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

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 cmH₂O 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 (12.7%) 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 cmH₂O 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 cmH₂O. 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 cmH₂O 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 cmH₂O and by 73% with pressure support of 10 cmH₂O. Jarreau et al. [6] studied six intubated preterm infants and found that patient-triggered ventilation with peak inspiratory pressure of 10 cmH₂O reduced the work of breathing by 40% compared with its level in intermittent mandatory ventilation, and that peak inspiratory pressure of 15 cmH₂O did not produce a greater decrease in work of breathing than the one observed with 10 cmH₂O.

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 cmH₂O 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 (PaO₂) higher than 60 mmHg while breathing with a fractional inspired oxygen (FIO₂) of 0.40 or less and a positive end-expiratory pressure (PEEP) of 5 cmH₂O 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 FIO₂ 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 (Pimax). 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. Pimax 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/Vt 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 cmH₂O 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 cmH₂O could be applied.