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Positive Expiratory Pressure Therapy Device, the Acapella in Post-ECMO Rehabilitation

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ABSTRACT

Depending on the choice of cannulation techniques, ECMO can deliver purely respiratory support, respiratory support with right ventricular support, and full cardiopulmonary support. Today, with careful patient selection, ECMO is used as a rescue therapy to allow for recovery or bridge to transplant for hypoxic respiratory failure and severe refractory cardiogenic shock. The adverse effects of deep sedation and paralysis including bradycardia, ICU-acquired paresis, and ventilator-associated pneumonia pose valid concerns with reduction in lung volumes and capacities. One of the most frequently prescribed airway clearance therapy (ACT) options for patients with chronic lung conditions or decreased lung volumes is positive expiratory pressure therapy (PEP) device (Acapella) which causes reduction in hyperinflation and many other positive facts described in this review.

Keywords: ECMO; Acapella, rehabilitation, positive expiratory pressure therapy

INTRODUCTION

Extracorporeal membrane oxygenation (ECMO)

The use of cardiopulmonary bypass technologies such as ECMO allows for more aggressive lung rest strategies and cardiovascular support than could be provided otherwise. Depending on the choice of cannulation techniques, ECMO can deliver purely, respiratory support with right ventricular support, and full cardiopulmonary support. Today, with careful patient selection, ECMO is used as a rescue therapy to allow for recovery or bridge to transplant for hypoxic respiratory failure and severe refractory cardiogenic shock.

Chest physiotherapy strategies for the patient on ECMO

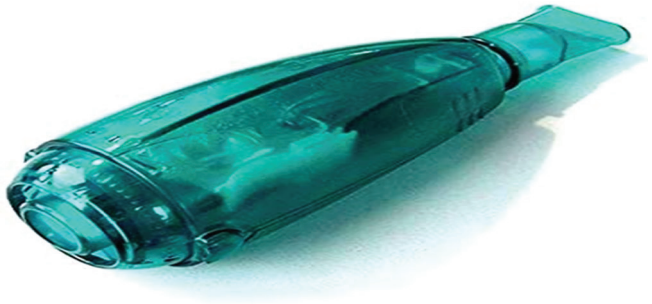
Once the patient gets selected for ECMO, would be kept on acceptable ventilator settings and depending on the hemodynamics of the patient and clinical indications, the passive airway clearance therapy, that is, manual ventilation/manual hyperinflation and airway suctioning need to be started to ensure adequate ventilation in lungs. When the patient becomes fit for ECMO discontinuation and decannulation, the same passive airway clearance therapy (manual ventilation/manual hyperinflation and airway suctioning) can be continued with closed sternum along with various positioning techniques and chest maneuvers (Chest Percussions and Vibrations). The main intention of applying all these techniques is to make the patient fit for extubation. Once the patient gets extubated, he may have following complications.

Post-ECMO complications

Prolonged controlled ventilation without diaphragmatic contraction may result in severe atrophy and increased duration of ventilatory support. Furthermore, the adverse effects of deep sedation and paralysis including bradycardia, ICU-acquired paresis, and ventilator-associated pneumonia pose valid concerns with reduction in lung volumes and capacities.

Acapella

One of the most frequently prescribed airway clearance technique (ACT) options for patients with chronic lung conditions or decreased lung volumes is positive expiratory pressure therapy (PEP) device (Acapella).



During PEP therapy, the patient exhales against a fixed-orifice resistor, generating pressures during expiration that usually range from 10 to 20 cm H_2O. PEP does not require a pressurized external gas source.

The therapy which is administered by breathing through a special device helps:

- Air get behind the mucus
- Move mucus from lung and airway walls
- To hold the airways open for longer.

MECHANISM OF PEP

- The increase in pressure is transmitted to airways creating back pressure stenting them during exhalation, preventing premature airway closure and reducing gas trapping
- Promotes collateral ventilation, allowing pressure to build up distal to the obstruction (collateral ventilation is a phenomenon found in the human lungs where alveolar structures are ventilated through channels that bypass normal airways)
- Retains airways from collapsing and prolongs expiratory flow
- Effective airway clearance promotes movement of mucus proximally
- Also when a patient breathes out. The vibrations move mucus from the surface of the airways. After blowing through the device several times, the person will huff and cough to clear the mucus from the lung also create vibrations.[1]

INDICATIONS FOR PEP

- Acute and chronic respiratory failure for reasons of surgery
- Neurological or musculoskeletal dysfunction, for example, MND
- Old age and immobility
- To increase lung volume by increasing forced residual capacity (FRC) and tidal volume (VT)
- Reduce hyperinflation/air trapping in, for example: Emphysema, bronchitis, and asthma[2]
- Improve airway clearance in; cystic fibrosis (over 4 y.o); chronic bronchitis; bronchiectasis; and bronchiolitis obliterans
- To maximize the delivery of bronchodilators in patient's receiving bronchial hygiene therapy.

RELATIVE CONTRAINDICATIONS FOR PEP[3,4]

- Untreated pneumothorax
- Intracranial pressure >20 mm Hg
- Active hemoptysis
- Recent trauma or surgery to skull, face, mouth, or esophagus
- Patient with acute asthma attack or acute worsening of chronic obstructive pulmonary disease unable to tolerate increased work of breathing
- Acute sinusitis or epistaxis
- Tympanic membrane rupture or other known or suspected inner ear pathology
- Nausea.

There are no absolute contraindications to PEP that have been noted by the literature.

PHYSIOLOGY OF PEP

Increasing lung volume FRC and VT

- A progressively temporary increase in FRC has been found to be proportionally correlated when increasing PEP
- An increase in FRC is attained by alteration of breathing pattern that is a product of a decrease in expiratory flow and an increase in expiratory time leading to exhalation of smaller volumes
- Lung volume increase is achieved by altering breathing pattern, thereby increasing VT and decreasing respiratory frequency, which is due to an increase in muscle activity of inspiratory and expiratory muscles
- Improved gas exchange is a result of breathing during a prolonged period with normalized lung volumes.[5-7]

Reduction of hyperinflation

- Hyperinflation is a result of air entrapment causing the lungs to over inflate. It is caused by muscle spasm,

mucosal inflammation, hyper-secretions, and reduced lung elasticity due to destruction of lung parenchyma. If untreated may lead to inspiratory muscle exhaustion, decreased ventilation, and deficient gas exchange
- PEP reduces expiratory flow, which in return decreases the declining pressure across the airway wall thereby reducing collapse
- Increasing pressure within airways transports expiratory positive pressure (EPP) centrally and in stable airways therefore stenting them. Reduction of airway collapse increases expired volume leading to additional emptying of lung volume thus lowering FRC and improving ventilation distribution and gas exchange.

Airway clearance

- It homogeneously mobilizes secretions in collapsed airways. It aims toward increasing FRC by recruiting collapsed lung volumes and uses resistance to obtain progressive homogenization emptying of the lungs
- Homogenization is achieved by the facilitation of EPP to move peripherally during expiration avoiding collapsed airways, trapped gas, and atelectasis. This results in reduction of respiratory flow and an increase in expiratory flow combined with an increase in FRC. In doing so secretion is mobilized in closed or collapsed and unreachable parts of the lungs
- The oscillating property is achieved by bursts and turbulent expiratory airflow due to the opening and closing of the valve. Oscillations during expiration decrease the viscoelasticity properties of mucus, affecting its movement which depends on the oscillating frequency. OscPEP is equally as effective as other Airway Clearance Technique (ACT) as PEP and Active Cycle Breathing Technique.

INSTRUCTIONS FOR THE USE OF PEP DEVICES

Physiotherapist will set device to the amount of pressure needed (Can be used as an adjunct to Active Cycle of Breathing Technique).

Instructions

Repeat below steps at least 5 times to make one cycle. Repeat the following steps as many times as directed to complete one cycle:

Loosen mucus

- Sit up with your back straight and your chin slightly up. This position allows your throat to be open so air can move easily without blockage
- You may need to put your elbows on a table. This may keep you from slouching and blocking air from moving freely
- Take a deep breath and hold it for 2–3 s
- While you hold your breath, place the mouthpiece in your mouth
- Breathe out at a steady rate for 4–6 s or as long as you can. Keep your cheeks as flat as possible. You may have to use your fingers to hold your cheeks down. Try not to cough
- You may be able to keep the mouthpiece in, or your mask on, as you repeat. Take a deep breath in through your nose.

Cough and bring up mucus

- Remove the mouthpiece from your mouth or the mask
- Do 2–3 huff coughs. Take a deep breath in. Use your stomach muscles to breathe out 3 quick, forceful breaths. Make a ha, ha, ha sound[7,8]
- Then, cough hard to bring up mucus. Spit the mucus out. Do not swallow the mucus
- You may need to rest for 1–2 min
- This cycle should continue for 10–20 min or until you have cleared all your sputum.

SCIENTIFIC LITERATURE ABOUT PEP

- Following meta-analyses of the effects of PEP versus other airway clearance techniques on lung function and patient preference, a review demonstrated that there was a significant reduction in pulmonary exacerbations in people using PEP where exacerbation rate was a primary outcome measure.[9]
- Another review suggests that PEP therapy appears to have similar effects on health-related quality of life, symptoms of breathlessness, sputum expectoration, and lung volumes compared to other ACTs when prescribed within a stable clinical state or during an acute exacerbation.[10]
- A systematic review investigated the effect of PEP breathing after an open upper abdominal or thoracic surgery. Questionable quality standards, different protocols, and PEP devices used among the six RCTs included concur to uncertainty about PEP effect. It is not possible to assume that a prophylactic chest physiotherapy treatment is superior to a PEP device protocol in preventing within 5-day post-operative complications.

DISCUSSION

Limited evidences are available regarding effectiveness of various rehabilitative interventions or techniques in post-ECMO rehabilitation. However, in context of subjects receiving ECMO, the PEP therapy through Acapella may be effective

to overcome pulmonary complications and respiratory muscle weakness post-ECMO decannulation, as Acapella therapy is backed by several evidences related to the similar complications. Hence, the effectiveness of Acapella needs to be explored further in post-ECMO rehabilitation program.

CONCLUSION

Limited evidences are available regarding effectiveness of various rehabilitative interventions or techniques in post ECMO Cardio-Pulmonary Rehabilitation. However in context of subjects receiving ECMO , the the PEP Therapy via Acapella may be effective to overcome pulmonary complications and respiratory muscle weakness post ECMO decannulation, as Acapella therapy is backed by several evidences related to the similar complications.On the other hand the patients receiving routine Cardiopulmonary Physiotherapy Rehabilitation Program: (1) positioning; (2) passive range of motion (PROM) training; (3) neuromuscular electrical stimulation (NMES); (4) surface electrical phrenic nerve stimulation (SEPNS); (5) respiratory proprioceptive neuromuscular facilitation (PNF) techniques; and (6) airway clearance techniques also got some benefit. So the effectiveness of Acapella needs to be explored further in post ECMO Rehabilitation Program along with routine Cardiopulmonary rehabilitation Program.

Declaration of patient consent

Patient's consent not required as their identity is not disclosed or compromised.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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