Physiotherapy and airway clearance techniques and devices

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The focus of this talk is on the use of airway clearance techniques to assist in the removal of secretions from the lungs with particular emphasis on their use in the NICU and PICU setting. Until the early 1990’s the term, “Chest Physiotherapy” was synonymous with the terms, “airway clearance techniques, or postural drainage and percussion” with the latter being the traditional method of airway clearance used by Physiotherapists. Over the past 15 years, it has been recognized that we must be more comprehensive in our approach to the cardiopulmonary system. Modalities now used by Physiotherapists to treat cardiopulmonary pathology include airway clearance techniques, exercise, positioning, re-education of breathing, thoracic mobility exercises and inhalation therapy.

There are currently a number of airway clearance techniques available for use, although not all of them have been validated by scientific data. Postural drainage and percussion was first described by William Ewart in 19011 who referred to it as “empty bronchus treatment by posture in the bronchiectasis of children”. To enhance clearance of secretions chest wall clapping or percussion was added to postural drainage. Flower2 showed mechanical percussion increases intra-thoracic pressure, but no studies have been performed to examine the effects of manual percussion. Physiological rationale for the use of postural drainage to assist in the clearance of secretions is based on the use of gravity to assist with the mucociliary action. However, for gravity to be effective, the patient would have to be placed in head down positions for between 60–100 minutes. MacKenzie et al.3 in a study on 42 ventilated patients, were able to demonstrate an increase in total lung compliance following chest physiotherapy consisting of postural drainage, percussion and vibration for a mean of 57 minutes. He suggested that chest physiotherapy needs to be of 1-hour duration to be effective.

Thomas et al.4 attempted to review the use of vibration in airway clearance. The physiological literature suggests a rationale to support the use of vibrations with a frequency of &lt;60 Hz, by improving mucociliary transport and altering the thixotropic property of mucus.5 However, there are few clinical trials examining the effect of vibration as an adjunct to PD.

DETREMENTAL EFFECTS OF POSTURAL DRAINAGE AND PERCUSSION

Until recently, it was thought, there were no detrimental effects to performing PD&P. As a result PD&P was often over prescribed with the rationale, “lets try it, as it can only help”. However, recent studies have suggested that PD&P may have a detrimental effect on patients. Button et al.6 demonstrated that PD&P performed in head down positions may aggravate gastro esophageal reflux in infants with CF. As a result of this study, Button et al.7 modified PD positions to no tipping and recently published the results of using these modified non tip positions over a five year period in patients with CF, showing improved outcomes.

In the NICU, PD&P has been associated with neurological sequelae. Three studies have reported conflicting results on neurological outcomes following neonatal chest physiotherapy. One study from New Zealand reported neurological sequelae following the use of chest physiotherapy.8 Two other studies could not find any correlation between chest physiotherapy and negative neurological
outcomes. In the New Zealand paper, vigorous percussion was performed by nurses in the low birth weight infant <1000 grams. In the other 2 papers only gentle physiotherapy using vibrations was performed in the LBW infant and no neurological sequelae was reported.9,10

Rib fractures are another complication to be aware of in the very young paediatric patient with the incidence being reported as 1:1000 infants median age 3 months treated for bronchiolitis and Pneumonia.11 Other adverse reactions to PD&P include bronchospasm, changes in cardiac rhythm,12 and raised intracranial pressures in head-down positions.

NEW EVIDENCE TO SUPPORT THE USE OF PERCUSSION AND VIBRATION IN NON-TIPPED POSITIONS

As a result of the research concerning the detrimental effects of PD&P, the practice of Physiotherapy in relation to PD&P in Canada has changed. No longer are head-down positions used to assist in secretion removal, rather patients are placed in positions to optimize ventilation to specific lung regions. It has been speculated that the redistribution of ventilation, as occurs with a change in body position, might alter the local airway patency and gas/liquid pump.13,14 Consequently, it can be hypothesized that the physiological basis on which the concept of PD was originally developed, may not be the only mechanism for the improvement seen with changes in position as used in PD positions. This hypothesizes is partly supported by Lannefors and Wollmer15 who noted that more secretions were cleared from the dependant lung rather than from the uppermost lung during postural drainage.

AIRWAY CLEARANCE TECHNIQUES IN NICU

For this Paper, eighteen studies were reviewed and summarized. Three systematic reviews could find no evidence to support the routine use of prophylactic airway clearance techniques for neonates. There was some evidence to indicate the need for physiotherapy in neonates with CXR changes and/or mucus plugging.16,10,17

There was substantial evidence to support the use of physiotherapy to prevent post-extubation atelectasis and reintubation.16,19 however, physiotherapy needs to be given 2 hourly to obtain this effect. NIPPV and Nasal CPAP are both effective evidence based treatments to facilitate weaning and extubation of preterm infants.20 As physiotherapy may have deleterious consequences, it should only be initiated by a physiotherapist after careful assessment and an initial treatment to assess the effects of the treatment and modifications necessary to accommodate the fragile state of the patient. Only gentle physiotherapy with vibrations should be performed in the low birth weight infant <1000 grams.

Necessary oxygenation is required during chest physiotherapy and suctioning to prevent hypoxemia.

CURRENT AIRWAY CLEARANCE TECHNIQUES

Over the past 20 years, other airway clearance techniques have been developed which utilize ventilation to get the air behind the secretions and then the expiratory airflow to mobilize the secretions up the airways. These newer techniques have been scientifically validated.21

VENTILATION

Ventilation may be altered by a variety of methods. The method chosen will depend upon the patient, lung pathology and the level of co-operation from the patient.

Simple positioning in side lying will alter ventilation to a specific lung. Prone positioning will increase PaO2 by as much as 10%, due to enhanced ventilation, although prone positioning is not very practical in the PICU setting. Ventilation will be improved by an inspiratory vital capacity maneuver with a three second breath hold. This maneuver allows air to get behind secretions and avoids ventilator asynchronism. It utilizes the principles of interdependence and collateral ventilation.

Several airway clearance techniques incorporate these breathing manoeuvres. The Active Cycle of Breathing (ACBT) utilizes both a deep inspiration with or without a 3 second breath hold, while Autogenic drainage uses only the 3 second breath hold. The three second breath hold is very useful in post-operative patients or patients who have restrictive lung disease.

Breath stacking performed with a one way valve and Ambu mask is another method used to increase ventilation and get air behind secretions in patients with restrictive lung disease who are unable to take a full inspiratory effort independently, i.e. neuromuscular patients and spinal cord patients.

The Positive Expiratory Pressure Mask (PEP) increases ventilation by applying a positive pressure of 10–20 cms H2O at the mouth. FRC is increased during breathing through the device and air moves behind secretions by use of collateral ventilation. The Flutter and Acapella devices both utilize positive expiratory pressure but the Flutter is based on different physiological principles which decreases FRC during use. This has been shown to have detrimental effects.22

High Frequency Chest Wall Oscillation (HFCWO) or the “Vest” does not allow for increasing ventilation to a particular lung region.

EXPIRATORY AIRFLOW

The use of the expiratory airflow to mobilize the secretions up the airway has proven to be very effective. Lung volumes, intra-bronchial pressures and pleural pressures
are all adjusted to create optimum airflow to mobilize the secretions.

Huffing uses a strong expiratory airflow which compresses the airways and squeezes the mucus up the airways. It is based on the equal pressure point theory. ACBT and PEP both use huffing to mobilize secretions up the airways. Care needs to be taken to avoid too strong a compression leading to bronchospasm. AD works well when hyperinflation is present such as in Asthma, bronchiolitis, and cystic fibrosis. It utilizes lower expiratory flow rates, avoiding airway compression, and exhaling into expiratory reserve volume. In infants or when a patient is on a ventilator it can be performed passively on the patient by the Physiotherapist.

Oscillating devices such as the Flutter and HFCWO have a twofold effect on secretion clearance. Oscillation has been shown to decrease the viscoelastic properties of mucus hence making it easier to mobilize up the airways. The second effect of the oscillations is to cause short bursts of increased acceleration of the expiratory airflow which assist in mobilizing the secretions up the airways. In patients with a neuromuscular disorder or a spinal cord injury, assisted coughing may be helpful to assisting in mobilizing secretions up the airways.

UPPER AIRWAY SECRETION CLEARANCE

When secretions are mobilized to the upper airways, a strong cough will clear the secretions. If the patient is unable to cough, suctioning may be required in the very ill patient. In patients with a neuromuscular disorder or a spinal cord injury, a coughalator is very effective in clearing secretions.

CONCLUSION

Physiotherapists now have a variety of airway clearance techniques and devices available for use. Applying them to the patient takes expertise not only in knowing the techniques but in understanding the physiology behind the techniques and being able to adapt and apply the techniques to the individual patient. The Physiotherapist also needs to know when airway clearance will be helpful to the patient and when it will have no effect.

REFERENCES