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Does Airway Pressure Release Ventilation Mode Make Difference in Cardiopulmonary Function of ICU Patients?

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ABSTRACT

Introduction: Mechanical ventilation is essential in intensive care unit (ICU) patients who are unable to maintain adequate gas exchange without support. Different ventilation modalities have been introduced to imitate normal respiratory pattern but there are some disadvantages in each modality. The aim of present study was to compare the cardiopulmonary and airway pressure changes in ICU patients undergoing pressure controlled ventilation (PCV), one of the basic modalities with airway pressure release ventilation (APRV), an advanced ventilation mode which allows spontaneous breathing in any time of respiratory cycle.

Materials and Methods: In this cross over study, 18 patients were randomized to receive either PCV or APRV ventilation for 30 minutes then after washout period, switched to another group. Cardiopulmonary and arterial blood gas variables and airway pressure were recorded prior to study and after 30 minutes of starting each modalities and compared between groups.

Results: Airway pressure were significantly higher in APRV mode (9.3±3.3 vs. 6.9±1.5, p=0.044 in PCV group and 9.1±3.4 vs. 6.6±1.4, p=0.021 in APRV group) and arterial blood gas in PCV mode was insignificantly higher than APRV mode in both protocols. There was no significant difference in other cardiopulmonary variables.

Conclusion: This study has shown no hemodynamic change's difference due to two studied protocol. The mean airway pressure in APRV mode was more than PCV mode with lower arterial blood O_2 pressure in both protocols.

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Introduction

Mechanical ventilation is utilized in patients who are unable to maintain adequate gas exchange without support to provide better clinical outcome while avoiding lung injury and other adverse effects. Different approaches and ventilation modalities have introduced to imitate

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normal respiratory pattern but there are some disadvantages in each modality (1).

Pressure controlled ventilation (PCV) is one of the basic modalities in intensive care unit (ICU) patients to achieve adequate oxygenation and normocapnia. In PCV mode, decelerating flow provide positive effect on the patient's hemodynamics and can reduce the risk of barotrauma (2). The greatest limitation of pressure control modes is the variations in tidal volume that occur in the case of changes in impedance. Since this mode is characterized by a fixed inspiratory time, any increase in frequency without adjusting inspiratory time can produce not only dyssynchrony but also auto-PEEP (Positive End Expiratory Pressure) and its adverse effects. The combination of excessive inspiratory efforts with high pressures can also generate a large tidal volume, and this may give rise to lung injury (3).

There are some studies to support better clinical outcome and improved oxygenation of APRV mode (6-8) but there is not APRV setting in older ventilators. The aim of present study was to compare cardiopulmonary and airway pressure changes in ICU patients undergoing PCV or APRV modes.

Materials and Methods

The protocol of this randomized crossover interventional study was approved by Zahedan University of Medical Sciences Ethics Committee and written informed consent form were obtained from all unconscious patients relatives. All mechanically ventilated ICU patients with 18-70 years old and Ramsay sedation score of II-IV and normal hemodynamic and oxygenation condition were eligible for the study. Exclusion criteria included chronic or acute lung or heart disease, consumption of vasopressor or cardiac depressant agents and raised intracranial pressure.

According to these inclusion and exclusion criteria, during October 2014- March 2015, 18 patients were eligible and enrolled to the study. Initial ventilator modality for all of them was Synchronized Intermittent Mandatory Ventilation (SIMV). Patients received continuous infusion of Midazolam and Fentanyl as required to achieve a Ramsay sedation score of II-IV. After obtaining baseline measurements patients randomly (odd number to first and even number to second group) assigned to receive pressure-limited, time-cycled, controlled mechanical ventilation (PCV group; PEEP =5 mmHg, frequency= 10 breath/min, tidal volume= 8 cc/kg) or APRV with spontaneous breathing (APRV group; FIO_2(Fraction of inspired oxygen): 40%, P high=20 and P low as required to tidal volume of 8 cc/kg, Time high= 5.5 and Time low= 0.5 second) for 30 minutes. Then arterial blood gas (ABG) variables were recorded again and patients were switched to another modality for 30 minutes (Puritan Bennett 840, Pleasanton, CA USA). Before switching, patients receive SIMV modality for one hour as washing period.

Systolic and diastolic blood pressure, heart rate, mean arterial blood pressure (MAP), cardiac index (CI), stroke volume (SV), cardiac output (CO)(NOVAMETRIX NICO2 Non-Invasive Cardiac Output (NICO) Monitor), airway pressure and arterial blood gas variables (Osmetech, USA)were recorded prior to the study and 30 minutes after each studied ventilator modality. The nurse who was responsible to record the variables was blind to group assignment.

All statistical analyses were performed with SPSS software21 (using Wilcoxon signed-rank test and repeated measure ANOVA) and Statistical significance was considered at $P \leq 0.05$.

This interventional study was ethically approved by the research ethical committee of the Zahedan University of Medical Sciences.

Results

Eighteen patients evaluated in each group. The mean age of patients in PCV and APRV group were 33.0 ± 19.3 and 31.7 ± 17.7 years. There were no statistically significant differences between the PCV and APRV group in baseline characteristic data (Table1).

Cardiopulmonary variables and pressure of airway in three ventilator mode, SIMV, PCV and APRV in two groups are shown in Tables 2 and 3. There were no significant differences in cardiopulmonary changes when patients switched from SIMV mode to PCV mode and from PCV to APRV mode in PCV group just like APRV group who switched from SIMV mode to PCV mode and from APRV to PCV mode (both after wash out period).

Table 1. Baseline characteristic data at inclusion into the study*

	PCV group	APRV group	P Value
Number of patients, n (%)	9 (100)	9 (100)	
Age, yr	33.0 ± 19.3	31.7 ± 17.7	0.834
BMI, kg/m²	23.4 ± 3.2	23.3 ± 3.3	0.719
Hemoglobin, g/dl	12.1 ± 1.8	12.0 ± 1.3	0.792

*values are mean ± SD

Table 2. Cardiopulmonary changes in different ventilator modalities in PCV group which received PCV mode then switched to APRV mode

variables	SIMV	PCV	DIFF P-S	p- value	APRV	DIFF A-P	p-value
SBP	127.3±17.3	122.6±14.7	-4.8±11.1	0.173	127±22.8	4.4±9.4	0.207
DBP	84.7±11.3	78.6±11.0	-6.1±7.7	.050	78.7±16.4	0.1±7.1	0.674
MAP	99.2±15.0	92.9±12.6	-6.3±9.3	.109	94.2±18.3	13±8.2	.483
HR	76.7±9.7	79.9±12.2	3.0±7.4	.362	80.2±11.2	0.3±8.5	.833
CI	3.9±1.1	4.2±0.9	0.3±0.8	0.400	4.8±1.6	0.6±0.9	0.092
SV	82.7±23.3	95.6±15.6	12.9±23.8	0.093	93.4±32.2	-2.1±27.9	0.767
CO	7.2±1.9	7.6±1.7	0.5±1.5	0.398	8.7±2.7	1.1±1.5	0.050
Pao2	106.7±15.8	116.8±21.2	10.1±19.8	0.343	113.6±23.9	-3.2±14.0	0.612
PaCo2	32.9±3.2	35.3±4.8	2.4±4.4	0.153	35.7±5.81	0.4±4.7	0.512
Upper PAW	16.7±2.3	14.7±2.2	-0.6±6.8	0.056	15.9±6.8	1.26±6.1	0.731
Mean PAW	7.4±1.4	6.9±1.5	1.9±3.3	.260	9.3±3.3	2.4±3.3	0.044*

SBP: systolic blood pressure; DBP: diastolic blood pressure; MAP: mean arterial blood pressure; HR: heart rate; CI: cardiac index; SV: stroke volume; CO: cardiac output; Pao2: arterial pressure of oxygen; PaCo2: arterial pressure of carbon dioxide; PAW: pressure of airway; *statistically significant

Table 3. Cardiopulmonary changes in different ventilator modalities in APRV group which received APRV mode then switched to PCV mode

variables	SIMV	APRV	DIFF A-S	P value	PCV	DIFF P-A	P value
SBP	129.4±16.6	135.4±22.2	6.0±19.5	0.440	131.0±27.7	-4.4±10.0	0.213
DBP	87.6±10.9	85.3±11.9	-2.2±8.6	0.172	81.7±14.9	-3.7±7.8	0.213
MAP	89.9±32.2	99.7±12.8	9.8±32.3	0.477	95.3±15.9	-4.3±7.5	0.150
HR	76.3±10.2	76.6±12.6	0.2±8.2	0.677	80.4±13.6	3.9±16.2	0.624
CI	3.9±1.0	4.4±1.3	0.5±1.5	0.109	4.3±1.0	-0.1±0.9	0.906
SV	83.8±13.5	104.5±34.1	20.7±38.7	0.066	96.4±18.3	-8.0±31.2	0.514
CO	7.2±1.8	8.1±2.3	0.9±2.4	0.139	7.8±1.8	-0.3±1.5	0.575
Pao2	108.9±14.8	107.3±22.9	-1.6±26.0	0.767	116.2±27.1	8.9±24.4	0.407
PaCo2	33.2±4.4	36.7±6.9	2.4±4.7	0.400	34.7±6.3	-0.9±3.2	0.439
Upper PAW	15.6±3.4	14.2±2.9	9.8±32.3	0.282	14.1±2.3	-0.1±3.2	0.723
Mean PAW	7.6±1.6	9.1±3.4	-1.4±4.1	0.066	6.6±1.4	-2.5±3.0	0.021*

SBP: systolic blood pressure; DBP: diastolic blood pressure; MAP: mean arterial blood pressure; HR: heart rate; CI: cardiac index; SV: stroke volume; CO: cardiac output; Pao2: arterial pressure of oxygen; PaCo2: arterial pressure of carbon dioxide; PAW: pressure of airway; *statistically significant

The mean of airway pressure in PCV group and APRV group significantly by switching the ventilation mode (P value: 0.044, 0.021 in PCV and APRV group respectively) (Tables 2, 3).

In APRV group, by switching the mode from APRV to PCV, the mean of airway pressure decreased significantly (p= 0.021) and arterial pressure of oxygen raised insignificantly more than changes in PCV group.

Parameter changes (measurement in secondary mode - first mode) by switching the ventilation mode were compared between groups. There was no significant difference in parameters changes (p>0.05).

Discussion

This study comparing PCV and APRV mode in ICU patients and has shown no hemodynamic change's difference due to two studied protocol. The mean airway pressure in APRV mode was more than PCV mode with lower arterial blood O_2 pressure in both protocols.

According to the result of our study using APRV or PCV as an initial ventilation mode for ICU patients did not differ in cardiopulmonary variables and oxygenation. Myers and colleges in their review compared APRV and some other conventional ventilation modalities. They mentioned some simple clinical trials which found APRV better oxygenation than other controlled modalities because of prolonged inflation period and improved distribution with spontaneous breathing (2) which is different of our result.

Putensen designed a clinical trial with 30 patients at risk of acute respiratory distress syndrome and randomly divided them to APRV or PCV group (followed by weaning with APRV) for 72 hours. In their study primary use of APRV was associated with increases in respiratory

system compliance, PaO_2, cardiac index and oxygen delivery. Primary use of APRV was associated with shorter duration of ventilation support and length of ICU stay. He concluded that APRV with spontaneous breathing improves cardiopulmonary function (3).

Based on our data, PaO_2 in PCV mode was better than APRV mode. Varpula compared APRV and pressure support mode (PS) combined with SIMV and showed significantly lower inspiratory pressure in APRV group within the first week of the study but there was no significant difference in ventilator-free days and mortality rate between groups. Cardiac output, mean arterial pressure, minute ventilation, $PaCO_2$ were comparable between groups. He concluded that APRV did not differ from SIMV+PS in clinical outcome (5).

Daoud and colleges in their review concluded that APRV supplied higher mean airway pressure but lower minute ventilation than biphasic positive airway pressure, another advanced modality with spontaneous breathing (BIPAP). They mentioned some weak clinical trials with small sample size and short term observation comparing APRV and other conventional modalities and most of them have been shown improvement in oxygenation with APRV (6). But in our study arterial blood O_2 pressure in PCV mode was better than APRV mode in both groups.

APRV mode became available from 1990 and there is not available in earlier ventilator instrument (9). Our study showed no priority of APRV mode on PCV mode in ICU patients with regard to cardiopulmonary and oxygenation variables.

In present study, only 18 patients were eligible and enrolled for intervention which small sample size is our study limitation and can affect on power of the study. It seems more clinical trials with bigger sample size and longer duration of intervention is needed to compare PCV and APRV mode in mechanically ventilated patients.

We did not record study variables in wash out period which is our another study limitation, so we could not discuss about first modality effect on second modality changes.

Conflict of Interest

The authors declare no conflict of interest.

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