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# التوثيق الالكتروني والميكروفيلم

شبكة المعلومات الجامعية

# جامعة عين شمس

## التوثيق الإلكتروني والميكروفيلم

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## نقسم باللّه العظيم أن المادة التي تم توثيقها وتسجيلها علي هذه الأقراص المدمجة قد أعدت دون أية تغيرات

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# Comparative Study between Automatic Tube Compensation (ATC) and pressure support ventilation (psv) as a mode of weaning from mechanical ventilation in patients with respiratory failure

## Thesis

**Submitted for Partial Fulfillment of**

*Master Degree in General Intensive care*

**Presented by**


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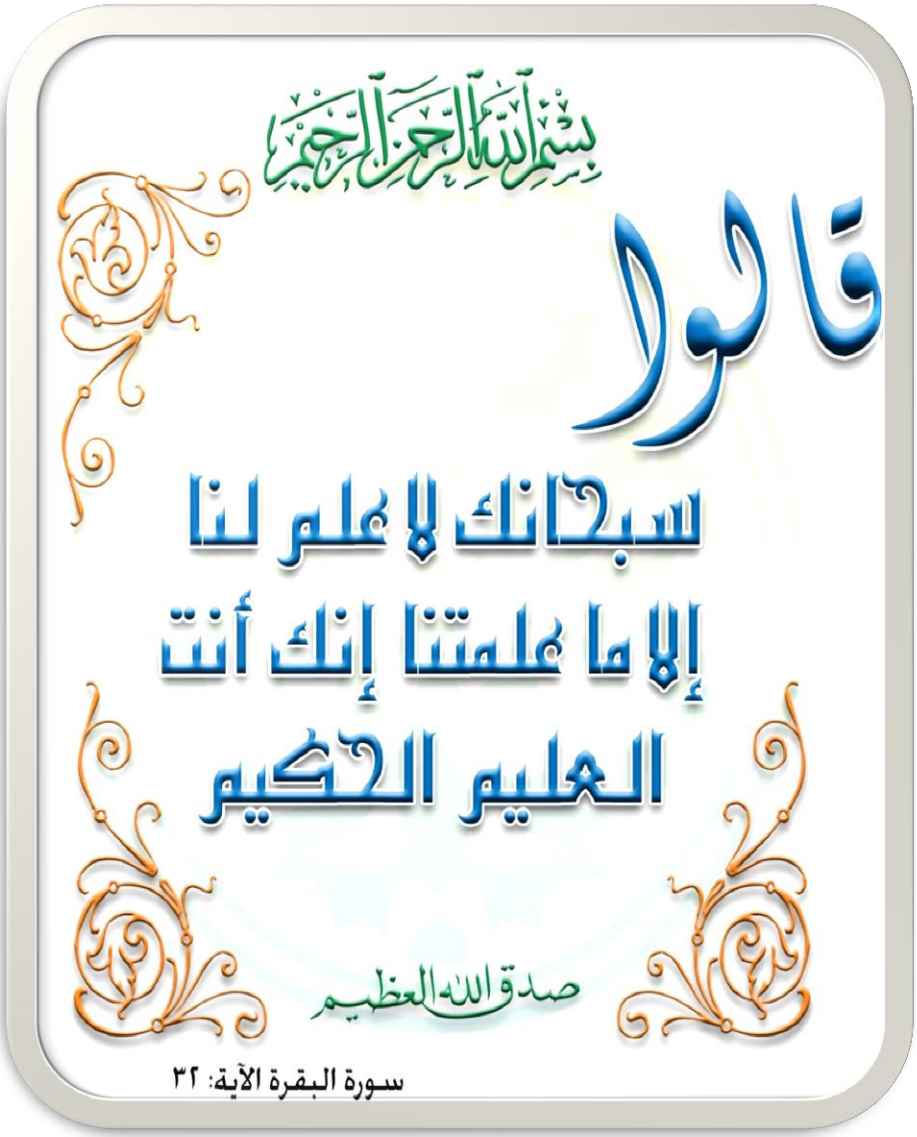
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# Comparative Study between Automatic Tube Compensation (ATC) and Pressure Support Ventilation (PSV) as a Mode of Weaning from Mechanical Ventilation in Patients with Respiratory Failure

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## Abstract

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**Background:** Weaning covers the entire process of liberating the patient from mechanical support and from the endotracheal tube (ETT). Weaning from mechanical ventilation (MV) is a challenge. Its prolongation is related to increased mortality. **Aim of the Work:** is to assess the value of ATC in predicting successful weaning and hastening the weaning process. This study will compare the benefits and effects of ATC versus PSV as weaning modes on spontaneous breathing trials and work of breathing. **Patients and Mehtods:** This prospective non randomized was done on 50 adult patients admitted to the Critical Care Medicine Department in Ain shams University Hospital presenting with ARF and mechanically ventilated for at least 24 hours. They were divided into two groups: **Group I:** "ATC group" Each underwent a 1-hour spontaneous breathing trial, using ATC mode and **Group II:** "PSV group" PSV mode was used. **Results:** In the present study we have found that the use of ATC during a spontaneous breathing trial was as effective as PSV in predicting the ability of patients to maintain spontaneous, unassisted breathing for more than 48 hours after removal of the endotracheal tube. In our study, there was no significant difference in the number of patients who tolerated the spontaneous breathing trial and then extubated between ATC and PSV groups (60 % vs. 56% respectively, p >0.05). Both modes had comparable sensitivity, and +ve predictive value. Sensitivity was 80.0% versus 75.0% and the positive predictive value was 88.0%, versus 87.0% for ATC versus PSV respectively. The specificity was comparable (76.8% versus 80.0 % in ATC versus PSV respectively). ATC group had higher negative predictive than PSV group (82.0% versus 70.1%, respectively). In our study, criteria for successful extubation were met in 56.0%. In ATC group 60.0% met the criteria for successful extubation vs. 60% in PSV group. In the present study it was found that male patients were the most predominant in both groups (72.0% in ATC group and 68% in PSV group). This is expected as cigarette smoking is prevalent among males and is the single most important and most prevalent risk factor for the development of COPD. In our study, about one third of patients had COPD exacerbation as a cause for ARF. **Conclusion:** In ICU population, ATC was safe, reliable, and can be reasonably used for weaning trials. ATC confers a potential benefit in weaning duration, weaning category, number of Ss, failure of first SBT extubation outcome, ICU length of stay, complication, and mortality rate. In addition, ATC improves the predictive value of RR/TV and IWI in predicting weaning success.

**Key words:** Automatic tube compensation, pressure support ventilation, weaning, mechanical ventilation, respiratory failure

# Introduction

Weaning from mechanical ventilation allows patients to resume spontaneous breathing gradually. Predictive criteria of weaning may help to evaluate the suitability of disconnecting a patient from a ventilator. However, some of the classic criteria – vital capacity, maximum inspiratory pressure, minute ventilation, and clinical and laboratory indicators – are frequently inaccurate. The major factor in successful weaning is the resolution of precipitating illness and a stable low requirement for oxygen. So far, the criteria of respiratory mechanics that could reliably predict successful weaning have not been strictly defined [(1)].

The working principle of ATC is based on continuous calculations of tracheal pressure, whereby calculation is based on continuously measured flow and airway pressure (at the proximal end of the ETT) and tube-specific coefficients. ATC compensates for the pressure drop across the endotracheal or tracheostomy tube by delivering exactly the amount of pressure necessary to overcome the resistive load imposed by the tube. However, partial tube obstruction as a result of secretions and kinking might result in

undercompensated ETT resistance with the ATC mode [2].

ATC has been shown to decrease the work of breathing (WOB) necessary to overcome ETT resistance more effectively than pressure support ventilation (PSV) or continuous positive airway pressure (CPAP). So, it can simulate spontaneous breathing without ETT, so it has been designated as '**electronic extubation**'. Therefore, ATC is ideally suitable for use during the weaning period. It is possible; however, that ATC could allow more marginal patients to tolerate a breathing trial, who then would develop ventilatory failure after extubation. This mode therefore theoretically can decrease the weaning duration and increase the probability of successful extubation by decreasing the WOB [3].

Pressure support ventilation (PSV) is a mode of positive pressure mechanical ventilation in which the patient triggers every breath. PSV is deliverable with invasive (through an endotracheal tube) or non-invasive (via full face or nasal mask) mechanical ventilation. This ventilatory mode is the most comfortable for patients and is a useful ventilator setting for weaning from invasive ventilation and for providing supportive care with non-invasive ventilation. Flow (L/min) delivery is by setting a driving pressure (cmH2O). The flow delivered will be dependent on the set driving pressure, airway resistance, lung compliance, and inspiratory effort of the patient [1].

## Aim of the work

The aim of the study is to compare the benefits and effects of ATC versus PSV as weaning modes on spontaneous breathing trials and work of breathing.

## Patients and Methods

The study was a prospective non randomized done on 50 adult patients admitted to the Critical Care Medicine Department in Ain shams University Hospital presenting with ARF and mechanically ventilated for at least 24 hours. Informed consent was taken from every patient included in the study or from his or her relatives. All patients were screened daily to assess their feasibility of weaning from mechanical ventilation.

The study included patients with ages above 18 years, patients showed significant improvement or resolution of the underlying reason for mechanical ventilation, fully awake, having no or minimal need for vasoactive drugs, no or only minimal sedation, patient showing adequate gas exchange, as indicated by a ratio of the partial pressure of arterial oxygen ($PaO_2$) to the fraction of inspired oxygen ($FIO_2$) above 200 at a positive end-expiratory pressure (PEEP) of 5 $cmH_2O$ while breathing an $FiO_2$ <0.5 and patient with RVR (respiratory rate to tidal volume ratio) <105 breaths/min/L. The RVR was calculated after 1 min of spontaneous breathing with PEEP of 5 $cmH_2O$ and no mandatory machine breaths supplied from the ventilator. While patients <18 years, with tracheostomy or pregnant women were excluded from the study.

Full history including age, sex, cause and period of mechanical ventilation, length of hospital stay, complete general and systemic examination and relevant investigations were obtained for all patients. Severity of critical illness was assessed by calculation of SAPS and APACHE II scores on day one of hospital admission.

## Statistical Analysis

Statistical presentation and analysis of the present study was conducted, using the mean, standard deviation and chi-square test by SPSS V.16. P value < 0.05 was considered significant.

# Results

## Severity of critical illness scores on admission:

Using SAPS and APACHE II scores, both groups were comparable to each other regarding the severity of critical illness upon admission, with P value > 0.05; **Table (1).**

**Table (1):** SAPS and APACHE II scores on admission

| Variables | ATC Group "n=25" | PSV Group "n=25" | Test P value |
|---|---|---|---|
| **SAPS** | | | |
| Range | 24-65 | 27-65 | 0.438 |
| Mean | 43.16 | 43.72 | |
| S.D. | 13.40 | 11.80 | |
| **APACHE ll Score** | | | |
| Range | 10-29 | 10-28 | 0.129 |
| Mean | 20.64 | 18.76 | |
| S.D. | 5.98 | 5.64 | |

## ABG parameters at the beginning and at the end of the trial:

Both groups were compared to each other regarding their ABG parameters and there were no statistically significant differences.On comparing the parameters within each group at the beginning and at the end of the trial there were no statistically significant differences.**Table (2)**

**Table (2):** ABG parameters at the beginning and at the end of the trial

| | ATC Group "n=25" mean±S.D. | PSV Group "n=25" mean±S.D. | P1 value |
|---|---|---|---|
| **1-pH** (begning) | 7.40±0.02 | 7.39±0.02 | 0.375 |
| pH (end) | 7.41±0.03 | 7.38±0.04 | 0.287 |
| P2 value | 0.985 | 0.88 | |
| **2-$PCO_2$ (mmHg)** (begning) | 39.80±3.28 | 39.456±3.81 | 0.367 |
| $PCO_2$ (end) | 39.28±3.11 | 39.11±3.26 | 0.408 |
| P2 value | 0.136 | 0.411 | |
| **3-$PaO_2$ (mmHg)** (begning) | 106.07±16.76 | 100.66±11.31 | 0.069 |
| $PaO_2$ (end) | 101.1±15.9 | 100.96±12.42 | 0.106 |
| P2 value | 0.109 | 0.822 | |
| **4-$HCO_3$ (mEq/L)** (begning) | 23.85±1.75 | 25.456±2.52 | 0.06 |
| $HCO_3$ (end) | 24.01±1.86 | 25.062±2.077 | 0.106 |
| P2 value | 0.310 | 0.685 | |
| **5-$SaO_2$** (begning) **%** | 96.25±1.11 | 95.672±1.06 | 0.33 |
| $SaO_2$ (end) | 96.01±1.72 | 95.71±1.34 | 0.298 |
| P2 value | 0.811 | 0.78 | |

*-ABG= arterial blood gases, $PaCO_2$= arterial carbon dioxide tension, $PaO_2$= arterial oxygen tension, $HCO_3$= bicarbonate, $SaO_2$= arterial oxygen saturation.*

*-Data was presented as mean±S.D. -Statistical significance was defined as P ≤ 0.05 -P1 comparison between ATC and PSV group at the same time assessed by student's t test.-P2 comparison between beginning and end of trail assessed by paired t test.*

## Respiratory parameters at the beginning and at the end of the trial:

At the end of the trial $SPO_2$, $PaO_2$, $PaO_2/FIO_2$ ratio, R/TV ratio (rapid shallow breathing index) and dynamic compliance were significantly higher in ATC group.On the other hand, airway resistance and auto PEEP were significantly lower in ATC than in PSV group. However, there were no statistically significant differences between both groups regarding $PaCo_2$.

On comparing respiratory parameters with in each group at beginning and at the end of the trial it was found that:

-$SPO_2$, $PaO_2/FIO_2$ and Auto PEEP ($cmh_2o$) in both groups have statistically significant changes.
-In ATC group: airway resistance was significantly lower and the dynamic compliance was significantly higher at end of the trial.
-In PSV group: Rapid shallow breathing index(R /TV) was significantly higher at the end of the trial. **Table (3)**

**Table (3):** Respiratory parameters at the beginning and at the end of the trial

| | **ATC Group "n=25" mean±S.D.** | **PSV Group "n=25" mean±S.D.** | **P1 value** |
|---|---|---|---|
| **Tube size (mm)** | 7.78±0.13 | 7.698±0.16 | 0.129 |
| **Duration of mechanical ventilation (days)** | 4.23±0.97 | 4.546±0.84 | 0.113 |
| **1-R/TV ratio** (begning) **(breath/min/L)** | 53.03±8.18 | 52.5±6.89 | 0.412 |
| R/TV ratio (end) | 61.00±16.53 | 70.88±15.70 | 0.018* |
| P2 value | 0.102 | 0.013* | |
| **2-$FIO_2$** (begning) **(%)** | 37.15±2.71 | 37.052±2.23 | 0.444 |
| $FIO_2$ (end) | 38.84±5.46 | 40.872±8.46 | 0.159 |
| P2 value | 0.114 | 0.098 | |
| **3-$SPO_2$** (begning) **(%)** | 96.38±0.99 | 95.904±0.99 | 0.074 |
| $SPO_2$ (end) | 90.12±5.26 | 80.88±15.70 | 0.010* |
| P2 value | 0.036* | 0.013* | |
| **4-$PaO_2/FIO_2$** (begning) | 287.80±49.53 | 271.204±42.77 | 0.098 |
| $PaO_2/FIO_2$(end) | 316.32±96.09 | 211.4±77.06 | 0.0001* |
| P2 value | 0.013* | 0.015* | |
| **5-Dynamic compliance ($ml/cmh_2o$)** (begning) | 21.89±4.03 | 21.328±10.10 | 0.399 |
| Dynamic compliance (end) | 28.52±11.83 | 23.688±5.36 | 0.0001* |
| P2 value | 0.033* | 0.105 | |
| **6-Airway resistance ($cmh_2o/L/sec$)** (begning) | 5.25±1.03 | 5.65±1.01 | 0.089 |
| Airway resistance (end) | 3.37±1.53 | 6.12±2.42 | 0.0001* |
| P2 value | 0.013* | 0.115 | |
| **7-Auto PEEP ($cmh_2o$)** (begning) | 3.63±1.66 | 3.89±1.86 | 0.094 |
| Auto PEEP ($cmh_2o$) (end) | 2.29±0.21 | 4.9±2.61 | 0.0001* |
| P2 value | 0.021* | 0.016* | |

*-R /TV ratio (rapid shallow breathing index) =Respiratory rate to Tidal volume ratio, FIO2 = Fractional concentration of inspired oxygen, SPO2 = O2 saturation, PaO2 = arterial oxygen tension, PEEP=Positive end expiratory pressure. R/TV ratio =rapid shallow breathing index*
*-Data was presented as mean±S.D.*
*-Statistical significance was defined as P ≤ 0.05*
*-P1 comparison between ATC and PSV group at the same time assessed by student's t test.*
*-P2 comparison between beginning and end of trail assessed by paired t test.*

## Extubation Outcome:

Both groups were comparable to each other regarding their outcome.

In **ATC** group, 15 patients out of 25 (60%) were able to tolerate the weaning trial.

In **PSV** group 14 patients out of 25 (56%) were able to tolerate the trial. There was no statistically significant difference between both groups (p>0.05). **Table (4).**

**Table (4):** Extubation Outcome in both groups

| Outcome | ATC Group | | PSV Group | | $X^2$ | p. value |
|---|---|---|---|---|---|---|
| | N | % | N | % | | |
| **Succeeded** | 15 | 60 | 14 | 56 | **0.102** | **0.582** |
| **Failed** | 10 | 40 | 11 | 44 | | |

## Comparison between ATC and PSV as predictors of successful weaning:

Successful completion of SBT on ATC showed 80.0% sensitivity, 76.8% specificity, +ve predictive value of 88.0%, -ve predictive value of 82.0%, and AUC 0.672.

Successful completion of SBT on PSV showed 75.0% sensitivity, 80.0 % specificity, +ve predictive value of 87.0%, -ve predictive value of 70.1%, and AUC 0.771.**Table (5).**

**Table (5):** Comparison between ATC and PSV as predictors of successful weaning

| Group | Area under the curve | Cutoff | Sensitivity | Specificity | PPV | NPV |
|---|---|---|---|---|---|---|
| **ATC** | 0.672 | 0.75 | 80.0 | 76.8 | 88.0 | 82.0 |
| **PSV** | 0.771 | 0.53 | 75.0 | 80.0 | 87.0 | 70.1 |

# Discussion

In our study, we have found that There was no statistically significant difference in extubation outcome between ATC and PSV groups (60 % vs. 56% respectively, p >0.05).

Both modes had comparable sensitivity, and +ve predictive value. Sensitivity was 80% versus 75% and the positive predictive value was 88%, versus 87% for ATC versus PSV respectively. The specificity was comparable (76.8% versus 80.0 % in ATC versus PSV respectively). ATC group had higher negative predictive value than PSV group (82% versus 70.1%, respectively).

This is compatible with results obtained by elbatanouny et al., who randomized 60 patients in intensive care unit receiving mechanical ventilation into 2 groups (ATC, N=35 and PSV=25 ) in ATC group 20 of 35 patients (57.1%) had successful weaning, while in PSV group 15 out of 25 patients (60%) had also successful weaning. The difference had no statistical significance (p = 0.7). Sensitivity of 80.36% with a positive predictive value (PPV) of 90.14% and a specificity of 79.63% with a negative predictive value (NPV) of 81.25% were shown in ATC, while PSV showed a sensitivity of 76.35% with a PPV of 88.63% and a specificity of 80.36% with a NPV of 71.4 %.[(4)]

This is also in agreement with the results obtained by Cohen et al., who randomized 180 intensive care unit patients receiving mechanical ventilation into 2 groups (ATC, n = 87 and PSV, n = 93). They found that there was no statistically significant difference between both groups as regards the extubation outcome (ATC, 65 of 87 (74.7%) vs. PSV, 68 of 93 (73.1%) the difference was not significant (P = 0.81). [(5)]

This is became highly supported by a study carried out by Elbeledy et al., comparing ATC with PSV during a spontaneous breathing trial in pediatric ICU, of the 36 patients enrolled in the study, 17 were weaned from mechanical ventilation on ATC (ATC group) and 19 were weaned on PSV (PSV group). They found that there was no statistically significant difference between both groups as regards the extubation outcome; in the ATC

group 11 of 17 (65%) passed the SBT compared with 10 of 19 (53%) in the PSV group, (p value = 0.69).[6]

In our study, At the end of the trial $SPO_2$, $PaO_2$, $PaO_2/FIO_2$ ratio, R/TV ratio and dynamic compliance were significantly higher in ATC group.On the other hand; airway resistance and auto PEEP were significantly lower in ATC group.this indicate that tolerance of an SBT was higher in ATC versus PSV in spite of being statistically non significant as regard extubation outcome.

This is compatible with the results obtained by elbatanouny et al., who found that ATC was superior to PSV regarding $PaO_2/FIO_2$ ratio, oxygen saturation, oxygen tention, dynamic compliance and airway resistance.[4]

This is also in agreement with a study by Haberthur et al., where patients under go a 2-hr breathing trial with ATC and CPAP of 5 cm $H_2O$, PSV, or T-tube The main finding was that half the patients who failed a breathing trial with PSV or T-tube tolerated a subsequent trial with ATC and were successfully extubated. [5]

This became highly supported by results obtained by Cohen et al., who found that significantly more patients were successfully extubated after SBT using CPAP + ATC than those who underwent SBT using conventional CPAP alone. [5]

In spite of higher $SPO_2$, $PaO_2$, $PaO_2/FIO_2$ ratio, dynamic compliance, and lower airway resistance and auto PEEP (P value <0.05) for ATC versus PSV group at the end of the trial. We found that 42.9% of patients in the ATC group required reintubation, vs. 40% in the PSV group, a difference which could not be explained by any pretrial factors since the two groups were similar with respect to patient characteristics, duration of mechanical ventilation, and respiratory and hemodynamic parameters measured before the trial. An opposite outcome might have been expected, since the use of ATC could potentially allow more marginal patients to tolerate a breathing trial.

The possible cause for failure to find any superiority of ATC to PSV could be attributed to the use of a commercially available ventilator with built-in ATC, namely Puritan-Bennett 840, in almost all other studies, ATC was done by using ventilators equipped with prototype ATC software. The differences are related to simplifications and limitations of the ATC algorithms incorporated in the commercially available ventilators. In particular, no negative pressure source is incorporated in the commercially available ATC, and the only expiratory assistance results from a flow-dependent lowering of external PEEP to zero. [7]

The accuracy of ATC in commercially available mechanical ventilators, such as used in our study, has been formally assessed by Elsasser et al., They found that these ventilators may provide adequate inspiratory but probably not expiratory tube compensation. [8]

# Conclusion

According to the current study results, we can conclude that in a medical ICU population, ATC was safe, efficient and can be successfully used for weaning trials. It has a potential benefit in weaning duration, extubation outcome and ICU length of stay, complications and mortality rate. So, ATC may be a valuable mode for use during the process of weaning of mechanically ventilated patients.

Although ATC was superior to PSV regarding $PaO_2/FIO_2$ ratio, $SpO_2$, $PaO_2$, dynamic compliance and airway resistance at the end of the trial, extubation outcome has no statistically significant differences.

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