Zagazig University Medical Journal
www.zumj.journals.ekb.eg
Doi: 10.21608/zumj.2019.14885.1345
Pediatric
ORGINAL ARTICLE

Airway pressure release ventilation in pediatric respiratory failure. Does it really work?

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Submit Date 2019-07-16
Revise Date 2019-08-02
Accept Date 2019-08-03

ABSTRACT

Background: Airway pressure release ventilation (APRV) is a novel mode of ventilation. It is a form of bi-level assisted ventilation using continuous positive airway pressure (CPAP) with periodic decrease in pressure, either to a lower CPAP pressure or to atmospheric pressure. Aim of the work: to assess the ability of the APRV mode to improve the oxygenation and the mortality in cases with respiratory failure. **Subjects and methods:** A clinical trial was conducted in Pediatric intensive care unit in Zagazig university children's hospital included 76 patient. They were selected after failure of conventional mechanical ventilation, all patients were subjected to full history taking and full physical examination, routine labs and serial Chest X-rays, serial arterial blood gases and serial follow up of the ventilator parameters were observed. **Results:** APRV showed significant improvement in PaO2/FiO2 ratio and O2 saturation. **Conclusion:** APRV showed promising gateway to the cases of respiratory failure who failed their chances on conventional mechanical ventilation. Future studies are needed to compare both modes to assess the superior of one to another.

INTRODUCTION

APRV is a novel mode of ventilation and was first described by Stock et al in 1987.It is a form of bi-level assisted ventilation using continuous positive airway pressure (CPAP)with periodic decrease in pressure, either to a lower CPAP pressure or to atmospheric pressure [1]**.** These intermittent decreases in pressure provide a background tidal volume exhalations and respiratory rate enabling carbon dioxide clearance, whereas the periods of sustained CPAP produce a high mean airway pressure resulting in lung recruitment and effective oxygenation [2]. In APRV continues lung recruitment can be achieved as the ventilation will take place at the "easy to breathe area "on the pressure volume curve. Like most other modes, APRV uses 4 elements to shape the breath and respiratory cycle framework: (1) pressure, (2) flow,(3)time ,and (4)volume. It is the configuration of these elements and method of application that create the unique pressure-time profile (PTP) of APRV that promotes alveolar recruitment and stability through a near-continuous positive airway pressure (CPAP) or the combined P High and T High phase [1]**.** Spontaneous breathing can be integrated within the cycle of the ventilator and is independent of it. The active exhalation valve enables continuous control of airway pressure and compensates for pressure variations normally found in the ventilator circuit [3]. If the airway pressure drops below the set level because of spontaneous inspiration, gas is supplied rapidly to ensure a return to the preset pressure level [4].

SUBJECTS AND METHODS

Study design and subjects:

This single-center, clinical trial was conducted in Pediatric intensive care unit at Zagazig University children's hospital. The

study was held over a 26 month period between April 2017 and June 2019. Written informed consent was obtained from all participants and the study was approved by the research ethical committee of Faculty of Medicine, Zagazig University. The work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans. The sample calculated to be 76 cases. Inclusion criteria included: Age 1month to 15 years, Confirmed diagnosis of respiratory failure either clinically or by blood gases. Exclusion criteria included: Patients stable on conventional mechanical ventilation, patents with congenital heart disease, air-leak syndromes, congestive heart failure, Patient with congestive heart failure. All patients were subjected to full history taking and full physical examination, routine labs and serial Chest X-rays, serial arterial blood gases and serial follow up of the ventilator parameters were observed.

Interventions:

Ventilation strategy for the intervention group was designed based on the available APRV literature as of Aug 2016and the unit's experience with APRV[1].Initial Pressure high was estimated based on plateau pressure (PPLAT) during an inspiratory hold after optimization of Positive end-expiratory pressure (PEEP) with recruitment maneuvers. Pressure low, Pressure high, time low and Time high were adjusted according the most recent pediatric guidelines according to age and weight. Manipulation was guided by the chest X-ray inflation, the tidal volumes and the hemodynamic status. We scaled down the Pressure high if domes of the diaphragm were visible below the 9th posterior rib and were flattened on chest radiograph. As patient's clinical condition and oxygenation index improved, FiO2 levels were decreased. We then weaned to either to pressure support or continuous positive airway pressure (CPAP) of 8-10cm H2O, from which the patient could be extubated directly to nasal cannula. All data were recorded on a pre-designed master sheet. We recorded the ventilatory settings, PaO2/FiO2 ratio, oxygenation index (OI),sedative agent use, hemodynamic status and fluid balance, chest radiography, and other laboratory parameters. We recorded set and delivered ventilation parameters such as mean airway pressures, respiratory rates 12 hourly for the first 24 hours and 24 hourly thereafter.

Statistical analysis:

The collected information were coded, entered, presented, and analyzed by computer via a data base software program, Statistical Package for Social Science (SPSS) version 12.0.1 (SPSS, Inc., Chicago, IL, USA). Parametric variables were represented as the mean and standard deviation (SD), and non-parametric data expressed as median and range. Chi square (X^2) or Fisher tests were used to detect relation between different qualitative variables. P value≤0.05 means statistically significant.

RESULTS

Demographic and clinical characteristics of patients:

Cases in the study were 60% females, 40% males with mean age of 4 years. Most cases were of respiratory failure type 1 (76%) and respiratory causes of respiratory failure were the most common etiology (60%).

Outcome:

There was statistically significant difference between the studied group regarding PH measured after 2 hours, half of MV duration or just before weaning,(Table 1). There was statistically significant difference between the studied group regarding PaO2 measured at half of MV duration while there is non-significant difference between them reading PaO2 after 2 hours or just before weaning, (Table 2). There is significant change in O2 saturation in the studied group over time, (Table 3). There is significant change in PaO2/FiO2 in the studied group over time, (Table 5). There is significant change in OI in the studied group over time, (Table 6)

Table (1) Demographic data of the studied group

APRV studied group	
number	N=76 (%)
Gender: Male Female	 30 (39.5) 46 (60.5)
Age (years): Mean ± SD Median Range	 4.39 ± 4.64 2 0.08 - 15
Body weight (kg): Mean ± SD Median Range	 18.86 ±16.61 12 2 - 70

Table (2) types of respiratory failure in the studied group

Type of respiratory failure	APRV
	N=76 (%)
Hypercapnic Hypoxic Mixed	2 (2.6) 58 (76.3) 16 (21.1)

Table (3) Percent changes in PH throughout the duration of mechanical ventilation.

PH	APRV
	Mean ± SD
After 2 hours (mmHg)	7.2 ± 0.14
At half of MV duration	7.3 ± 0.24
Just before weaning	7.32 ± 0.12
P (F)	<0.001**

Table (4) Comparison between the studied groups regarding PaO2 change

PaO2	APRV	
	Mean ± SD	**Median**
After 2 hours (mmHg)	48 ± 17.23	46.5
At half of MV duration	67.41 ± 16.75	
Just before weaning	82.08 ± 18.59	
P (Friedman test)	<0.001**	

Table (5) Comparison between the studied groups regarding change in O2 saturation.

O2 sat	Groups
	APRV
	Mean ± SD
After 2 hours (mmHg)	77.34 ± 10.46
At half of MV duration	85.78 ± 6.73
Just before weaning	89.75 ± 11.06
P	<0.001**

Table (6) Comparison between the studied groups regarding change in PaO2/FiO2.

PaO2/FiO2	Group	
	APRV	
	Mean ± SD	Median
Initial	63.14 ± 28.7	60.5
Final	175.57 ± 95.64	200
P (Wilcoxon)	<0.001**	

DISCUSSION

Airway pressure release ventilation (APRV) conveys a constant positive airway pressure with a short discontinues release stage, permitting the release of only partial lung volume and unconstrained breathing all through the high level. Late trails have recommended that in comparison with the low tidal volume ventilation (LTV), the use of more physiology- like APRV protocols improved alveolar recruitment and gas exchange, increased homogeneity, and reduced lung injury [5].A study conducted by **Ganesan et al** included only 52 patients. With some of the exclusion criteria we used .they excluded children with air leaks. Another study performed by **Schuktz et al** included 33 pediatric patient with respiratory failure assigned to APRV mode. Other than those two studies. there are only few scattered pediatric case reports utilizing APRV [6,7]. When we observed the changes in the PaO2 level we noticed that the studies groups showed statically significant difference in improving the oxygenation. The **Zhou et al** study concluded that APRV is excellent improving oxygenation. And a case series by **Krishnan et al** also stated improved oxygenation by APRV. Another case series by **Garcia et al** resulted in improved oxygenation only in cases that were plotted electively to APRV. But not such in rescue cases [7,8].As for the improvement in PaO2/FiO2 and OI we found an agreement to our observation in a study done by **Maung et al** which stated that patients on APRV showed improvement in PaO2/FiO2 and OI [9]. By looking to a study performed by **Ganesan et al** they observed a much higher PaO2/FiO2 by using APRV mode versus SIMV mode. Also the same was noticed by a study conducted by **Hanna et al** [7,10].

CONCLUSION

The current study concluded that APRV showed promising gateway regarding the improvement in oxygenation in the cases of respiratory failure who failed their chances on conventional mechanical ventilation. Future studies are needed to compare both modes to assess the superior of one to another.

Conflict of Interest: None declared.
Funding: No funding sources.

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How to cite Nafea, A., abdellatif, D., Rasheed, E. Airway pressure release ventilation in pediatric respiratory failure. Does it really work?. *Zagazig University Medical Journal*, 2020; (753-757): -. doi: 10.21608/zumj.2019.14885.1345