Review Article

CHEST PHYSIOTHERAPY FOR INFANTS

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ABSTRACT

ABSTRACT: In the normal lung, secretions are removed by Mucociliary activity, normal breathing cycles, and cough. In disease, increased secretion viscosity and volume, dyskinesia of the cilia, and ineffective cough combine to reduce the ability to clear secretions, and may increase exacerbations and infections. Many chest physiotherapy techniques like postural drainage, percussion and vibration are used since many years. These techniques are derived from adult studies but these techniques are quite stressful for the infants as the infant respiratory system is different from the adult respiratory system. Advance chest physiotherapy techniques were developed specifically for infants; in accordance with their physiological characteristics. So this review is to introduce some new chest physiotherapy techniques helpful for newborn infants.

Key Words: Chest Physiotherapy, Prolonged Slow Expiratory Technique, Expiratory Flow Increased Technique, Lung Squeezing Technique, Vojta Method.

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INTRODUCTION

Chest physiotherapy (CPT) is the treatments generally performed by physiotherapists and respiratory therapists whereby breathing is improved by the indirect removal of mucus from the breathing passages of a patient.

In the normal lung Mucociliary activity, normal breathing cycles, and cough are the primary mechanisms of removing secretions from the lung. In disease, increased secretion viscosity and volume, dyskinesia of the cilia, and ineffective cough combine to reduce the ability to clear secretions, and may increase exacerbations and infections. A variety of breathing maneuvers have been developed, refined, and used to assist patients in mobilizing secretions from the lower respiratory tract.[1]

Almost all physiotherapy techniques available for infants are derived from adult studies,[2-5] but the infant respiratory system is different from the adult respiratory system, and the effects of chest physiotherapy may not be the same.[6, 7] New chest physiotherapy techniques were developed specifically for infants, in accordance with their physiological characteristics.[8, 9]

Anatomic and Physiologic Differences between Adult and Infant:

Several structural and functional differences from older children and adults make neonates more vulnerable to respiratory distress. A newborn has a high larynx enabling the epiglottis to guide the larynx up behind the soft palate to produce a direct airway from the nasal cavity to the lungs. Newborns are, therefore, obligate nose breathers who can almost simultaneously breathe and swallow until two to three months of age. Infant's ribs are positioned horizontally, and the intercostal muscles are weak, resulting in a predominantly abdominal (diaphragmatic)

pattern of breathing. Infant's lungs are less compliant, but his chest wall is more compliant than that of an adult.[10, 11] This difference can lead to an increase in both airway resistance and obstruction. The narrow diameter of the infant's airway and a weak or absent cough reflex can also lead to airway obstruction. The newborn or premature infant is highly susceptible to diaphragm fatigue and compensates for respiratory difficulty by increasing the rate rather than the depth of ventilation. [10] All the above factors, although normal for the infants, contribute to respiratory distress and possible respiratory failure.

Positioning for the purpose of improving ventilation/ perfusion matching differs between infants and adults. In adults ventilation and perfusion are preferentially distributed to the dependent lung because of gravitational effects and arterial oxygenation is therefore better in the dependent lung.[12] In infants the opposite applies: oxygenation is better in the uppermost lung. The soft infant chest wall does not support the lungs thus the infant's resting pleural pressure is closer to atmospheric pressure than that of the adult and therefore airway closure occurs in more dependent regions.[13]

Infants have an increased metabolic rate for oxygen consumption and therefore hypoxaemia can develop rapidly. The hypoxia response in infants is bradycardia (due to myocardial hypoxia and acidosis), whereas in adults the response is tachycardia and systemic vasodilatation. The infant's respiratory rate is high, around 40 breaths per minute. Because of the immature respiratory system, infants are unable to respond by increasing their tidal volume and therefore increase their respiratory rate instead. This can be as high as 50–60 breaths per minute and explains why infants can rapidly develop respiratory fatigue and respiratory failure.[12]

DISCUSSION

Percussion, Vibration And Postural Drainage:

Chest Percussion: Chest percussion, also referred to as chest physiotherapy, is an airway clearance technique that involves clapping on the chest and/or back to help loosen thick secretions. Doing this makes mucus easier to expel, or cough up.[14] Percussion results in a coarse shaking of the underlying tissue and is used to initiate the movement of the secretions to be drained.[10]

The exact mechanism by which percussion may assist in the removal of secretions is unknown. Mechanical percussion increases intra-thoracic pressure.[15] But no studies have been performed to examine the effects of manual percussion. It has been hypothesized that the air trapped between the cupped hand and the chest wall creates a vibratory wave that is transmitted through the chest wall and loosens secretions attached to the airway walls.[16]

Chest percussion is often coupled with postural drainage and vibration, and can be performed using either cupped hands or a mechanical airway clearance device.[14]

Chest Vibration: Chest Vibration helps to gently shake mucus and secretions into the large airways, making them easier to cough up. During vibration, the caregiver places their flat hand firmly against the chest wall, atop the appropriate lung segment to be drained. The caregiver then stiffens their arm and shoulder, applies light pressure and creates a shaking movement, similar to that of a mechanical vibrating device.[14] If the infant has stiff,non-compliant lungs then great care is taken not to do this springing too vigorously as it may cause rib fracture. These techniques are most useful in pushing the loosened secretions along the bronchi to the trachea.[10]

Thomas et al.[18] 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 <60 Hz by improving mucociliary transport and altering the thixotropic property of mucus.[19]

Postural Drainage: Postural drainage consists of placing the patient in a position that employs gravity to move mucus centrally from the targeted lung unit. There are 12 different postural drainage positions, one for each pulmonary segment. With the patient in a selected position, percussion is applied over the relevant chest for varying periods of time.[16]

In mature patients deep-breathing exercises, vibration during expiration and huffing are

sometimes incorporated in the technique.[16] In infants the technique is applied without the active participation of the infant. The first reference to the use of postural drainage was in 1901 by Ewart, who referred to it as 'empty bronchus treatment by posture in the bronchiectasis of children'. Ewart advocated continuous drainage for hours at a time with the patient sleeping in this positions.[17]

Evidence:

In 1997 Wong and co-workers described that in patients with Cystic Fibrosis (CF), where the mucociliary action is impeded, mucus was found to move up the trachea at the slow rate of 3–5 mm/min, but approached normal rate when patients were placed in head down postural drainage positions.[20] Theoretically, if the rate of movement in the small airways is similar to that in the trachea in CF (which is doubtful) then to be effective in moving secretions from the basal segments of the lungs to the larynx would require the patient to be placed in a head down position for 60–100 min.

A study of 42 ventilated patients showed an increase in total lung compliance following chest physiotherapy consisting of postural drainage, percussion and vibration for a mean of 57 min. It was suggested that chest physiotherapy needs to be of 1 h duration to be effective. It is quite stressful for the infants. Nowadays 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.[21]

There is wide spread clinical impression that CPT helps to correct Atelectasis but there are two clinical trials that shown CPT was ineffective. The incidence of Atelectasis was higher in the CPT groups in both of the trials. A study in children receiving mechanical ventilation after cardiac surgery suggested that lung compression from percussion may cause more lung Atelectasis by decreasing functional residual capacity.[22, 23]

Based on the results of three Randomised Control Trials by Perrotta C. in 2007, chest physiotherapy using vibration and percussion techniques does not reduce length of hospital stay, oxygen requirements, or improve the severity clinical score in infants with acute bronchiolitis. These were infants who were not on mechanical ventilation and who did not have any other co-morbidity. Chest physiotherapy using forced expiratory techniques needs to be further evaluated by clinical research. [24]

Role of CPT in reducing respiratory morbidity in infants and neonates remains debated and needs further evaluation.[25,26,27] Use of CPT thus needs to be validated using well-controlled studies with large sample size, especially in relation to techniques and specific protocols employed.

Prolonged Slow Expiratory Technique:

Prolonged slow expiration (PSE) is one of these new techniques, employed in clinical practice in infants with bronchial obstruction and hypersecretion.[28] PSE is used in several countries, mainly in Europe. In 2001, some possible benefits of PSE were described, including improved secretion clearance and reduced hyperinflation.[29]

Technique:

First record 60 seconds of normal breathing, then follow the PSE protocol. Place the hypothenar region of one hand on the thorax, precisely below the suprasternal notch, and the hypothenar region of the other hand on the abdomen, under the umbilical scar. The therapist visually identifies the inspiratory and expiratory phases by observing the thorax movement and at the end of the expiratory phase apply compression with both hands. Move the hand on the thorax in the cranial-caudal direction while the hand on the abdomen moves in the caudal-cranial direction. The subsequent 3 inspirations will be restricted, and the compression movements will continue into the expiratory phase, per the standard PSE technique.[30, 31] Repeat this procedure 3 times (sequences A, B, and C), with an interval of 30 seconds between each sequence. In PSE, pressure is exerted on the thorax and abdomen to prolong the expiratory phase and thus promote secretion clearance. In infants with viral bronchiolitis, PSE improves respiratory distress, lowers heart rate, and increases SpO2.[32]

Evidence:

In 2006, Postiaux and co-workers found reduced

respiratory distress, lower heart rate, and increased SpO2 after PSE in 19 infants with viral bronchiolitis.[30]

In 2011 Fernanda C Lanza and co-workers conducted a study to describe PSE's effects on respiratory mechanics in infants. PSE promoted sigh breaths, thereby demonstrating that the change in volume caused by PSE stimulates the Hering-Breuer deflation reflex. So it is possible to reach the fraction of Expiratory Reserve Volume (ERV) with PSE. Thus, %Expiratory Reserve Volume exhaled is greater, increasing the number of successive PSE sequences (cumulative effect).Age was negatively correlated with the %ERV changes, so we must be careful with younger infants, whereas the severity of the illness did not affect %ERV.[33]

In 2012 Évelim L.F.D. Gomes and co workers conducted a randomized controlled trial To evaluate the effectiveness of chest physical therapy (CPT) in reducing the clinical score in infants with acute viral bronchiolitis, in which comparison was done between three groups: G1 - new Chest Physical therapy- nCPT (Prolonged slow expiration - PSE and Clearance rhino pharyngeal retrograde - CRR), G2 - conventional Chest Physical therapy- cCPT (modified postural drainage, expiratory compression, vibration and percussion) and G3 - aspiration of the upper airways, and concluded that the CPT was effective in reducing the Clinical Score in infants with acute viral bronchiolitis compared with upper airway suction only. After 48 hours of admission, both techniques were effective and new CPT techniques were also effective in the 72 hours after hospitalization compared with conventional CPT techniques [34]

Expiratory Flow Increased Technique:

The Expiratory Flow Increased Technique (EFIT) was first broadly mentioned by Huault [35] in the sixties and defined in 1973 by Barthe. [36]

As described by Fausser, a qualitative protocol and guidelines for the EFIT have been established but no quantitative definition has been given to characterize the manoeuvre.[37] Little is known about the characteristics of the pressure applied and the speed of execution. The lack of scientific measurements arises mainly from the lack of reliable and valid tools able to assess the EFIT. Almeida et al, Postiaux et al for instance, performed measurements on patient's clinical state parameters before and after management to assess efficacy of the EFIT but never during the care session.[38, 39]

So in 2009 LMar Echal conducted a study to provide an important contribution to the definition of the expiratory flow increase technique (EFIT). They designed and realized customized instrumented gloves endowed with pressure and displacement sensors, and the associated electronics and software.[40]

Technique:

This technique consists in a synchronized thoracic–abdominal compression of the infant's chest. The infant is lying on its back. The physiotherapist applies pressure with his two hands; one hand should be on the thorax beneath the neck; the other one on the abdominal belt. Therapist performs dynamic compressions that generate an increase in the expiratory airflow inside the infant's bronchial tree in order to remove sputum. The practitioners can't feel the airflow. But as the air flow is characterized by the sound of the expiratory flow produced at the infant's mouth, their manoeuvres rely on it and not on the flow itself. Therapist should also pay attention to the speed of execution and to the maximum manual pressure exerted through their hands.[41]

Evidence:

In 2005 Almeida et al found that EFIT is useful for short-term improvement in the oxygenation of infants.[42]

In 2005 Antunes LCO and co-workers did a comparative study between conventional chest physiotherapy and expiratory flow increase technique, in which they found that the EFIT technique is less stressful than Conventional CPT and can be used for preterm infants following extubation. In these infants, EFIT was seen to be safe and beneficial over the short term.[43] In 2007 Bruno Demont et al stated that the incidence of post-extubation atelectasis in babies treated with the EFIT technique is low and this chest physiotherapy does not appear to increase the incidence of brain lesions above the percentage normally seen in newborns with respiratory failure.[44]

Lung Squeezing Technique:

The lung squeezing technique (LST) is used to restore homogeneous inflation of the lungs by means of small amplitude oscillatory chest wall compressions.

Technique:

Lung Squeezing Technique[45] differs from conventional chest vibration and percussion in the following aspects: each set of "Lung Squeezes" consists of three to four cumulative chest compressions lasting for 5 seconds, followed by a gentles low "release phase", with the chest wall completely released; the second compressions are performed successively for 5 minutes on one hemi thorax, then 5 minutes on the other hemi thorax. The infant should be in supine position, and without body tilt, for a total of 10 minutes. Use both hands to perform the squeeze on one hemi thorax at one time. Place One hand on the posterolateral aspect of the hemi thorax and the other hand covered the anterior chest extending from the lower ribs to above the clavicle of the infant.[46]

These compressions are given without vibration and not in a gravity-assisted position. In order to minimize the potentially deleterious effect of lowering the end expiratory lung volume, the delivery of the chest compressions is not intended to be in synchrony with the infant's breathing pattern, and full range compression from full inspiration to end expiration is avoided.[47]

Evidence:

In 1998 Ivor Nga Chung Wong introduced Lung Squeezing Technique as a Volume Recruitment Manoeuvre in Correcting Lung Atelectasis for Preterm Infants on Mechanical Ventilation.[48]

In 2003 Tai Fai Fok stated that LST was more effective than conventional Postural Drainage Percussion Vibration (PDPV) for re-expansion of lung Atelectasis among the ventilated pre-term neonates in our study.[49]

In 2006 ivor wong and co-worker found that it improves respiratory system compliance in preterm infants with respiratory distress syndrome who require mechanical ventilation . Respiratory system resistance showed no significant change after LST.[46]

The lung mechanics findings provided some supporting evidence for the physiological rationale of LST, including: decompression of the slowly emptying, hyperinflated alveolar units and facilitation of the recruitment of atelectatic acini. LST may be used as an intervention to enhance even distribution of ventilation in mechanically - ventilated infants with respiratory distress syndrome. The impact of body positioning combined with LST on lung function for conditions with localized over inflation or unilateral pathology is another area that deserves further investigation.[46]

Vojta Method:

The Vojta method is a physical therapy, initially developed in the 1960's for the treatment of children with or at risk of cerebral palsy. It is a program that employs isometric strengthening techniques through tactile stimulation, to encourage the development of normal movement patterns and therefore to improve respiration.

Technique:

The neonates underwent phase 1 of reflex rolling according to Vojta. This manoeuvre does not require the newborn to be moved, but only a slight rotation of the head towards the side from which the stimulus is delivered. The starting position for performing the first phase of reflex rolling is the asymmetric supine position, with the limbs freely lying on the resting surface. A digitopressure will exert on the chest area, where the mammillary line crosses the insertion of the diaphragm, either at the level of the 6th rib, or between the 5th and the 6th, or between the 6th and the 7th. Each treatment consist in delivering four stimuli, two to the left half of the chest (stimulations I and II) and two to the right half of the chest (stimulations III and IV). Each stimulus consisted of a slight pressure, progressively oriented in dorsal, medial and cranial directions, diagonally to the spine. The treatment should repeat three times a day, at time intervals of 0, 2 and 4 hours.[50]

Evidence:

In 2010 Carmen Giannantonio and co workers found that this method is safe for preterm infant, but further investigations are necessary to confirm its positive effects and to evaluate long-term respiratory outcomes.[50]

In 2014 Jaitty Kole and colleagues concluded that reflex rolling is a safe and effective method in improving Oxygenation in preterm neonates with respiratory problems and can be applied in clinical settings. Newer physiotherapy techniques like LST and reflex rolling are equally effective in improving oxygenation in preterm neonates with respiratory problems[51]

CONCLUSION

In accordance to uniqueness of infant anatomy and physiology, advance chest physiotherapy should be apply in clinical practice along with conventional chest physiotherapy.

ABBREVIATIONS

CPT: Chest Physiotherapy Technique
CF: Cystic Fibrosis
EFIT: Expiratory Flow Increase Technique
LST: Lung Squeezing Technique
PD: Postural Drainage
PDPV: Postural Drainage Percussion Vibration
PSE: Prolonged Slow Expiratory Technique
SpO2: Saturation of Arterial Oxygen

Conflicts of interest: None

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