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Chest Physical Therapy For Pneumonia In Preterm Neonates

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ABSTRACT
Preterm neonates are particularly vulnerable to respiratory complications, including pneumonia, due to their underdeveloped lungs and immature immune systems. These vulnerabilities significantly contribute to high morbidity and mortality rates in this population. Effective management of neonatal pneumonia is critical for improving survival rates and minimizing long-term respiratory sequelae. Chest physical therapy (CPT) serves as a valuable adjunctive treatment, complementing medical interventions to enhance respiratory function in preterm neonates with pneumonia. To enhance mucus clearance and maximize lung function, conventional CPT procedures such postural drainage, percussion, and vibration have been used extensively. However, these methods may have limitations in addressing the unique needs of preterm infants. In recent years, innovative CPT techniques, including reflex rolling and lung squeezing, have emerged as promising alternatives. These techniques are designed to provide gentler, more targeted interventions, aligning with the physiological requirements of preterm neonates. Ongoing research is crucial to establish the safety, efficacy, and long-term benefits of these advanced approaches in neonatal care.

Keywords: *Lung squeezing, Preterm neonates, Reflex rolling.*

Introduction

Chest physical therapy (CPT) is generally improving breathing by removing mucus from the breathing airways of the patient. However, when applying CPT to preterm neonate, it is crucial to consider the unique characteristics of their respiratory systems. In neonates, the mechanical principles of chest physical therapy techniques are significantly different from those used in adults. The respiratory system of is under continuous structural and functional changes from birth to adulthood which requires ongoing adjustments to chest physical therapy techniques based on age. These changes may restrict the use of certain physical therapy methods **(Oberwaldner, 2000).**

Around the 4th week of gestation, a bud on the embryonic gut is developed as the beginning of lung development, while during the 4th–10th week of gestation the the diaphragm forms. In a fetus younger than 23 weeks of gestation, lung development is not sufficient, while Around 24 weeks of gestation alveolar or saccular stage takes place. Not until the last month of gestation (34 weeks) the secretion of surfactant, which reduces alveolar wall surface tension and increases alveolar distension and aeration become adequate **(Sinha, 2023)**.

During intrauterine life, the lungs have no function as it still filled with water. At birth, the neonate undergoes essential and rapid respiratory and cardiovascular changes to support them in life. The maturation of circulatory and respiratory systems must be rapid and adequate to align with these rapid changes, which occur at first minutes of birth **(Motoyama and Finder, 2011)**.

During the first year of life, there is rapid rate of lung development and growth. Around the 6th week of gestation, the lungs originate as a branch of the primitive foregut. At birth, the lungs are still immature, while postnatally, the number of alveoli increases by 15 times, and the air-tissue contact expands by more than 25 times (**Langston et al., 1984).**

The static, elastic recoil of the lungs is relatively very low in neonates that is because elastic fibers do not fully mature until the postnatal era; elastic fibers keep alveoli and respiratory bronchioles from collapsing by providing shape and outward traction. Neonatal lung compliance is very high, indicating a very low elastic recoil pressure **(Fagan, 1977)**.

The neonatal respiratory tract is compeletly different from adults due to its immaturity. Neonates have a flatter diaphragm, a wider sterno-costal angle, a more cartilaginous, cylindrical rib cage, and ribs positioned more horizontally, all contribute to neonates' smaller size. Their intercostal muscles are not-yet-fully-developed or functional, thus, work much less efficiently and the neonate becoming very dependent on their diaphragm for respiration. This flatter diaphragm is less effective and has more type 2 (fast-twitch) fibers in a higher ratio to type 1 (endurance) fibers, so it is more prone to respiratory fatigue than that of a fully developed individual **(Fouzas et al., 2023).**

Chest Physical Therapy

Chest physical therapy (CPT) is an essential part of neonatal care in neonatal intensive care units (NICU) and plays a vital role in the management of differenet respiratory disorders. CPT composed of various techniques; including percussion, vibration, airway suctioning and postural drainage. These techniques leads to facilitate airway clearance, remove tracheobronchial secretions, improve gas exchange, reduce airway resistance and enhance breathing **(Alfarizi et al., 2024; Chaves et al., 2019)**. In addition , CPT Speeds up the weaning of the ventilator, reduces respiratory complications, and support the re-expansion of collapsed lung lobes, contributing to faster recovery. It also improves respiratory muscles strength, increases lung expansion, reduces airways secreations, and enhances overall efficiency of respiration **(Battaglini et al., 2020)**.

Incorporating chest physical therapy as a supplementary approach to the treatment of hospitalized neonates with pneumonia remains a topic of discussion. Chest physical therapy has been widely applied to pneumonic neonates as it helps in evacuating inflammatory exudates, removing airway secretions, decreasing airway resistance, enhancing gas exchange, and improving the work of breathing **(Balachandran et al., 2005)**.

Chest physical therapy has been utilized as a supplementary treatment of neonates with pneumonia, leading to improved survival rates. It is divided into conventional, modern, and instrumental. Postural drainage, percussion and vibration, are considered conventional chest physical therapy techniques **(Freitas et al., 2018)**.

Postural Drainage

The earlist document mentioned the use of this technique was by Ewart in 1901, who described it as ‘empty bronchus treatment by posture in the bronchiectasis of children.’ Ewart recommended that patients sleep in specific positions that promote continuous drainage. Traditionally, they used head-down tilted positions. The anatomy of the lungs, especially different lobes and segments was described in 1934, which greatly contributed to the development of postural drainage **(Lannefors et al., 2004)**.

It involves positioning the child using the effect of gravity to mobilize secretions towards the main bronchus. Using chest radiographs and auscultation to detect the optimal position for postural drainage, in which the child can be positioned correctly to ensure more effective drainage of secretions from the most affected areas. The way that pediatrics respond to postural drainage is differes significantly from adults which requires modifications for this techniques when applied to pediatrics especially neonates **(Chaves et al., 2019).**

As a result of gravity, the movement of secretions is facilitated from the peripheral to the central airways, enhancing their clearance, enhancing the work of breathing, reducing cardiac workload, and helping in ventilation **(Clini et al.,2005)**.

There are two types of postural drainage techniques; standard and modified postural drainage. Standard postural drainage includes head-down tilt from 30° to 45°, while modified postural drainage includes 30° head-up tilt for the supine position, in addition to three horizontal positions; right side lying, left side lying, prone **(Main and Denehy, 2016**).

Preferring modified postural drainage rather than standard postural drainage (SPD) for preterm neonates with pneumonia may be attributed to the fact that modified postural drainage (MPD): Provides more stability in oxygen saturation than standard postural drainage (SPD), that crying lowers oxygen saturation during SPD and sleep shows higher saturation than wakefulness. On the other hand, in modified postural drainage (MPD), crying or arousal state has no effect on oxygen saturation, with similar values during sleep and wakefulness. It decreases frequency of upper respiratory tract symptoms and episodes of gastroesophageal reflux compared to standard postural drainage (SPD) **(Freitas et al., 2018)**.

Chest percussion

Chest percussion involves tapping with the cup of the hand in the chest to create vibrations in the airways, helping to loosening mucus which improving coughing efficiency. The purpose of chest percussion is to assist in the mobilization of bronchial secretions, making it easier for the patient to clear their airways **(Sharath et al., 2024**). This technique is performed by wrist motion, with support applied to the side of the chest opposite the area being percussed. Percussion can be performed during inspiration and expiration. It should be firm but not painful **(Hamed et al., 2022)**.

The chest physical therapist may use three fingers, both cupped hands, or a single hand, to perform percussion. he strikes repeatedly at a rate of about three strikes per second over the part of the chest lobe that requires drainges **(Chaves et al., 2019)**.

The cupped hand technique creates a cushion of air, which softens the impact during percussion. This air pocket inside the cupped hand helps effectively dislodge secretions in the underlying bronchus. The compression wave generated during percussion is transmitted to the bronchus, assisted by gravity, helping to move the secretions from the bronchus towards the glottis **(Balachandran et al., 2005)**.

Chest vibration

Neonates with respiratory disorders are treated with vibration as part of their chest physical therapy. The vibration is the application of gentle oscillatory Movement and rib compression by the hands during the chest wall's expiratory movement. The primary Purpose of vibration therapy is to aid in secretion Clearance. Vibration has been incorporated into Multimodal treatment regimens for patients with Excessive secretions in a number of studies **(Belli et al.,2021).**

Vibration technique is based on the principle that applying an external force to the chest wall loosens mucus, facilitates clearance of airway secreations. It involves rhythmically tapping the chest wall over specific lung areas with the flat hands **(Meawad et al.,2018).**

In this technique, a rapid vibratory impulses are transmitted from the flattened hands of the therapist by isometric alternate contraction of the forearm flexor and extensor muscles through the chest wall, which helps loosen the airway secretions **(Chaves et al., 2019)**. A brief, gentle, trill-like motion is used to produce gentle vibration during exhalation,. Gentle vibrations are applied to help moving secretions toward the proximal airways. The therapist apply manual vibrations using the fingers while, supporting the neonate's by the other hand **(Sharath et al., 2024)**.

Reflex rolling technique

Reflex rolling is a technique derived from Vojta therapy. It was developed in the 1960s by the Czechoslovakian neurologist Václav Vojta. This therapy is based on the observation of motor reactions occurring throughout the body in response to peripheral stimulation in specific positions. Dr. Vojta concluded that components of the muscle activity triggered by these stimuli are present in all forms of human movement **(Menéndez et al., 2023)**.

Reflex rolling has become a standard physical therapy treatment, particularly for children with mobility and respiratory problems. Through empirical observations, Dr. Vojta refined his method by studying the body's reactions to peripheral stimulations in specific positions. He discovered that certain elements of the general muscle activity provoked by this stimulation are fundamental to all forms of human locomotion **(Jung et al, 2017)**.

Reflex rolling is utilizing external stimuli in the form of digito-pressure on predefined body zones to activate the central nervous system (CNS) that employs tactile stimulation to the chest wall muscles to enhance the development of normal respiratory movement patterns **(Christian et al., 2014)**.

This technique involves a slight rotation of the head towards the stimulus side. For this technique, the starting position is the supine lying position, with the limbs resting freely beside the body. The therapist applies pressure by their fingers to the neonate's chest area where the mammillary line crosses the diaphragm, usually at the level of the 6th rib or between the level of 5th and 6th ribs. Each treatment consists of four stimuli: two stimulus applied to the right side and two to the left side of the chest. The stimuli are gradually applied in cranial, caudal, and medial directions, diagonally toward the spine **(Shanmugananth et al., 2017)**.

Lung squeezing technique

There are several important ways that the lung squeezing technique is different from conventional chest physical therapy techniques such as postural drainage, vibration and percussion. Each set of "lung squeezes" consists of three to four cumulative chest compressions, each lasting for five seconds, These are followed by a gentle "release phase," in which the chest wall is fully loosened. These compressions are applied to one chest side for five minutes at a time, and then to the other side for five minutes **(Wong and Fok, 2003)**.

Unlike conventional chest physical Therapy, these compressions are applied without vibration or the use of gravity. The application of chest compressions is not synchronized with the neonate's breathing pattern, and full-range compressions from full inspiration to the end of expiration are avoided to reduce the potential of harmful effects of reducing the end-expiratory lung volume **(Unoki et al., 2005)**.

The lung squeezing technique was performed to promote even airflow distribution throughout the lungs. It is performed by the same therapist on each side of the thorax, with the neonate placed in the supine position without body tilt. placing one hand on the posterolateral aspect of the hemithorax and the other covering the anterior chest, extending from the lower ribs to above the neonate's clavicle. **(Unoki et al., 2005)**. The procedure involved delivering three to four full chest compressions, each lasting five seconds, followed by a gentle, slow release phase. The same method was then applied to the opposite side **(Wong and Fok 2003)**.

Conclusion

In accordance to unique anatomy and physiology of lungs of preterm neonates, advanced chest physical therapy technigues such as reflex rolling and lung squeezing should be implemented in clinical practice alongside conventional chest physical therapy.

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The author reports no conflicts of interest in this work.

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