

## Airway Pressure Release Ventilation in Management of Acute Respiratory Distress Syndrome: a 2-Years Experience From Upper Egypt



### Medical Science

**KEYWORDS :** Airway, Pressure, Ventilation, Acute, Respiratory, Distress, Syndrome, Egypt

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### ABSTRACT

**BACKGROUND:** Airway pressure release ventilation (APRV) is an inverse ratio, pressure controlled, intermittent mandatory ventilation. We aimed to report our experience with the use of APRV in management of acute respiratory distress syndrome (ARDS).

**METHODS:** Patients with ARDS were mechanically ventilated; then, shifted to either synchronized intermittent mandatory ventilation, pressure control; Group I, or to APRV; Group II. The following parameters were monitored and compared after 1h, 6h, and 24h: vital signs, ABGs, and ventilatory parameters [VT, RR, P peak, FiO<sub>2</sub>, PEEP].

**RESULTS:** Thirty patients were enrolled. No significant difference between both groups in demographic, baseline clinical and gasometric parameters, and outcome. A significantly higher VT ( $p < 0.01$ ) was found in Group II after 1h, 6h, and 24 hours. There were no significant differences in oxygenation or static compliance between both groups at any time.

**CONCLUSION:** In patients with ARDS, compared with conventional ventilation, APRV offers better alveolar ventilation, similar oxygenation at the same safe inspiratory pressure level with less hemodynamic compromise, and without the need for neuromuscular blockade.

### Introduction

Acute respiratory distress syndrome (ARDS) is characterized by collapse of the alveoli, pulmonary infiltrates, decreased compliance, and hypoxemia. Lung protective strategies (LPS) have been successfully used in patients with ARDS<sup>1</sup>. However, using low tidal volumes may also limit inflation and promote alveolar derecruitment and hypoxemia<sup>2</sup>. Airway pressure release ventilation (APRV) is an inverse ratio, pressure controlled, intermittent mandatory ventilation with unlimited spontaneous breathing; that is based on the principle of open lung approach<sup>3</sup>. APRV uses a release of airway pressure to simulate expiration and elevated baseline pressure to improve oxygenation. Few studies had addressed the use of APRV in management of ARDS<sup>3-5</sup>. In the current study, we aimed to report our experience with the use of APRV as a mode of ventilation in management of ARDS.

### Patients and Methods

The study was performed in the Respiratory ICU, Department of Chest Diseases, Assiut University Hospital from June 2012 to June 2014. Patients who diagnosed as ARDS according to Berlin criteria<sup>6</sup> were enrolled into the study. Exclusion criteria included: Age <18 or >60 years, history of rheumatic or ischemic heart disease, chronic pulmonary disorders [chronic obstructive pulmonary disease (COPD), idiopathic pulmonary fibrosis (IPF), or suppurative lung disease].

The patients were intubated and mechanically ventilated via Puritan Bennett, 840 ventilator in volume assist control mode (VC-AC) with a constant inspiratory flow. The following measures were obtained:

1. Haemodynamic monitoring: Arterial systolic blood pressure (BP), heart rate (HR), and arrhythmias. 2. Respiratory rate (RR), and use of accessory respiratory muscles.

3. Arterial blood gases (ABGs): were obtained by blood sample from radial artery and analyzed using a blood gases analyzer (Rapid lab 850; CHIRON/Diagnostics; critical care systems), including pH, PaO<sub>2</sub>, PaCO<sub>2</sub>, PaO<sub>2</sub>/FiO<sub>2</sub>, and SpO<sub>2</sub>.

4. Static respiratory system compliance (Cst); was measured by

using the inspiratory pause button of the ventilator. This is automatically displayed and calculated by dividing the tidal volume by PEEP subtracted from plateau pressure (pressure measured at zero flow with a pause of 1.2 sec. at the end of inspiration).

5. Static inflation P-V curve was obtained at zero end-expiratory pressure (ZEEP). Subsequently the lower inflection point (LIP) and upper inflection point (UIP) were identified.

To evaluate the use of airway pressure release ventilation (APRV); it was compared to synchronized intermittent mandatory ventilation, pressure control (SIMV- PC) mode. Thus, after 20 minutes, patients were shifted to either (SIMV- PC) and named Group I, or to APRV using bilevel mode with longer time in high pressure and named Group II.

The following settings were adjusted for Group I: RR; 15 breath/minute, PEEP at 2 cmH<sub>2</sub>O higher than lower inflection point (LIP), inspiratory pressure is adjusted to 30 cmH<sub>2</sub>O. Inspiratory time was adjusted to maintain I:E ratio at 2:1, and FiO<sub>2</sub> set at 60%.

The following settings were adjusted for Group II: RR; 15 breath/minute, P high at 30 cmH<sub>2</sub>O, P low at 0 cmH<sub>2</sub>O, T high around 4 sec. to maintain I:E ratio at least 8:1 and up to 12:1. Mean airway pressure is automatically calculated<sup>7</sup> as  $(P_{\text{High}} \times T_{\text{High}}) + (P_{\text{Low}} \times T_{\text{Low}}) / (T_{\text{High}} + T_{\text{Low}})$ .

Continuous midazolam infusion (0.15-0.3 mg/kg/h) was given for sedation. Neuromuscular blocking agent (NMBA), Atracurium besilate in infusion dose (0.1mg/kg/h) after initial bolous dose of 0.2 mg/kg was administered, but was discontinued after 12 hours in Group II to permit spontaneous breathing.

The following parameters were monitored after 1hour, 6 hours, and 24 hours from beginning of the studied mode: vital signs, ABGs, and ventilatory parameters [V<sub>T</sub>, RR, Peak airway pressure (P peak), FiO<sub>2</sub>, and PEEP]. Measurements of lung mechanics including PV curve and Cst were achieved by temporary shifting (1 minute) to VC- AC after 1hour, 6 hours, and 24 hours from beginning of the studied mode.

If the patient became ready for a weaning trial, midazolam dose was gradually decreased and the drug was finally discontinued. Successful outcome was defined as successful weaning with persistent improvement of clinical, haemodynamic and gasometric parameters at least 72 hours after extubation.

The study was approved by the Local Ethical Committee and a written consent was obtained from the patient or his/her sponsor before enrollment into the study.

**Statistical analysis**

Statistical analysis was performed using SPSS (version 16). All data are expressed as mean ± SD for numerical data or frequencies for nominal data. Clinical characteristics of the patients as well as the haemodynamic and gasometric parameters were compared using Student's *t* test for numerical data, and chi-square tests for frequencies. A *p* value ≤ 0.05 was considered statistically significant.

**Results**

Thirty patients (12males and 18 females) were enrolled and included 15 patients in each group. Demographic data as well as baseline clinical and gasometric parameters are shown in table (1) with no significant difference between both groups. There was no significant difference between the outcomes of both groups (figure 1).

Figure 2 (a, b, c) shows follow up of HR, RR, and BP in both groups. A highly significant reduction of HR in both groups (*p*<0.001) after 1 hour was observed which persisted in both groups up to 24 hours ventilation, with a significantly higher (*p*<0.05) HR in Group II after 24 hours ventilation (Figure 2,a). A highly significant reduction of RR in both groups (*p*<0.001) after 1 h was noticed and persisted up to 24 hours ventilation, with a significantly higher (*p*<0.01) RR in Group II after 1h (Figure 2,b). There was a significantly higher (*p*<0.01) BP in Group II after 1h which continued up to 24 hours ventilation (Figure 2,c).

Gasometric parameters are demonstrated in figure 3(a,b,c). A highly significant decrease of pH and increase of PaCO<sub>2</sub>, and PaO<sub>2</sub>/FiO<sub>2</sub> after 1 h, from the baseline, were observed in both groups (*p*<0.001), then a significantly higher pH and lower PaCO<sub>2</sub> were observed in Group II after 1 h and up to 24 hours ventilation (*p*<0.01 and *p*<0.05, respectively). No significant differences were found in oxygenation between both groups at any time.

Mechanical parameters of both groups were shown and compared in figure 4 (a,b). There was a significantly higher (*p*<0.01) tidal volume in Group II after 1 h, 6 h, and 24 hours ventilation. No significant difference was found between both groups regarding the static compliance at any time.

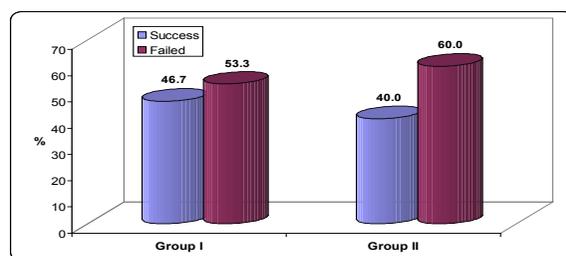
**Table (1): Demographic and baseline clinical, and gasometric parameters of both groups**

Parameters	Group I (15) Mean ± SD	Group II (15) Mean ± SD	P- value*
Age (years)	39.80 ± 8.96	41.47 ± 8.88	NS
Gender: No(%)Male Female	5 (33.3%) 10 (66.7%)	7 (46.7%) 8 (53.3%)	NS
RR, breath/min	42.27 ± 3.45	42.00 ± 3.02	NS
HR, beat/min	130.20 ± 9.54	129.93 ± 7.54	NS

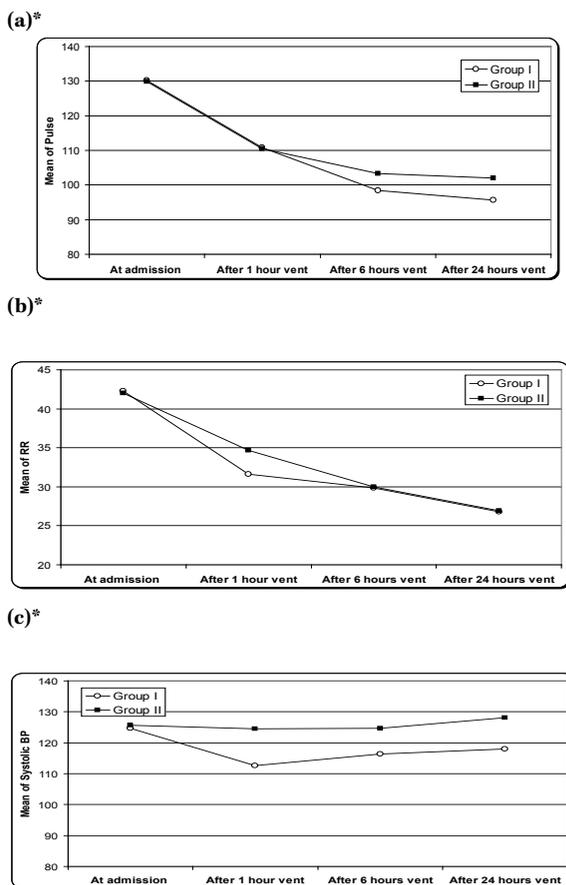
Systolic BP, mmHg	124.67 ± 10.03	125.73 ± 10.16	NS
pH	7.50 ± 0.03	7.49 ± 0.03	NS
PaCO <sub>2</sub> , mmHg	31.00 ± 2.51	32.20 ± 3.34	NS
PaO <sub>2</sub> , mmHg	43.20 ± 4.89	42.20 ± 4.90	NS
PaO <sub>2</sub> /FiO <sub>2</sub>	71.40 ± 8.21	71.20 ± 8.44	NS

\*NS, Non-significant

**Figure (1): Outcome of both groups**

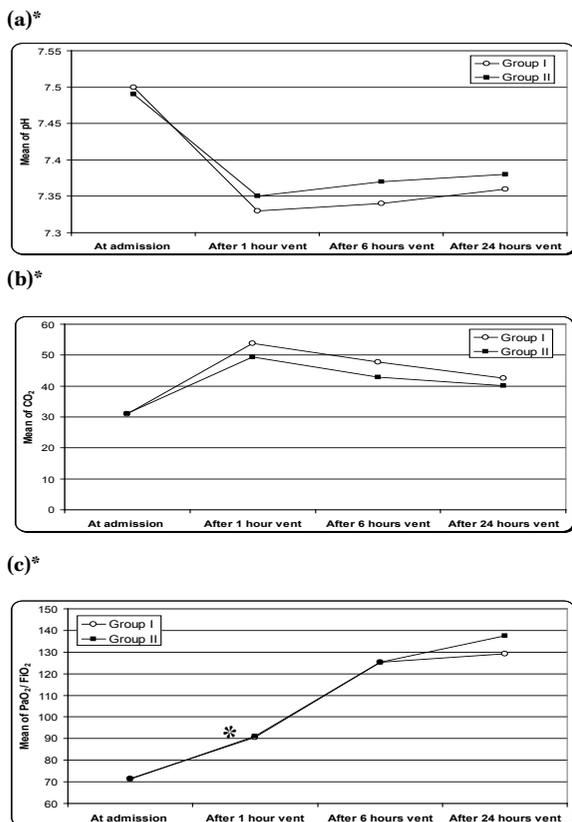


**Figure (2): Follow up of heart rate (a), respiratory rate (b), and systolic blood pressure (c) in both groups\***



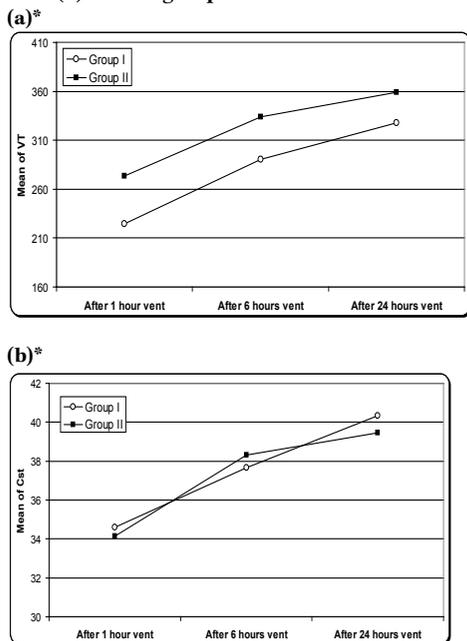
\*significant; *p*<0.05

**Figure (3): Follow up of pH (a), PaCO<sub>2</sub> (b), and PaO<sub>2</sub> /FiO<sub>2</sub> (c) in both groups**



PaCO<sub>2</sub>, partial pressure of arterial carbon dioxide; PaO<sub>2</sub> /FiO<sub>2</sub> ratio of partial pressure of arterial oxygen to fractional inspired oxygen; \*significant difference, p<0.05

**Figure (4): Follow up of tidal volume (a), and static compliance (b) in both groups**



V<sub>T</sub>, Tidal volume; Cst, static compliance; \*significant difference, p<0.05

**Discussion**

Assiut University Hospital is the largest tertiary referral centre in Upper Egypt, where many patients are referred. To the best of our knowledge, this is the first Egyptian study that evaluates the use of APRV in management of ARDS.

ARDS is associated with collapse of alveoli, pulmonary infiltrates, decreased compliance, and hypoxemia. Patients with severe ARDS usually require mechanical ventilation (MV) to improve oxygenation and decrease the work of breathing. The use of small V<sub>T</sub> + PEEP set at 2 cm H<sub>2</sub>O above the LIP of the P-V curve as a lung protective strategy (LPS) provided a great improvement in survival<sup>8</sup>. However, several studies have shown that patients ventilated with small V<sub>T</sub> developed progressive alveolar collapse and hypoxemia which were prevented by using large tidal volumes delivered either continuously or intermittently<sup>1,2</sup>. APRV is an inverse ratio, pressure controlled ventilation with unlimited spontaneous breathing; that is based on the principle of open lung approach<sup>3,5</sup>. It uses a release of airway pressure to simulate expiration and elevated baseline pressure to improve oxygenation. However, few studies had addressed the efficacy of APRV in management of ARDS.<sup>3,4,9</sup>

In this study, our results showed better vital signs, gasometric and mechanical parameters, and better outcome in patients in whom APRV was used (Group II), in comparison to those in whom SIMV-PC was used (Group I). These findings are consistent with those reported in the literature.<sup>7,9-11</sup> Systolic blood pressure was significantly higher in APRV group which is consistent with findings of Daoud, et al<sup>3</sup> who stated that APRV had improved haemodynamics. In their 10-year literature review of APRV, Calzia and Radermacher<sup>9</sup> were unable to document any severe adverse effects of APRV on cardio-circulatory function. Moreover, Putnsen et al<sup>10</sup> compared APRV with PCV in 30 trauma patients, and found significantly less vasopressors and positive inotropes usage, with significantly increased cardiac index and oxygen delivery, with the use of APRV. In a recent study comparing APRV with SIMV<sup>11</sup>, vasopressors were less used in APRV group which is compatible with less haemodynamic compromise.

Our results revealed no significant difference in oxygenation between the studied modes. Many studies have shown improved oxygenation, better V/Q match and lesser dead space with the use of APRV in comparison to conventional mechanical ventilation.<sup>7,10-12</sup> Sydow, et al<sup>7</sup> demonstrated that the maximal beneficial effect of APRV upon oxygenation occurred 8 hours after implementation. This is compatible with PaO<sub>2</sub>/FiO<sub>2</sub> in our study that was increased in both groups above 120 after 6 hours with slight increase later on up to 24 hours. Varpula and coworkers<sup>13</sup> observed no difference in oxygenation between APRV and SIMV with pressure support. APRV after 24 hours enhanced improvement of oxygenation in response to prone positioning with significant increase of PaO<sub>2</sub>/FiO<sub>2</sub> versus that of SIMV-PC<sup>14</sup>. Notably, other studies have shown no significant differences in oxygenation parameters, but with significantly less applied pressures and adverse effects than conventional MV.<sup>15</sup>

Our data showed that tidal volume is significantly higher in APRV group which is most probably due to sustained inflation at fixed inspiratory pressure. APRV begins on the P-V curve between upper and lower inflection points and uses a release of pressure from its baseline. Therefore, alveolar ventilation occurs predominantly within the upper and lower inflection points<sup>16</sup>. This effect on alveolar ventilation was reflected in higher pH, and lower PaCO<sub>2</sub> among APRV group started 1 hour after MV and continued up to 24 hours. This is very important where during ventilation using APRV less acidosis is obtained than conventional SIMV at the same oxygenation level.

Our results could have important clinical implications. Taking into consideration that APRV can improve patients outcomes, with less duration of hospitalization and use of ICU resources; this can be important, particularly in the settings of developing countries, like Egypt.

### Conclusion

In patients with ARDS, airway pressure release ventilation, compared with conventional ventilation, offers better alveolar ventilation, similar oxygenation at the same safe inspiratory pressure level with less hemodynamic compromise, and without the need for neuromuscular blockade.

### Competing Interests

The authors declared no conflicts of interests

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