CLINICAL STUDY

The comparison of the effects of T-piece and CPAP on hemodynamic parameters, arterial blood gases and success of weaning

Cekmen N, Erdemli O

Güven Hospital Department of Anesthesiology and Intensive Care, Kavaklidere, Ankara, Turkey.
nedimcekmen@yahoo.com

Abstract: Weaning from mechanically ventilation is a period of transition from total ventilatory support to spontaneous breathing. The aim of this study was to compare the effects of T-Piece and continuous positive airway pressure (CPAP) on hemodynamic parameters, arterial blood gases and success of weaning. In a prospective, randomized, controlled trial, 40 consecutive patients requiring mechanically ventilation in our 8-bed adult general intensive care unit (ICU) for > 48 hrs were considered eligible for this study. Patients were randomly divided into two groups (n: 20). Group T-piece received, 4 L/min, Group CPAP received, PEEP ≤5 cm H_2O, FiO_2 ≤0.4. At the beginning of the weaning, duration of extubation and after 48 hours of extubation the arterial blood samples were taken for blood gases analysis, also the mean arterial pressure and heart rate were recorded. 40 patients in the ICU were included in the study. There were no significant differences within and between T-piece and CPAP groups according to hemodynamic parameters and arterial blood gases at the weaning period. The number of patients who could be unsuccessful weaned in the T-piece group was higher than the number of patients in the group CPAP ($p<0.001$, $p<0.01$). Whether, the technique used to wean patients, in this setting, resulted in a clinically relevant improvement in the outcomes addressed above requires further carefully designed, randomized, controlled trials *(Tab. 4, Ref. 25).* Full Text in free PDF *www.bmj.sk.*
Key words: mechanically ventilation, weaning, T-piece, CPAP.

Weaning from mechanically ventilation (MV) represents the period of transition from total ventilatory support to spontaneous breathing. Different ventilatory techniques can be used to wean the patients from mechanical ventilation (1–3).

Weaning from MV has been described as either the process of gradually decreasing ventilatory support to allow successful weaning from the ventilator or determining when patients have the ability to be safely liberated from the ventilator (1, 3). Different techniques have been proposed to ease the transition; however, individual study results have been conflicting. Published narrative reviews of different modes of weaning have focused more on the impact of these modes on the work of breathing rather than more clinically relevant outcome of time to wean or the success of weaning (2, 4). A T-piece and continuous positive airway pressure (CPAP) are routinely used to evaluate the withdrawal of MV (5). Over the past 25 years, many devices have been used to administer CPAP (6, 7).

The most prominent life-support technology, which truly defines critical care medicine, is MV. Whereas the majority of patients receiving MV requires ventilatory support for a short duration, a significant number require prolonged MV. Most patients receiving MV improve, allowing MV to be easily discontinued. However, some patients do not tolerate removal from the ventilator, despite resolution of the initial process that prompted support. A dependence on the ventilator in these patients can be attributed to residual or premorbid compromise of the cardiorespiratory or neuromuscular system (1–3, 7, 8).

Extubation is the ultimate goal of weaning from invasive MV. Regardless the different weaning strategies used, extubation failure is defined by the necessity of reintubation within 24 to 48 hours of planned extubation and occurs in 2 % to 25 % of patients (1, 2, 7–9). Extubation failure prolongs MV duration and intensive care unit (ICU) and hospital length of stay. Discontinuing MV constitutes a major clinical challenge more particularly in patients with chronic obstructive pulmonary disease (COPD) in whom respiratory weakness and diaphragmatic dysfunction may occur. In these patients, the rate of weaning failure is higher and ranges from 35 % to 67 % (4, 5, 7–9).

However, few studies have focused on extubation failure outcome in patients with diseases requiring MV. It is generally accepted that a spontaneous breathing trial, most commonly performed with pressure support (PS), CPAP, or a T-piece, is the best way to assess whether a patient is able to breathe on his or her own before extubation (1, 2, 7).

The aim of this study was to compare the effects of T-Piece and CPAP on hemodynamic parameters, arterial blood gases and success of weaning.

Güven Hospital Department of Anesthesiology and Intensive Care, Kavaklidere, Ankara, Turkey

Address for correspondence: N. Cekmen, MD, Çayyolu mah., Güvengir 42 sitesi. Firüze sok. No: 52, Yenimahalle, Ankara, Turkey.
Phone: +90.312.2419454

Materials and methods

This study was approved by the local institutional review board and a written consent was waived due to the nature of the study.

Patient population

In a prospective, randomized, controlled trial, 40 consecutive patients requiring mechanical ventilation in our 8-bed adult general ICU for >48 hrs were considered eligible for this study. The patients ranged in age from 18 to 90 years. From January 2006 to April 2008, all patients with a history of respiratory failure requiring an invasive MV were eligible. All hemodynamically and clinically stable patients receiving MV in the ICU due to acute respiratory failure of different origin, and judged ready to undergo an extubation trial by their primary physicians, were included in the study. All patients were monitored with respiratory frequency, heart rate, pulse oxymetry and electrocardiography and were controlled hemodynamically from an arterial (radial or femoral) line.

Study protocol

At the time of the inclusion in the study, all patients were mechanically ventilated via Servo 300 A (Siemens-Elema, Solna-Sweden) with a minimal ventilatory support (i.e., sencronized intermittent mandatory ventilation (SIMV) rate ≤4 breaths/min) with no pressure support ventilation and with an FiO_2 of 40 %.

During the study period, all patients were extubated following a standardized procedure; T-piece and CPAP trial was initiated when the following criteria were present: a significant improvement or resolution of the underlying reason for MV; adequate oxygenation (eg, pO_2/fraction of inspired oxygen (FiO_2) >150; VT ≥5 mL/kg, requiring positive end-expiratory pressure (PEEP) ≤8 cm H_2O; FiO_2 ≤0.4) and pH (eg, ≥7.35); require bronchial toilet less than twice in the 8 hrs preceding the assessment; body temperature below 38 °C, hemoglobin equal to or higher than 8 g/dL, cardiovascular pharmacologic therapy (including inotropic agents, vasodilators, and/or diuretics) considered appropriate by the primary physician when cardiac insufficiency and/or ischemia was known or suspected, systolic blood pressure, >90 mmHg, correction of electrolyte disorders, no intravenous sedatives (including benzodiazepines, opiates, propofol, and barbiturates) given for at least 48 h before the weaning trial, hemodynamic stability, full level of consciousness, and effective cough strength on command. The neurologic status was evaluated using the Glasgow coma scale, and 11 points were necessary for inclusion in the study. pO_2/FiO_2 ratio could be inferior to 150 in patients with severe chronic hypoxemia (2,6,7). The ventilator mode used in all patients before beginning the study was SIMV, with a constant inspiratory flow pattern.

In both groups, the FiO_2 was initially set withto the same level required before the breathing trial. For patients showing poor tolerance to the breathing trial, full ventilatory support was immediately recommened. This was defined by a decrease in oxygen saturation to <90 % while requiring an FiO_2>0.4; evidence of respiratory distress (respiratory rate ≥35/min for more than 5 mins, presence of respiratory acidosis (arterial pH <7.35 with pCO_2 >45 mmHg, in the presence of diaphoresis or thoraco-abdominal paradox), sustained increase in heart rate (>20 % baseline or >140 /min), or significant change in systolic blood pressure (>180 or <90 mmHg) (2, 3, 6, 7). Patients who tolerated the spontaneous breathing trial underwent an immediate extubation and received supplemental oxygen via a facemask. If both groups were not tolerated by the patients, SIMV was used.

Patients were randomly divided into two groups (n:20). Group T-piece received, 4 L/min oxygen, Group CPAP received, PEEP ≤5 cm H_2O, FiO_2 ≤0.4. At the beginning of the study, duration of extubation and after 48 hours of extubation arterial blood samples were taken for blood gases analysis, also mean arterial pressure and heart rate were recorded. The primary outcome measure was successful weaning, defined as the ability to maintain spontaneous breathing for 48 hours after discontinuation of mechanically ventilation and extubation. Unsuccessful weaning was defined as the need for re-intubation within 48 hours following extubation trials.

Data and statistical analysis

Patient demographics and Acute Physiology and Chronic Health Evaluation (APACHE II) score measured at the time of admission, duration of MV, size of endotracheal tube, or reasons for MV to the ICU were noted. The primary physicians were blinded to the study design and to the measurements obtained during the, although arterial blood gas values and routine measurements by respiratory therapist (i.e., spontaneous tidal volume, spontaneous and total respiratory rate, peak airway, peak alveolar pressures, laboratory data, and vital signs) were available to them.

Results are expressed as the mean±SD. Descriptive analysis (frequencies for categorical data, mean, SD, and box plot for numerical variables) was performed according to 2 groups, successful and failed weaning. Categorical variables were compared using the χ^2 test or Fisher exact test when χ^2 was not appropriate. Differences between groups were assessed for statistical significance using the Kruskal-Wallis test. P value of ≤.05 was considered significant. All statistical analyses were performed using the SAS Software version 8.2.

Results

40 patients in the ICU were included in the study. There were no significant differences between the treatment groups regarding age, sex, weight, APACHE II score at ICU admission, duration of MV, size of endotracheal tube, or reasons for MV to the ICU (p>0.05) (Tab. 1). There were no significant differences within and between in T-piece and CPAP groups according to pO_2, pCO_2, pH values at the beginning of the weaning, duration extubation and after 48 hours of the extubation (p>0.05) (Tab. 2).

Tab. 1. Baseline characteristics by group at start of weaning trial.

Groups	T-piece (n=20)	CPAP (n=20)
Age(y)	67±17	71±15
Sex (M/F)	12±8	10±10
Weight (kg)	87±14	79±13
APACHE II	29±6	28±7
Duration of ventilation prior to weaning trial, days	6.2±5.0	7.2±5.4
Size of endotracheal tube, mm	7.7±0.3	7.8±0.5
Reason for initiating mechanical ventilation		
Multitrauma	2	1
Pneumonia	8	9
Heart failure	4	3
Sepsis with ALI	2	3
Neurological (SAH, CPR)	1	2
After emergency surgery	2	1
Other	1	1

*Data are presented as n (%) or mean ±SD. Among medical patients, many diagnoses at admission were possible, **p >0.05, *** CPAP: continuous positive airway pressure, APACHE II: Acute Physiology and Chronic Health Evaluation ALI: acute lung injury, SAH: subarachnoid hemorrhage, CPR: cardiopulmonary resuscitation.

Tab. 2. Arterial blood gases duration of weaning trial.

Groups	T-piece (n=20)	CPAP (n=20)
At the beginning of the weaning		
pO_2	79±14	86±23
pCO_2	40±5	31±9
pH	7.4±0.2	7.4±0.12
duration extubation		
pO_2	86±41	122±21
pCO_2	39±4	34±4
pH	7.38±0.13	7.39±0.12
After 48 hours of the extubation		
pO_2	70±21	77±20
pCO_2	43±9	40±8
pH	7.39±0.11	7.39±0.09

*$p > .05$

There were no significant differences within and between groups according to hemodynamic parameters in T-piece and CPAP groups at the beginning of the weaning, duration extubation and after 48 hours of the extubation ($p > 0.05$) (Tab. 3). The number of patients who could be unsuccessful weaned in T-piece group was higher than the number of patients in the group CPAP ($p < 0.001$, $p < 0.01$). We found that the rate of reintubation was 25 % in the T-piece group (5/20) and 15 % in the CPAP group (3/20) ($p < 0.001$, $p < 0.01$) (Tab. 4). The mean time was 16±14 hrs. Reasons for reintubation included hypoxemia (due to inability to clear secretions, n=4), and respiratory distress (due to fatigue, n=2), new sepsis, n=2).

Tab. 3. Hemodynamic parameters duration of weaning trial.

Groups	T-piece (n=20)	CPAP (n=20)
At the beginning of the weaning		
MAP(mmHg)	88±6	78±9
Heart rate (beats/min)	100±9	97±10
duration of the extubation		
MAP(mmHg)	85±6	77±6
Heart rate (beats/min)	98±9	91±11
After 48 hours of the extubation		
MAP(mmHg)	82±6	74±8
Heart rate (beats/min)	96±19	87±12

* MAP – mean arterial blood pressure, HR – Heart rate, ** p >0.05

Tab. 4. Unsuccessful weaning duration of weaning trial.

Groups	T-piece (n=20)	CPAP (n=20)
Unsuccessful weaning	5 (25 %)	3 (15 %)

*($p < 0.001$, $p < 0.01$), $p < 0.05$

There were no significant differences between T-piece and CPAP groups according to pO_2, pCO_2, pH values and hemodynamic parameters at the weaning. However, in the T-piece group there were more patients unsuccessful weaned compared to the group CPAP.

Discussion

MV is commonly used for both postoperative recoveries and as a life saving measure for patients suffering from a multitude of medical conditions that result in respiratory failure. However, numerous side effects related to its use exist, and therefore MV should be discontinued as soon as the patient can sustain spontaneous respiration with an adequate gas exchange (1–3, 7, 10). Most commonly, patients are weaned from MV in a process, which gradually removes mechanical ventilatory support as the patient resumes spontaneous breathing. An extubation trial undertaken too early may predispose the patient to severe cardiorespiratory and/or psychological decompensation while a prolonged unnecessary MV exposes the patient to serious risks (2, 7, 10, 11).

Weaning from MV represents the period of transition from total ventilatory support to a spontaneous breathing. Different ventilatory techniques can be used to wean these patients from mechanically ventilation (1–3).

Successful, timely weaning and extubation of critically ill patients has a considerable bearing on the ultimate outcome (2, 3, 6, 8). Prolonged use of MV has been associated with infections, chronic lung disease, subglottic stenosis, aspiration and the need for reintubation is associated with an increased morbidity and mortality. A considerable effort is therefore directed towards an early weaning from the ventilator (12–14). A very low rate could reflect an unduly prolonged duration of MV, whereas a very high rate could reflect precocious extubation, which may

be a significant source of associated complications such as nosocomial pneumonia and ICU and hospital mortality (7, 13, 14).

Weaning may be influenced by the underlying disease (3). It is conceivable, however, that the need for reintubation is a marker of the severity of the illness rather than of mortality per se. From the little data available in the literature, the reintubation rate ranges from 4 to 19 % (3, 7, 14).

It has been reported that the weaning period represents 40 % of the total duration of mechanical ventilatory support (1, 11–13). Furthermore, morbidity and even mortality may be higher in these patients. Accordingly, both for clinical and economical reasons, every effort should be made to determine as soon as possible, which patients can be rapidly extubated, and to keep the weaning period to a minimum (1–3, 13, 14).

The weaning process begins in practice, and in many clinical studies when clinicians decide that a patient may be able to tolerate a reduction of mechanical ventilatory support (1, 7, 15–17). At that point, there are several options for a decreasing support, some of which may be more successful than others. The options include, but are not restricted to, intermittent T-piece trials, SIMV, PS weaning, CPAP, combinations of the above, and newer approaches to weaning such as volume support, proportional assist ventilation, and noninvasive positive pressure ventilation (NPPV) (15–19).

Clinicians reach another stage in the weaning process at the point, at which they suspect that the patient may tolerate the discontinuation of mechanical ventilatory support and extubation (2, 15). The most popular method of proceeding at this point is a T-piece trial. Within each of these approaches, numerous alternatives exist, such as T-piece trials of various durations, and different levels of CPAP and PS (2, 15–19).

Esteban et al (15) compared 2-h trials of unassisted breathing using PS of 7 cm H_2O vs a T-piece. A smaller proportion of patients in the PS group (14 %) failed to tolerate the weaning and to achieve extubation at the end of the 2-h trial than in the T-piece group (22 %). Of those patients who were extubated, 38 in the PS group and 36 in the T-piece group required a reintubation. The results of the second largest trial, by Esteban et al (15) have suggested a possible advantage of PS over T-piece trial of spontaneous breathing. 21

Esteban et al (18) found that 22 % of 246 patients failed a T-piece weaning trial, and of the 192 who were extubated, 19 % required a reintubation. In contrast, Jones et al (19) reported that only 4 % of 52 patients undergoing weaning with T-piece breathing were not extubated, and of those extubated, only 4 % of 50 patients required reintubation.

In both studies, the investigators recruited those who had already failed a T-piece trial of an unassisted breathing. Esteban et al (20) conducted their T-piece trial of an unassisted breathing in 546 patients, only 130 of whom had respiratory distress during a 2-h T-piece trial. Brochard et al (21) found a similar strikingly high proportion of patients who tolerated their 2-h T-piece trial of unassisted breathing. Of 456 patients who underwent the T-piece trial, only 109 had been unable to tolerate spontaneous breathing and, therefore, were randomized (21).

Cohen et al (22) found that the rate of reintubation was 14% in the automatic tube compensation group and 24 % in the CPAP group. Vallverdu et al (23) showed that well supported 2-hour T-piece weaning trial predicted a favorable outcome in extubation procedure for patients with COPD. Butler et al (24) did not identify a superior weaning technique among the three most popular modes, T-piece, PS, SIMV. Cabello et al (25) trial was performed either using the T-piece disconnected from the ventilator, either using a low level of pressure support with or without positive end-expiratory pressure. A higher rate of failure occurred during the T-piece than during the pressure support trial, but once the patient had a success, the rate of reintubation was similar (25). We found that the rate of reintubation was 25 % in the T-piece group and 15 % in the CPAP group.

The other randomized studies, all of which compared T-piece strategies to alternative strategies, usually included some form of PS, had much smaller sample sizes, and generally had lower event rates.

The major outcome of these studies on modes of weaning was weaning failure and, in particular, the need for reintubation. While the need for reintubation is important, it is prior to reintubation that patients often experience distress, the most important consequences of which is the major morbidity such as pneumonia, further lung injury or cardiac complications, and possibly death (1, 4, 5, 7, 8).

In the setting of a high threshold and low failure rates, investigators would need to recruit patient sample sizes in the thousands, or even the tens of thousands, to be able to demonstrate differences between the techniques (4, 5, 7, 8). Such studies are unlikely to be feasible, and, even if they were feasible, they would consume substantial resources. Thus, investigators interested in studying the optimal use of ventilation strategies for weaning in the future should first establish plausible event rates, and if they are very low, should reconsider embarking on trials comparing alternative approaches. In situations, in which event rates are high, it would be reasonable to reexamine whether a difference between PS and T-piece breathing could be confirmed (7, 15–20).

There are few trials designed to determine the most effective mode of ventilation for weaning, and more work is required in this area. From the trials reviewed, we could not identify a superior weaning technique among the three most popular modes, T-piece, PS, CPAP, SIMV. Such studies could be helpful in designing management strategies that can expedite successful discontinuation of mechanical support and minimizing risks associated with MV (7).

Finally, very recent advances in technological areas not specifically related to intensive care medicine, such as artificial intelligence and the use of knowledge-based systems, are proving to be useful in the management of the weaning process. When such systems are applied to modern microprocessor mechanical ventilators, they can provide significant help in the process of weaning by automatically reducing the ventilatory assistance and by indicating the optimal time to withdraw the patient from the ventilator and proceed with extubation.

Conclusions

Finally, there were no significant differences within and between T-piece and CPAP group according to pO_2, pCO_2, pH values and hemodynamic parameters at the weaning. However, in the T-piece group there were more patients unsuccessfully weaned compared to the group CPAP.

We found out that CPAP group was more successful than the T-piece group in the weaning. We think that it was due to the positive pressure support, which applied in CPAP mode makes better outcome than the T-piece procedure, which has no positive pressure support and entirely spontaneous breathing and oxygen support. Whether, the technique used to wean patients, in this setting, resulted in a clinically relevant improvement in the outcomes addressed above requires further carefully designed, randomized, controlled trials.

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