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Original Article

The Comparison of Automatic Tube Compensation (ATC) and T-piece During Weaning

Çiğdem Selek, Perihan Ergin Özcan, Günseli Orhun, Evren Şentürk, İbrahim Özkan Akıncı, Nahit Çakar
Department of Anaesthesiology and Reanimation, İstanbul University İstanbul Faculty of Medicine, İstanbul, Turkey

Abstract

Objective: Automatic Tube Compensation (ATC) is a newly developed mechanical ventilatory support method. The aim of this study was to compare the ATC and the T-piece as a weaning method.

Methods: Patients who were treated in ICU with mechanical ventilation for longer than 24 hours were included in this prospective clinical study. Fifty patients were divided into two groups for weaning, ATC or T-piece group. Patients tolerating 30 minutes spontaneous breathing trial underwent immediate extubation. The following parameters were recorded just before the spontaneous breathing trial and every 5 minutes during the 30 minute period; PEEP, Pplt, Pmean, FiO_2, heart rate, systolic blood pressure, diastolic blood pressure, respiratory rate, SaO_2, $ETCO_2$. The primary outcome of the study was successful extubation defined as the ability to maintain spontaneous breathing for 48 hours after extubation.

Results: The mean duration of weaning were 4.96 days and 7.42 days in the ATC and T-piece groups, respectively (p value 0.022). There were no significant differences between the groups with respect to the hemodynamic parameters, mechanical ventilation and gas exchange parameters.

Conclusion: In terms of success for weaning, there was no superiority between the ATC and the T-Piece methods for spontaneous breathing and it was concluded that each of the methods can be used for weaning. The ATC group were compared in terms of successful weaning period but have shown no significant periods of time were found to be lower.

Key Words: Mechanical ventilation, endotracheal tube resistance, spontaneous breathing trials, the T-piece, ATC

Introduction

Mechanical ventilation is a life-saving organ-support system when performed for correct indications. Separation from mechanical ventilation, as well as starting and performing mechanical ventilation, is a process that requires scientific background and experience. "*Weaning*" process succeeds the improvement of the event that causes respiratory failure and is defined as the gradual reduction of mechanical support and completely leaving respiration work to spontaneous breathing of patient. It has been reported that "*weaning*" process accounts for about 40% of mechanical ventilation procedure (1). Although "*weaning*" is completed easily and in a short time in great majority of the patients, prolonged and difficult separation from the ventilator is in question in approximately 10% (2). Studies determined that "*weaning*" techniques shorten the duration of artificial breathing but there is no specific technique superior to other. T-piece is the most frequently used method in spontaneous breathing trials. However, the duration of T-piece trials to make decision for extubation, is debatable. Although 120-minute trials has been recommended in the previous years, it is being told in the recent years that 30 minutes of problem-free T-piece trial is adequate for extubation.

Various degrees of resistance occur based on internal diameter of endotracheal tube and nonlinear flow rate of gas passing through the tube (3, 4). Moreover, in time, deformation of the tube and accumulated mucous secretions as well cause an increase in tube resistance. A study conducted by Wright et al. determined a 45% increase in endotracheal tube resistance in the same gas flow in patients that remained intubated by intubation tube of size 8 for at least 3 days (5). It has been demonstrated that failure in overcoming respiratory workload, which is produced by intubation tube, is the reason for unsuccessful "*weaning*" in some patients (6). Automatic tube compensation (ATC) has been developed to overcome respiratory work produced by this resistance (7, 8). In the ventilators equipped with ATC, auxiliary pressure that is necessary to overcome endotracheal tube resistance is regularly and continuously added to flow-dependent pressure that occurs during respiratory cycle.

Address for Correspondence: Dr. Perihan Ergin, Department of Anaesthesiology and Reanimation, İstanbul University İstanbul Faculty of Medicine, İstanbul, Turkey Phone: +90 212 531 31 26 E-mail: pergin@istanbul.edu.tr

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Thus, the pressure passing through the endotracheal tube is increased during inspiration and decreased during expiration, and additional workload for breathing is met by ATC, i.e., it automatically regulates instant pressure that passes through the tube (8). Hence, comfortable breathing is provided by better patient-ventilator harmony with natural type breathing without another additional ventilatory support in intubated patient (9).

Based upon the benefits of ATC, the present study compared classical T-piece and ATC trials in terms of duration and success of "*weaning*" in patients scheduled "*weaning*" in the intensive care unit.

Methods

The present study included 50 patients hospitalized in the Intensive Care Unit of Istanbul Medical Faculty after obtaining ethics committee approval (document No. 2009/1480 and dated 13.05.2009) from the Ethics Committee of Istanbul University Istanbul Medical Faculty. Conscious, cooperating, haemodynamically stable patients, aged between 18 and 80 years, who were mechanically ventilated for longer than 24 hours, and were considered to be ready to be separated from mechanical ventilation by the clinician were included in the study, after obtaining consents from their relatives. Patients with controlled disease (that caused acute respiratory failure) and those with fractional inspired oxygen (FiO_2) ≤%50 and positive end expiratory pressure (PEEP) ≤5 cm H_2O after discontinuation of vasoactive and sedative agents were randomly assigned to two groups. Patients aged less than 18 years and over 80 years, those with tracheostomy, heart failure and chronic obstructive pulmonary disease (COPD) were excluded. Underlying diseases, duration of mechanical ventilation, APACHE II score, diameter of intubation tube, mode of mechanical ventilation, plateau pressure (P_{plt}), mean airway pressure (P_{mean}), heart rate, blood pressure, respiratory frequency, and SpO_2 values of the patients that have been considered available for "*weaning*" process were measured and recorded before starting the procedure. Patients that have been considered available for separation from the ventilator were monitored either using T-piece under spontaneous breathing or in the ATC group with continuous positive airway pressure (CPAP) without changing FiO_2 levels. Within 30-minute monitoring period, data were recorded at 5, 10, 15, 20, 25 and 30 minutes. Patients that remained problem-free within 30-minute period in terms of monitored parameters by means of selected and implemented method were extubated. In patients that failed to tolerate spontaneous breathing (developed severe agitation, respiratory frequency >35/minute, blood pressure 20% higher than baseline values, heart rate 20% higher than baseline values and SaO_2 <90%) the ventilation mode was switched to that used before the trial. Patients were monitored for 48 hours after extubation and evaluated in terms of heart beat rate, blood pressure, respiratory frequency, SpO_2 values, and presence of agitation, anxiety and perspiration. Patients that did not display symptoms of respiratory distress within this period were considered as successful "*weaning*". Patients that displayed symptoms of respiratory distress were reintubated, mechanical ventilation was restarted and those patients were included in the reintubated patient group.

Statistical analysis

Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL, USA) for Windows version 16 was used for statistical analysis. Quantitative data were presented as mean±standard deviation. The student's t test was used for the comparison of groups for data with normal distribution, whereas categorical variables were compared using the chi-square test. $P<0.05$ was considered significant.

Results

Of the patients included in the study, 2 patients from the ATC group (at 20 and 25 minutes) and one patient from the T-piece group (at 15 minutes) were excluded from the study in 30-minute monitoring period because of worsened clinical status and signs of poor tolerance observed; ventilation with the initial ventilation mode was started in these patients. No statistically significant difference was found between the groups in terms of age, gender, APACHE II score and underlying diseases (Table 1).

Comparison between the groups in terms of duration of "w*eaning*" is presented in Table 2. No statistically significant difference was found between the patient groups that were considered ready to be separated from mechanical ventilation and extubated, in terms of initial P_{plt} and P_{mean} values at the current mechanical ventilation mode. No statistically significant difference was determined between the groups in terms of changes in haemodynamic parameters monitored over the course of study (Table 3).

No statistically significant difference was found between the groups, when the patients that were separated from mechanical ventilation and extubated in each group, were compared in terms of reintubation rates (Table 4).

Two of 7 reintubated patients in the automatic tube compensation group and one of 9 reintubated patients in the T-piece group died within the monitoring and treatment periods due to additional problems independent of the "*weaning*" method.

Discussion

In the present study, which compared ACT and T-piece trials in terms of separation from mechanical ventilation and success of extubation, weaning time was found to be shorter in ACT group despite the absence of any difference between ACT and T-piece trials in terms of success of extubation and reintubation rates. Clinicians accept that "weaning" time accounts for a substantial proportion of mechanical venti-

lation period and different modes of artificial breathing are being used as "weaning" method. The studies performed have concluded that daily spontaneous breathing trial is the best technique (10, 11). New methods of "*weaning*" are under investigation, and ACT, mode that is included in some of the new-developed mechanical ventilators, is one of these methods (6, 7). In intubated patients, various degrees of resistance occur depending on the internal diameter of endotracheal tube and the nonlinear flow rate of gas that passes through the tube (12, 13). In addition, in time, tube resistance increases with deformation and mucous secretions accumulated in the endotracheal tube. Wright et al. (14) determined 45% increase in endotracheal tube resistance with the same gas flow in patients that remained intubated an endotracheal tube of size 8 for at least 3 days. The aim of developing ACT method is to compensate the increase in resistance. Cohen et al. (15) compared the patients that underwent CPAP+ATC with the patients that underwent CPAP alone, and obtained better outcomes in CPAP+ATC group, even though there was no significant difference in terms of tolerating spontaneous breathing and extubation. In another study conducted by the same group (16), patients using PSV and ACT as "*weaning*" method were compared in terms of successful "*weaning*" and reintubation. Patients with successful and unsuccessful "*weaning*" were compared in terms of age, baseline SAPS II scores, number of mechanical ventilation days before extubation, respiratory frequency and baseline respiratory pressure, and no statistically significant difference was found. In the present study as well, no statistically significant difference was observed between the groups in terms of age, APACHE II scores and baseline P_{plt} and P_{mean} values. Baseline PEEP values were found to be higher in the ATC group in comparison to the T-piece group; however, the statistical significance determined was of no clinical importance, since 5-6 cm H_2O PEEP is used for the patients that are ready for ''*weaning*" in our clinic. In the present study, no significant difference was observed between the two patient groups in terms of heart rate, systolic blood pressure, diastolic blood pressure, FiO_2 values, saturation values and respiratory frequency measurements both at baseline and over the course of the study period. This finding suggests that both methods can be conveniently used in terms of both separation from mechanical ventilation and extubation. Likewise, Haberthur et al. (17) conducted a study with 90 patients, and compared spontaneous breathing via ACT, PSV and T-piece, and found no difference between the patients with successful extubation and reintubated patients, in terms of apical heartbeat, systolic blood pressure, diastolic blood pressure, saturation values and respiratory frequency. In the present study, no statistically significant difference was observed between two "weaning" methods in terms of reintubation rates (ACT group: 28%, T-piece group 36%). The reintubation rates are lower in the literature (15). However, we can say that this result could not be evaluated objectively because of limited patient number of the present study. Cohen et al. (15), in their study on 99 patients, compared the "*weaning*" methods of CPAP and CPAP+ATC. They found that reintubation rate was 24% with CPAP and 14% with CPAP+ATC with higher rates of successful extubation determined in the CPAP+ATC group. The lower rates of reintubation in the ATC group had been explained by the fact that compensation of the resistance in the intubation tube

Table 1. Baseline values of patients in the groups before weaning

Characteristic	ATC (n=25)	T-piece (n=25)	p value
Age (years)	51.68	55.72	0.38
Gender (M:F)	14:11	16:9	0.88
APACHE II score	14.56	15.24	0.63
Reasons for respiratory failure			
Pneumonia, n (%)	5 (20%)	9 (36%)	
Sepsis, (%)	6 (24%)	4 (16%)	
Trauma, (%)	2 (8%)	2 (8%)	
Neurological, (%)	1 (4%)	3 (12%)	
Postoperative, (%)	5 (20%)	3 (12%)	
Other, (%)	6 (24%)	4 (16%)	
Diameter of Endotracheal tube, mm	8.1	8.2	0.77

APACHE II: Acute Physiology and Chronic Health Evaluation Score II; ATC: Automatic Tube Compensation

Table 2. Evaluation of groups in terms of duration of "weaning"

	Group	Mean	p value
Duration of "Weaning" (days)	ATC	4.96	0.022
	T-Piece	7.42	

ATC: Automatic Tube Compensation

Table 3. Baseline respiratory and hemodynamic characteristics of patients before spontaneous breathing trial

	ATC	T - Piece	p value
Apical heartbeat (minutes)	93±18;93	91±14;92	0.70
Systolic BP (mmHg)	140±22;13	135±20;13	0.39
Diastolic BP (mmHg)	71±11;73	69±11;68	0.52
Respiratory rate (minutes)	19±4;19	18±4;18	0.63
$EtCO_2$	36±8;34	36±4;36	0.98
SaO_2 (%)	99±1;99	99±2;10	1.0
Plateau pressure (cmH_2O)	18.24±15.93	18.12±4.04	0.93
Mean airway pressure (cmH_2O)	10.28±2.90	9.84±2.26	0.55
PEEP (cmH_2O)	6.04±0.84	5.44±0.82	0.01

BP: Blood pressure, $EtCO_2$: End-tidal carbon dioxide pressure, SaO_2: Peripheral oxygen saturation, FiO_2: Fraction of inspired oxygen, ATC: Automatic Tube Compensation, PEEP: Positive end-expiratory pressure

Table 4. Evaluation of groups in terms of reintubation

	Reintubation			
	No	Yes	Total	p value
ATC	18	7	25	0.544
T-piece	16	9	25	
Total	34	16	50	

ATC: Automatic tube compensation

via ATC and decreasing the workforce used for respiration is important for successful extubation. As the consequence, they stated that ACT can be used in critical patients as a new "*weaning*" method with a higher success rate. Because of the alternative treatment implementations that would be formed to reduce potential mortality risk, attention must be paid to determine patients that might need reintubation. In the present study, out of 50 patients, no significant difference was found between 16 patients that underwent reintubation and 34 patients with successful "weaning" in terms of reasons for reintubation. There was also no difference between reintubated patients in each group in terms of duration and reasons for reintubation. Cohen et al. (16), who obtained similar results with us, conducted a study in 187 patients, and performed ATC in 87 and PSV in 93 patients. They found no significant difference between these two groups in terms of reasons for reintubation and duration of reintubation. As the consequence, they stated that ATC is a new method that is effective as PSV in providing successful "*weaning*". Another point that comes to mind is whether poor outcomes in reintubated patients depend on baseline clinical event that leads to need for mechanical ventilation, and whether the method of "*weaning*" performed in these patients contributes to mortality by influencing need for reintubation. There is yet no study that demonstrates that any of the assisted breathing methods used for "*weaning*" is correlated with reintubation and mortality. In various studies that compared "*weaning*" methods, the incidence of reintubation was generally found to be 3-19%, whereas the incidence was 31.8% in another study conducted in 217 patients (7, 15, 18-21).

Study limitations

Limited number of patients might hinder obtaining definite results from this study; studies that would be conducted with larger patient groups are needed. The present study determined a high reintubation rate; whether this high rate is because of the method of "*weaning*" or the baseline weaning criteria should be studied in a larger patient group.

Conclusion

In conclusion, "*weaning*" process accounts for a substantial proportion of mechanical ventilation duration. Each "*weaning*" does not result in extubation. Again, each extubated patient has the probability of reintubation and reconnection to mechanical ventilation. How a reduction in reintubation rate can be achieved and what is the most appropriate time for starting "*weaning*" remains as the questions to be answered. The main factor that determines these steps is the stage of disease that leads to mechanical ventilation requirement and/or whether there is a new concomitant disease. Complications directly associated with "*weaning*" process are rare. However, attention should be paid to complications likely to occur during "*weaning*" period, because they not only cause an increase in mortality rate, but also may cause serious cardiac or respiratory problems, and patients must be closely monitored by the intensive care team within this period. Numerous new studies that would be conducted in high number of patients are needed to specify standard methods that provide low reintubation rates.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of İstanbul University Faculty of Medicine (13.05.2009, Protocol No: 2009/1480).

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