

Immediate Effects of Acapella® on Dynamic Lung Compliance in Mechanically Ventilated Patients with Acute Respiratory Distress Syndrome: A Case Series

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Abstract

Background and Aims: One potential complication of acute respiratory distress syndrome (ARDS) is reduced dynamic compliance, saturation for peripheral oxygenation (SpO₂) and increased sputum in patients that are mechanically ventilated. Airway clearance technique is the treatment given for patients on mechanically ventilator with ARDS. The purpose of the case series is to know the immediate effects of Acapella® on dynamic lung compliance (C_{dyn}) in subject with ARDS. **Subjects and Methods:** Patients who are on ventilator for more than 48hrs were included in the study. Readings for C_{dyn}, SpO₂ were noted at baseline, immediately post treatment, 10, 20, 30 and 60minutes. Pre and post treatment sputum volume was also noted. **Results:** Five patients were included with age range of 25 to 75 years. Clinical improvement was seen immediately after treatment in C_{dyn} and SpO₂. There was not much change in sputum volume. **Conclusion:** Acapella® increased the dynamic compliance of lungs and sputum clearance in mechanically ventilated ARDS patients.

Keywords: Acapella®, acute respiratory distress syndrome, airways clearance technique, mechanical ventilation

INTRODUCTION

Acute respiratory distress syndrome (ARDS) is a life-threatening complication causing respiratory insufficiency in critically ill patients. This syndrome is associated with a high mortality rate varying between 30% and 60%.^[1]

In mechanically ventilated ARDS patients, there is increased mucus production and decreased dynamic compliance (C_{dyn}) due to impairment of mucociliary clearance, lesions caused by suctioning, inadequate humidification, administration of paralytic agents,^[2-5] and drugs which decrease chest wall tone.^[6] Airway clearance techniques are commonly used for clearing secretions, improving gas exchange, oxygenation, and work of breathing.^[7-12]

Acapella® is an airway clearance device that combines the resistive features of a positive expiratory pressure device with oscillations which diminishes the mucus adhesiveness and decrease the collapsibility of airways.^[13]

Earlier study using Acapella® demonstrated improvement in sputum clearance, respiratory mechanics, and oxygen

saturation (SpO₂) in mechanically ventilated patients with acute exacerbation of chronic obstructive pulmonary disease (COPD).^[14]

This case series reports the immediate effects of Acapella® on the dynamic compliance of the lungs (C_{dyn}), SpO₂, and sputum volume.

MATERIALS AND METHODS

The study was approved by Institutional Review Board of Manipal Academy of Higher Education and ethical clearance was taken from Manipal hospital, Bangalore Written consent form was taken from relatives of all patients. Five patients over 18 years of age on mechanical ventilator for more

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than 48 h with positive end-expiratory pressure ≤ 8 , $\text{FIO}_2 \leq 0.6$, heart rate $\leq 125/\text{min}$, $\text{SpO}_2 \geq 88\%$, blood pressure 110/70 mmHg (± 20 units), on paralytic agents, chest X-ray having bilateral pulmonary infiltrates, were included in this study. Patients with rib fracture and chest trauma, absence of cough reflex, untreated pneumothorax or pleural effusion, cardiac arrhythmia, intracranial hypertension (>20 mmHg), tracheal bleeding were excluded from the study.

Prestudy C_{dyn} was calculated, SpO_2 was seen on monitor, and Wet Sputum Volume was measured in the empty volumetric jar connected with the closed vacuum suctioning tube.

Acapella® is connected to the expiratory port of the mechanical ventilator with frequency dial set at minimum for 15 min. The exhaled air from the patient comes out of this expiratory port where the Acapella® is attached and passes through a pivoting cone and generates airflow vibrations between 0 and 30 Hz. These oscillations were felt and seen on the mechanical ventilator graphs. This generates a back pressure which in turn splits and opens the peripheral airways, which lessens airway collapse distally. This cause collateral ventilation, mucus can be mobilized from distal to peripheral airways to the larger and more central airways, thereby enhancing secretion clearance. Passive limb movements were also given during this period. At the end of the treatment session, C_{dyn} was calculated and SpO_2 was recorded immediately. Suctioning of the airway was done by a nursing staff of medical intensive care unit posttreatment. Sputum volume was measured by checking the reading of the sputum collecting volumetric jar and subtracting the amount of distilled water use to flush the secretions posttreatment. C_{dyn} and SpO_2 were noted postimmediately, 10, 20, 30, and 60 minutes.

Analysis

Descriptive analysis was done using Statistical Package for the Social Sciences version (SPSS 20.0, Armonk, NY: IBM Corp.) Mean and standard deviation were taken for all the outcome measures. Paired *t*-test was used to see the statistical significance at baseline and 60 min postintervention.

RESULTS

Demographics

Four females and one male with an age range of 27–71 years old (mean 44.8) were included in the study. Table 1 shows

Patient	Gender	Age at admit	Mode of ventilator	$\text{PaO}_2/\text{FiO}_2$
1	Female	42	IPPV	203.25
2	Female	52	PCV	203.25
3	Female	32	PCV	180
4	Male	27	VCV	134
5	Female	71	PCV	122.16

IPPV: Intermittent Positive Pressure Ventilation; PCV: Pressure Control Ventilation; VCV: Volume Control Ventilation

patient's characteristics such as gender, age, mode of ventilator, and $\text{PaO}_2/\text{FiO}_2$ ratio of the patients.

Dynamic Lung Compliance

For C_{dyn} , there was an improvement seen at all the time intervals. There is a significant change ($P = 0.004$) at 60 min posttreatment [Tables 2 and 5].

Oxygen saturation

There was no improvement for patient 1, 3, and 4. SpO_2 was improved in patient 2 and 5. There is no significant change in SpO_2 at the end of 60 minutes [Tables 3 and 5].

Sputum volume

There is an improvement of 20 ml in one patient only. Data were analyzed and showed ($P = 0.008$) which is significant [Tables 4 and 5].

Pre- and post-analysis showed significant improvement in dynamic lung compliance and sputum volume.

DISCUSSION

This case series describes the immediate effects of Acapella® on C_{dyn} , SpO_2 , and sputum volume for patients on mechanical ventilator with ARDS. Significant improvement was seen in C_{dyn} and sputum volume.

C_{dyn} is improved for all five patients. A previous study on mechanically ventilated COPD patients showed improvement from 3rd day after using Acapella®.^[14]

In the present study, the reason for increase in C_{dyn} could be due to the movement of secretion to central airway promoting expansion of affected lung.

There was an improvement of 3% and 1% at the end of 60 min in patient number 4 and 5, respectively. Minimal clinical important difference for SpO_2 is ± 4 .^[14] The mean and standard deviation from baseline and 60 min was 95.40 ± 4.50 and 95.20 ± 2.95 for all patients.

There was significant difference found in sputum collection from baseline and 60 min which is similar to the study of Abu-Rayan *et al.*^[15] This could be due to the enhanced mucociliary clearance caused by the oscillatory effects of the Acapella®.

There was no adverse event reported during the intervention.

CONCLUSION

Acapella® increased the C_{dyn} of lungs in mechanically ventilated ARDS patients.

Future recommendations

There is a need for further studies to be performed on large scale to study the long-term effects of Acapella® on weaning from mechanical ventilator, the length of hospital stay, and health-related quality of life in patients with ARDS.

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Table 2: Dynamic lung compliance (ml/cmH₂O)

Patient	Baseline	Immediately posttreatment	10 min	20 min	30 min	60 min
1	25	28.2	27.6	26.5	26	26
2	19.7	21.5	21.8	21.6	20	20.1
3	26.2	29.5	29.3	29	28.7	28
4	26	28	25	30	25	26
5	24	27	26	25	25	25

Table 3: Mean (standard deviation) for dynamic compliance, oxygen saturation and sputum volume at baseline and 60 min posttreatment

Cdyn			SpO ₂			Sputum volume		
Baseline	60 min	P	Baseline	60 min	P	Baseline	60 min	P
24.18 (2.65)	25.02 (2.95)	0.004	95.40 (4.50)	95.20 (2.95)	0.133	18 (17.88)	23 (24.20)	0.008

SpO₂: Oxygen saturation; Cdyn: Dynamic compliance

Table 4: Oxygen saturation (%)

Patient	Baseline	Immediately posttreatment	10 min	20 min	30 min	60 min
1	95	93	92	95	95	95
2	91	95	96	97	94	94
3	100	100	100	100	100	100
4	100	99	99	95	95	95
5	91	92	92	91	94	92

Table 5: sputum volume (ml)

Patient	Pretreatment	Posttreatment
1	0	1
2	30	30
3	20	22
4	40	60
5	0	2

Conflicts of interest

There is no conflict of interest.

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