COMPARISON OF PRESSURE SUPPORT VENTILATION AND T-TUBE AS SPONTANEOUS BREATHING TRIAL TO WEAN FROM MECHANICAL VENTILATION

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ABSTRACT

Objective:

The objective of this study was to determine weaning success between T-tube and Pressure Support ventilation (PSV) as Spontaneous Breathing trials in terms of total duration of Mechanical Ventilation, time of weaning from Mechanical Ventilation, length of Intensive Care Unit (ICU) stay, rate of successful extubation, failure of extubation and ICU mortality.

Materials and methods:

We carried out a prospective, randomized, observational study involving 42 patients who received mechanical ventilation for any duration in ICU. The patients were randomly assigned to a 2-h trial spontaneous breathing trial either with a T-tube (n = 21) or PSV of 8 cm H2O (n = 21), after fulfilling the clinical criteria for weaning. The patient who failed the initial spontaneous breathing trial was excluded from the study. The patients who successfully fulfilled weaning criteria were extubated. According to the patient characteristics, objective parameters, and procedure outcomes, the two methods of weaning were compared. The outcome measures included were total time of Mechanical Ventilation (MV), total time of weaning from MV, total length of ICU stay, rate of successful extubation, rate of reintubation required, and ICU mortality.

Results:

All 42 patients in both T-tube (n=21) and PSV (n=21) group completed 2-h trial of spontaneous breathing and were extubated. Two (9.52%) patients in T-tube group and one (4.76%) patient in PSV group required reintubation within 48 hours. Rate of successful extubation, total time of MV, total time of weaning from MV and total length of stay at ICU and ICU mortality were not statistically significant between two groups.

Conclusion:

In patients with simple weaning, T-tube and PSV of 8 cm H2O are suitable methods as SBT for successful liberation from MV.

Keywords: Weaning, Tracheal extubation, Mechanical ventilation

INTRODUCTION

Mechanical ventilation is important in caring for patients with critical illness and it is common life support modality in ICUs. Mechanical ventilation provides support to the respiratory system affected by various illnesses which decreases the work of breathing as well as improves oxygenation. While it helps physicians support patients with respiratory failure, invasive mechanical ventilation has been shown to injure lungs, increase pre-existing lung injury, and induce other abnormalities and complications.[1] These complications have in turn been associated with failure to wean from mechanical ventilation, prolonged duration of intubation, hospital stay[2,3] and increased intensive care unit (ICU) mortality.[4,5]

Weaning is defined as the gradual reduction of ventilatory support and its replacement with spontaneous ventilation. In some cases, this process is rapid and uneventful, however for some patients the process may be prolonged for days or weeks. There is uncertainty about the best methods for conducting this process, which will generally require the cooperation of the patient

during the phase of recovery from critical illness. This makes weaning an important clinical issue for patients and clinicians.

The weaning duration extends to 41% of the total time of mechanical ventilation. In patients with chronic obstructive pulmonary disease (COPD) and cardiac failure, the weaning duration can reach 59% and 48% of the total time of MV, respectively.[8] The incidence of unplanned extubation ranges 0.3–16%.[6] Almost half of patients with self-extubation during the weaning period do not require reintubation,[7] suggesting that many patients are maintained on mechanical ventilation longer than is necessary. In the study by Coplin et al[8] mortality was 12% if there was no delay in extubation and 27% when extubation was delayed. Thus, criteria for readiness to begin weaning should be systematically evaluated each day to allow prompt initiation of weaning as soon as the patient is ready.[9]This will shorten the weaning process and minimize time on mechanical ventilation.[10] This is also an independent predictor of successful extubation and survival.[11]

The simple weaning group includes patients who successfully pass the initial Spontaneous breathing trial (SBT) and are successfully extubated on the first attempt, and represents 69% of weaning patients. Spontaneous breathing trial (SBT) is defined as assessment of the patient's ability to breathe spontaneously. Prognosis in this group is good, with an ICU mortality of 5% [12,13] and an in-hospital mortality of 12%.[13] The remaining patients (31%) represent difficult and prolonged weaning group with ICU mortality of 25%.[12,13]

Weaning success is defined as extubation and the absence of ventilatory support 48 h following the extubation.[16] Weaning failure is defined as one of the following, failed SBT or reintubation and/or resumption of ventilator support following successful extubation or death within 48 h following extubation.[12,13]

MATERIALS AND METHODS

This is a prospective randomized observational study done in adult patients requiring mechanical ventilation for any duration. This study was done in 11 bed multidisciplinary ICU in Tribhuvan University Teaching Hospital, Institute of Medicine, Kathmandu, Nepal. The sample size was calculated assuming the effect size as 0.8. Total number of patients enrolled were 42 with 21 in each group. All adult patients requiring mechanical ventilation for any duration were included in the study. Patients with death or discontinuation of weaning from mechanical ventilation for some other associated disorder were excluded from our study. Other patients who were excluded from the study were accidental self extubated patient, weaning failure patient and patientswho left against medical advice. The history of patient, diagnosis at the time of admission, APACHE II score at admission and the reasons for the initiation of the ventilator support were recorded. Standard ICU care was received by all patients. All the resident doctors, medical officer and nursing staff were instructed about the protocol of the study regarding weaning procedure as well as how to enter the results in preformed data sheet. Until the first attempt to discontinue ventilator support, all patients were intubated with orotracheal tubes and received volume or pressure targeted assist control ventilation according to their clinical state. The procedure of weaning from MV began when patient's condition showed visible improvement or there was a resolution of the underlying cause of respiratory failure. The weaning procedure was started when following criteria were met: Adequate mentation (arousable, GCS >13), adequate cough, absence of excessive tracheobronchial secretion, resolution of disease in acute phase for which the patient was intubated, spontaneous respiration rate (f) <35/min, spontaneous tidal volume (V_T) >5 ml/kg body weight, heart rate <140, systolic BP 90-160 mmHg, body temperature <38.5°C, hemoglobin >70g/L, partial arterial oxygen pressure (PaO_2) >60 mm Hg with breathing a fraction of inspired oxygen (FiO_2) of 0.4 with a positive end expiratory pressure (PEEP) of < or equal to 5 cm H_2O, no or minimal need of vasoactive or inotropic support, PaO_2/FiO_2Ratio>150, f/V_T ratio <105 breaths $min^{-1}L^{-1}$The patients fulfilling the criteria were randomly assigned in a blinded fashion by using closed-envelope technique either to a group to be weaned with 2-h T-tube spontaneous breathing trial or to a group to be weaned with 2-h PSV at initial positive pressure of 8 cm H_2O.Patients were watched for 5 to 10 minutes and if no acute distress, SBT was continued for 2 hour. If signs of acute distress developed, patients were switched back to assist control mode. During the 2-h trial, the patient had to meet the following objective

criteria: spontaneous respiratory frequency <35/min, arterial blood oxygen saturation (SaO_2) >90% on FiO_2< or equal to 0.4, heart rate <140/min or >20% change from the baseline, systolic blood pressure <180 mmHg or not <90 mmHg, PaO_2>60 mm Hg, and stable clinical condition. The patient fulfilling the criteria at the end of the 2-h trial were extubated. The weaning procedure was considered successful if reintubation was not required within the 48 h of extubation. Statistical analysis was done by using statistical package for the social sciences (SPSS) software version 17.0 (SPSS Ltd, Chicago, IL, USA). Values were presented as median, 25%-75% interquartile range or number and percentage. Data were analyzed using Independent t test for those variables which are normal across groups and Mann-Whitney U test for those variables which are not normal across groups. Nominal categorical data such as gender was analyzed with Chi square test. For all determination p value <0.05 was considered statistically significant.

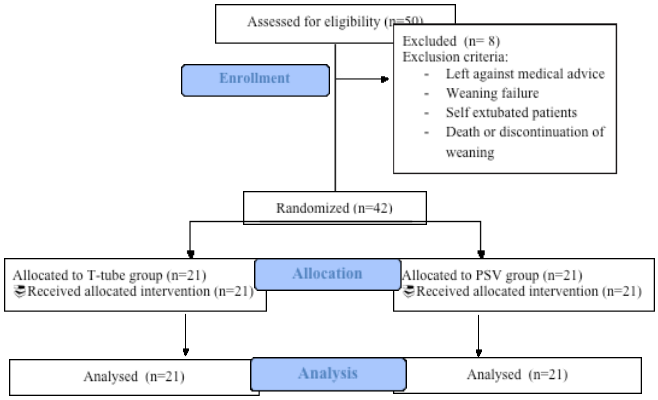

Figure I. CONSORT Flowchart

RESULTS

Out of the 42 patients who met the inclusion criteria, 21 patients were assigned to undergo spontaneous breathing trials with T-tube and 21 were assigned to pressure support ventilation of 8 cm of H_2O for 2 hours. The two groups were similar with respect to the patient's characteristics, indications for mechanical ventilation, and respiratory functional parameters measured before the trial of spontaneous breathing was performed (Tables 1 and 2).

The 21 patients (100%) in the T-tube group successfully completed a 2-h trial of spontaneous breathing and were immediately extubated; 2 of them (9.52%) required intubation within 48 h. In the PSV group 21 patients (100%) were extubated after a successful 2-h trial of spontaneous breathing, and 1(4.76%) required intubation within 48 h. The percentage of patients who remained extubated 48 h after a 2-h spontaneous breathing trial was not different when comparing T-tube and pressure support (90.48 versus 95.24%, p=1).

Table 1. Demographic profile of the patients weaned from mechanical ventilation by either T-tube or pressure support ventilation.

Patient characteristics	Type of weaning in group (n, %)		P – value
	T-tube (n=21)	PSV (n=21)	
Men	11 (52.4)	13 (61.9)	-
Women	10 (47.6)	8 (42.9)	-
Age (years, median, 25-75% interquartile range)	48 (34-58)	48 (37-57)	0.893

Table2. Clinical characteristics of the patients weaned from mechanical ventilation.

Reason for mechanical ventilation:	Type of weaning in group (n,%)	
	T-tube (n=21)	PSV (n=21)
COPD	2 (9.52)	2 (9.52)
postoperative state	3 (14.28)	4 (19.04)
Pneumonia	4 (19.04)	5 (23.8)
Polytrauma	2 (9.52)	0 (0)
Sepsis	1 (4.76)	2 (9.52)
ARDS	2 (9.52)	1 (4.76)
Other	7 (33.33)	7 (33.33)

Table 3. Clinical parameters of the patients weaned from mechanical ventilation by either T-tube or pressure support ventilation before the trial.

Parameter	Type of weaning (median, 25% - 75% interquartile range)		
	T-tube (n=21)	PSV (n=21)	p value
APACHE II score	22 (17.5 – 24)	21 (16.5 – 24)	0.944
Spontaneous respiration (rate/min)	24 (21.5 – 25)	23 (22 – 24.5)	0.858
Spontaneous respiration volume (ml)	385 (370 – 415)	390 (370 – 420)	0.919
PaO_2/FiO_2	280 (245 – 302.875)	292.5 (267.625 – 314.125)	0.116
fV_T (L/inspiration/min)	59.09 (54.9 – 65.38)	59.45 (55.675 – 63.19)	0.864
Heart rate (beats/min)	98 (89 – 105.5)	102 (92 – 104.5)	0.465
Hemoglobin (gm/dl)	10.2 (9 – 11)	10.8 (9.65 – 11.5)	0.151
PaO_2	112 (98 – 121.15)	116 (107.05 – 124.7)	0.133

The total time of mechanical ventilation in hours (median, 25% - 75% interquartile range) between two groups were 96.2(75.525 – 150.85) and 96.5(79.6 – 148.1) with p value of 0.852 which was not statistically significant. The time of weaning from mechanical ventilation in hours (median, 25% - 75% interquartile range) were 3.5(3.2 – 3.5) and 3.2(3.1 – 3.5) respectively between two groups with p value of 0.564 and was comparable between two groups. The length of ICU stays in hours (median, 25% - 75% interquartile range) between two groups were 38(28 – 52.8335) and 38 (31.5 – 46.5) respectively with p value of 0.831 which was not statistically significant. The ICU mortality (n, %) between two groups were 2(9.52%) and 1(4.76%) respectively and was comparable between two groups with p value of 1.

DISCUSSION

Whenever a mechanically ventilated patient is considered ready to be weaned, the best method to assess whether the patient is able to breathe on his or her own is to perform a trial of spontaneous breathing. Pressure-support, continuous positive airway pressure and T-piece trials are the common methods used in the trial of spontaneous breathing. Few randomized studies [18,23] have tried to evaluate the best technique for performing spontaneous breathing trials before extubation but controversies still exist.[17] There is no consensus as to how to conduct the SBT, leading to differing approaches across ICUs. Several studies have demonstrated that 60-80% of mechanically ventilated patients can be successfully extubated after passing a trial of spontaneous breathing.[10,12-15,18,23]

The duration of a spontaneous breathing trial has been set at 2 h in most studies.[10,12,14,15,23] One prospective, multicenter, randomized trial of 526 patients found that trials of spontaneous breathing for 30 or 120 min were equivalent in identifying patients who could tolerate extubation, and that patients had reintubation rates of approximately 13% at 48 h regardless of the duration of their T-tube trial.[13] In our study we also set the duration of a spontaneous breathing trial of 2 h. In a study done by Esteban A et al.[18] 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) and the percentage of patients failing the trial was significantly higher when the T-tube was used (22% versus14%, p = 0.03). In another studybyMatic I et al.[20] 73% in T-tubegroup and 80% in PSV group successfully completed the 2-h trial and were extubated. In a study by Esteban A et al.[14] showed 76.2% successfully completed a 2 h trial of spontaneous breathing, and 89.4% of them were immediately extubated and 15.6% required reintubation within 48 hours. In our study successful extubation rates between T-tube and PSV group was 90.48% and 95.24% respectively and reintubation required within 48 hours between two groups were 9.52% and 4.76% respectively, which was not different between two groups but higher than the study done by Esteban A et al.[18] This might be because of the small sample size in our study who underwent successful spontaneous breathing trial in first attempt. Besides that, we have excluded the patients with difficult and prolonged weaning in our study. In our study, the disease severity of the patients, measured as APACHE II score (median and IQR) at the time of the ICU admission was 22(17.5-24) and 21(16.5-24) respectively for T-tube and PSV in our study. When Compared to the study done by Matic I et al,[20]whose APACHE II score (median and IQR) was 24.3(18-29) and 26(16.4-29.25) respectively for T-tube and PSV. This might have influenced the result of our study. According to the literature, approximately 70% of mechanically ventilated patients fall into the simple weaning group.[12,14,15] In a study by Penuelas et al.[24]and Funk G et al.[25] the reintubation rate in the simple weaning group was 10% and 13% respectively, which was in accordance with our result.

Two hours spontaneous breathing trials with T-tube and PSV are both appropriate methods for successful weaning from mechanical ventilation in uncomplicated situation, [18,26]as confirmed in our study. The respiratory functional parameters measured before a trial of spontaneous breathing and the clinical evolution during the trial have not 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,[27] restless sleep,[28] use of sedative agents, volume of respiratory secretions, respiratory muscle weakness secondary to sepsis or muscle relaxant,[29] the patient's psychological status,

etc. Study focusing on these aspects is needed in future to find out the factors leading to the need for reintubation. This is the key issue in attempting to decrease reintubation rates.

In a study conducted by Brochard L et al.[15] showed the mean (± SD) duration of the weaning was significantly shorter with pressure support than with the two other modalities (T-tube and SIMV) pooled together (5.7 ± 3.7 d versus 9.3 ± 8.2 d, $p < 0.05$). In another study by Esteban A et al.[14] the median (25%-75% interquartile range) duration (d) of the weaning was 4(2-12) and 3(1-6) respectively for PSV and T-tube trial. Matic I et al.[20]reported the time (h) of weaning from mechanical ventilation in median (25%-75% interquartile range) as 94(79-132) and 54(47-88) respectively for T-tube and PSV. In our study the median (25%-75% interquartile range) duration (h) of weaning for T-tube and PSV was 3.5(3.2-3.5) and 3.2(3.1-3.5) respectively with p value of 0.564 which was comparable between two groups. The weaning duration was shorter in our study as compared to the study done by them, as they have conducted the study on patients with difficult and prolonged weaning groups who required prolonged duration to liberate from the mechanical ventilation. The rate of success and the duration of the weaning can be influenced by the underlying disease; since in our study the proportion of the patients with chronic obstructive pulmonary disease, patients with central nervous system disorders and patients with peripheral nervous system disorders are less, this might have influenced the result of our study. Also we have included patients requiring mechanical ventilation for any duration including postoperative cases whose cause for instituting mechanical ventilation resolved quickly, requiring less time for weaning. Total duration of mechanical ventilation in hours was evaluated by three studies, Vitacca M et al.[21] reported the mean duration of mechanical ventilation: 181 hrs. in the PSV SBT compared with 130 hours in the T-tube SBT, among 52 patients, there was mean difference of 51 hours, but without statistical significance (95% CI -23.09 to 125.09, $p = 0.18$). Matic I et al.[20] reported the total duration of mechanical ventilation in terms of medians and IQRs for T-tube and PSV SBTs for patients with weaning difficulties, which was 262 h (216 h - 328 h) and 215 h (187 h - 259 h) respectively, thus favouring the PSV group ($p< 0.001$). Matic I et al.[22] also reported median values favouring the PSV group (163 h, range 143 h to 203 h) compared with the T-tube group (187 h, range 143 h to 328 h), p value < 0.001. In our study the total time (h) of mechanical ventilation in terms of medians and IQRs between T-tube and PSV group was 96.2(75.525–150.85) and 96.5(79.6 – 148.1) respectively with p value of 0.852 and was comparable between two groups but the duration was shorter in our study as compared to other study because we have included the patients requiring mechanical ventilation for any duration of time, if we have included patients who received mechanical ventilation for more than 48 hrs. as in a study by Matic I at el,[20] the total duration of MV would have been longer. Also we have included patients with simple weaning group and excluded the weaning difficulties patients, who would require longer duration to be successfully weaned from the mechanical ventilation. The duration of the mechanical ventilation can be influenced by the severity of the underlying disease. In our study the APACHE II score of the patients in terms of medians and IQRs between T-tube and PSV group were 22(17.5 – 24) and 21(16.5 – 24) respectively which is lesser than a study done by Matic I et al.[20]This might have influenced the result of our study. In our study the rate (n, %) of ICU mortality was not statistically different among the patients who passed the SBTs using T-tube and PSV which was 2 (9.52%) and 1 (4.76%) respectively. In a study done by Brochard et al.[15] ICU mortality was 4/31 (13%) for PSV and 8/35 (23%) for T-tube which was higher than our study. This might be because we have included the simple weaning patients with a favorable pretrial clinical course and also the sample size of our study was small. Penuelas et al.[25] reported the mortality of 7% for patients with simple weaning group which was in accordance with our study.

In 2016 CHEST/ATS[30] recommended that for acutely hospitalized patients ventilated more than 24 hours, the initial SBT be conducted with inspiratory pressure augmentation (5-8 cm H_2O) rather than T-piece or CPAP for reducing the duration of mechanical ventilation and increasing the rate of successful extubation. However, in our study there was no

difference between T-tube and PSV as SBTs in terms of reducing the duration of mechanical ventilation and increasing the rate of successful extubation.

The evaluation of patient readiness for liberation from mechanical ventilation starts with the resolution of respiratory failure and/or the disease entity that prompted the initiation of mechanical ventilation as well as the presence of a basic level of physiological readiness. Prediction based on clinical judgement alone is frequently inaccurate. Thus there is a sound rationale that predicting readiness of patients to be successfully liberated from mechanical ventilation needs to be based on objective weaning predictors that can be applied in clinical practice.

A expert panel[31] sponsored by the American College of Chest Physicians, Society of Critical Care Medicine, and the American Association for Respiratory Care developed evidence-based weaning guidelines and noted that only eight variables had some predictive capacity: minute ventilation (V_E), negative inspiratory force, maximum inspiratory pressure, tidal volume (V_T), breathing frequency (f), the ratio of breathing frequency to tidal volume (f/V_T), $P_{0.1}/P_{Imax}$ (ratio of airway occlusion pressure 0.1 s after the onset of inspiratory effort to maximal inspiratory pressure), and CROP (integrative index of compliance, rate, oxygenation, and pressure). The rapid shallow breathing index (f/V_T ratio) appears to be the most accurate in predicting weaning outcome, and it is easy to measure.[31]

In a study by Matic I et al.[20] f/V_T (L/inspiration/min)between T-tube and PSV in median and IQRs was 63.4 (52.2-70.2) and 60.40 (49.1-73.5) respectively with p value of 0.680, which was comparable between two groups, and was similar to our study.

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. 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.[14,15] 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.[32-35] On the other hand, it has been reported in critically ill patients that the work of breathing significantly increases in the post-extubation period as compared with that while breathing spontaneously through an endotracheal tube.[19,36]

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 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.[19,32,36] 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.[36-39] 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. In our study we kept pressure support of 8 cm H_2O to overcome the resistance of ventilator circuit and imbalance between workload and inspiratory muscle strength in our patients.

The limitation of ths study was single centere study with small sample size. Larger studies need to be conducted for definitive conclusion. We evaluated the patients requiring mechanical ventilation for any duration of time. We excluded the weaning difficult patient from the study.

CONCLUSION

Based on the findings of our study, we can conclude that either T-tube or pressure support ventilation with 8 cm H_2O can be used as spontaneous breathing trial to wean patients from mechanical ventilation. We found no differences in the outcomes, measured in terms of rate of successful extubation, rate of reintubation, time of weaning from mechanical ventilation, total duration of mechanical ventilation, length of ICU stay and ICU mortality, between T-tube and PSV SBTs in simple weaning patient group. For simple

weaning patient group on mechanical ventilation for any duration, we suggest using either T-tube or pressure support ventilation with 8 cm H_2O as 2-hour trial of spontaneous breathing to wean from mechanical ventilation. However, further large randomized, trials are required to evaluate the best method for SBTs for patients who are in difficult and prolonged weaning group.

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