] is very similar to that reported in an cohort study on 5183 patients who received mechanical ventilation for more than 12 h [20].

In summary, our findings agree with those reported by others in adult patients [18] and show that a trial of breathing is a useful approach to identify those infants and children who are ready for extubation, and trials

lasting 2 h and performed with pressure support of 10 cmH_2O are as effective as trials performed with a T-piece.

Acknowledgements The writers thank all residents, respiratory therapists, nurses and physicians of the participant PICUs for dedication and help in this study.

References

1. Rivera R, Tibbalss J (1992) Complications of endotracheal intubation and mechanical ventilation in infants and children. Crit Care Med 20: 193–199
2. Farias JA, Alía I, Esteban A, Golubicki AN, Olazarri FA (1998) Weaning from mechanical ventilation in pediatric intensive care patients. Intensive Care Med 24: 1070–1075
3. Brochard L, Rua F, Lorino H, Lemaire F, Harf A (1991) Inspiratory pressure support compensates for the additional work of breathing caused by the endotracheal tube. Anesthesiology 75: 739–745
4. Banner MJ, Kirby RR, Blanch PB, Layon AJ (1993) Decreasing imposed work of the breathing apparatus to zero using pressure-support ventilation. Crit Care Med 21: 1333–1338
5. Tokioka H, Kinjo M, Hirakawa M (1993) The effectiveness of pressure support ventilation for mechanical ventilatory support in children. Anesthesiology 78: 880–884
6. Jarreau PH, Moriette G, Mussat P, Mariette C, Mohanna A, Harf A, et al. (1996) Patient-triggered ventilation decreases the work of breathing in neonates. Am J Respir Crit Care Med 153: 1176–1181
7. Iliff A, Lee V (1952) Pulse rate, respiratory rate and body temperature of children between two months and eighteen years of age. Child Dev 23: 237–245
8. Rusconi F, Castagneto M, Gagliardi L, Leo G, Pellegatta A, Porta N, et al. (1994) References values for respiratory rate in the first 3 years of life. Pediatrics 94: 350–355
9. Lowrey GH (1973) Organ development. In: Lowrey GH (ed) Growth and development of children. Year Book Medical Publishers, Chicago, pp 186–249
10. Takeuchi M, Imanaka H, Miyano H, Kumon K, Nishimura M (2000) Effect of patient-triggered ventilation on respiratory workload in infants after cardiac surgery. Anesthesiology 93: 1238–1244
11. Baumeister BL, El-Khatib M, Smith PG, Blumer JL (1997) Evaluation of predictors of weaning from mechanical ventilation in pediatric patients. Pediatr Pulmonol 24: 344–352
12. Khan N, Brown A, Venkataraman ST (1996) Predictors of extubation success and failure in mechanically ventilated infants and children. Crit Care Med 24: 1568–1579
13. Thiagarajan RR, Bratton SL, Martin LD, Brogan TV, Taylor D (1999) Predictors of successful extubation in children. Am J Respir Crit Care Med 160: 1562–1566
14. Venkataraman ST, Khan N, Brown A (2000) Validation of predictors of extubation success and failure in mechanically ventilated infants and children. Crit Care Med 28: 2991–2996
15. Manczur T, Greenough A, Pryor D, Rafferty GF (2000) Comparison of predictors of extubation from mechanical ventilation in children. Pediatr Crit Care Med 1: 28–32
16. Hubble CL, Gentile MA, Tripp DS, Craig DM, Meliones JN, Cheifetz IM (2000) Deadspace to tidal volume ratio predicts successful extubation in infants and children. Crit Care Med 28: 2034–2040
17. Epstein SK, Ciubotaru RL, Wong JB (1997) Effect of failed extubation on the outcome of mechanical ventilation. Chest 112: 186–192
18. Esteban A, Alía I, Gordo F, Fernández R, Solsona JF, Vallverdú I, et al. (1997) Extubation outcome after spontaneous breathing trials with T-tube or pressure support ventilation. Am J Respir Crit Care Med 156: 459–465
19. Esteban A, Alía I, Tobin MJ, Gil A, Gordo F, Vallverdú I, et al. (1999) Effect of spontaneous breathing trial duration on outcome of attempts to discontinue mechanical ventilation. Am J Respir Crit Care Med 159: 512–518
20. Esteban A, Anzueto A, Alía I, Tobin MJ, Benito S, Brochard L, et al. (1999) Clinical characteristics of patients receiving mechanical ventilation (abstract). Am J Respir Crit Care 159:A47