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Full Length Research Paper

Effect of cardiopulmonary physiotherapy on lung parameters in mechanically ventilated neonates

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Studies done in the past on cardiopulmonary physiotherapy in neonates, have not fully laid enough evidence, and several limitations have been quoted. The main purpose of this study was to evaluate the effect of chest physiotherapy, including suctioning on lung dynamics and lobar atelectasis. The secondary objectives were to explore sessions required to resolve collapse and the use of a detailed and replicable protocol of chest physiotherapy for ventilated neonates. Single group non-randomized blinded study design was used. Consecutive 42 mechanically ventilated neonates, consisting of 16 male and 26 female participants from a tertiary care hospital, with neonatal intensive care unit, was used for this study. Eleven babies were premature with 30 ± 3 weeks of gestational age whereas other babies had age of 15 ± 7 days after full term delivery. Techniques of cardiopulmonary physiotherapy, including humidification, positioning, postural drainage, percussion, vibration and endotracheal suctioning were applied. Dynamic compliance, inspiratory and expiratory resistance, reinflation of collapsed lung on chest x-ray were observed. The results found were statistically significant ($p < 0.0001$) for improvement in lung compliance, reduction in inspiratory and expiratory resistances, along with re-expansion of collapsed lobes. A carefully laid protocol of cardiopulmonary physiotherapy, individualized and when administered by an experienced and well trained cardiopulmonary physiotherapist, in association with multidisciplinary approach shows improvement in lung dynamics of ventilated neonates.

Key words: Neonates, mechanical ventilation, cardiopulmonary physiotherapy.

INTRODUCTION

Delivery of a baby from the mother's womb into the world is the most catastrophic event in a child's life. All babies compulsorily undergo the trauma of birth where there is a complex transition of placenta respiration to gas exchange in the lungs (Hough, 2001). Neonates, with compromised cardiorespiratory functions due to any reason, face a world where they have limited defenses in terms of respiration, kidney function or temperature control (Prasad and Hussey, 1995). Neonatal chest physiotherapy has become a routine method of care in neonatal intensive care units in the Western world while the same is less common in India, probably due to shortage of cardiopulmonary physiotherapy training in pediatrics and neonates (Bruno Demont and Claude Vincon, 2007).

Physiotherapy is generally sought when there is excess secretion, poor gas exchange, and increased work of breathing or radiologic evidence of atelectasis. Chest physiotherapy reference to treat post-extubation atelectasis is more common than treatment while babies are on mechanical ventilation. In our setting, chest physiotherapy for babies on ventilators is common, especially to treat lobar collapse. There are different techniques of cardiopulmonary physiotherapy (CPT) including humidification, positioning, postural drainage, percussion, vibration and endotracheal suctioning (Tudehope and

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Table 1. Demographic characteristics of subjects (n = 42).

Parameter	Mean ± SD
Age (days after delivery)	15±7
Age of 11 preterm babies (gestational age in weeks)	30±3
Gender (M/F)	16:26
Weight (g)	1577.8±331.7
ET size (mm internal diameter)	3.5±0.5
FiO_2 (%)	50±21
Respiratory rate (breaths per minute)	46±11
Peak inspiratory pressure (cmH_2O)	25±7.6
PEEP (cmH_2O)	5.0±2.8
Lobes involved (1:2 lobes)	29:13

Table 2. Primary medical diagnosis of subjects (n = 42).

Diagnosis	Subject (n = 42)
Respiratory distress syndrome	15
Transient tachypnea of newborn	04
Meconium aspiration	07
Pneumonia	11
Sepsis	02
seizure	03

Bagley, 1980; Oberwaldner, 2000).

Studies done in the past over CPT in neonates have not fully laid enough evidence, and several limitations have been quoted. A Cochrane review aimed to assess the effects of active CPT techniques, such as percussion and vibration, followed by suction compared with suction alone on the respiratory system in infants receiving mechanical ventilation. The results of this review did not provide sufficient evidence on which clinical practice can be based (Hough et al., 2008).

Another Cochrane review aimed to assess the effects of different positioning of newborn infants receiving mechanical ventilation on short term respiratory outcomes and complications of prematurity. The prone position was found to slightly improve the oxygenation in neonates undergoing mechanical ventilation. However, they found no evidence concerning whether particular body positions of the neonate during mechanical ventilation are effective in producing sustained and clinically relevant improvements (Balaguer et al., 2006).

The main purpose of this study was to evaluate the effect of chest physiotherapy, including suctioning on lung dynamics and lobar atelectasis. This study also tried to explore sessions required to resolve collapse, and lay down a detailed and replicable protocol of chest physiotherapy for ventilated neonates.

MATERIALS AND METHODS

This study was approved by the Institution's Ethic Committee. All mechanically ventilated neonates who were one month old after delivery were included in the study. Demographic characteristics of all subjects are shown in Table 1. A total of 42 subjects were recruited over a year. Out of 42 babies, 11 were pre-term. Age, gender, weight, primary medical condition, oxygenation and ventilation requirement, along with Positive end-expiratory pressure (PEEP) and PIP were recorded.

All the babies were followed up from the first day of ventilation. Prior to suctioning, all subjects were humidified with the help of an electronic nebulizer by bronchodialator. The babies were placed on both sides, lying for 10 min, and percussion was performed with the help of a mask. Vibrations with three fingers in tented position were applied to mobilize secretions for all the babies. Standard procedure was followed for each technique (Prasad and Hussey, 1995).

The suctioning procedure was performed as follows: (1) subjects were pre-oxygenated with 100% inspired oxygen for one minute prior to suctioning; (2) subjects were disconnected from the ventilator; (3) a suction catheter was passed down the endotracheal tube to beyond the tube tip while kinking the catheter; (4) on reaching the tip, continuous suction was applied, and the catheter was withdrawn while rotating slightly; (5) the subjects were then immediately hyperinflated with pediatric AMBU of 500 ml volume, while inflating only half the volume which was connected to 4 L/min of oxygen supply. If there was noted failure of desaturation with AMBU, the baby was reconnected to the ventilator circuit. Any adverse events were documented.

A catheter size of 6 fg was used, which was ideal according to endotracheal tube size. The suction apparatus was set to deliver a negative pressure of -60 to -80 mmHg. The suction catheter was in the endotracheal tube for <15 s.

Upon completion of suctioning, babies were reoxygenated with 100% FiO_2 for 30 s, and then the FiO_2 was immediately changed to presuction settings unless desaturation occurred, in which case, FiO_2 was gradually turned down as SpO_2 improved. Chest physiotherapy sessions, including suctioning, were provided by the first and the second authors. Recordings of outcomes were done for two sessions in morning and afternoon, on two consecutive days. Outcomes were recorded before and after each session at the 10th, 30th and 45th min. Dynamic compliance (DyC), inspiratory resistance, and expiratory resistance were major outcomes to understand the effect of intervention over lung dynamics. A chest X-ray was taken after an hour of each session to confirm resolution of lobar collapse.

Data analysis

Data was analyzed by SPSS (version 16.0; SPSSinc. Chicago, Ill USA). A blinded data analysis was used. ANOVA with repeated measures was used to analyze the changes in outcome variables across the sessions. Adjustments for multiple comparisons were done by Boneferroni test.

RESULTS

A total of 42 neonates were recruited for this study out of which 11 babies were preterm. Baseline characteristics of all neonates, including age, gender, weight, ET size, FiO_2, respiratory rate (RR), positive end expiratory pressure (PEEP), and lobar collapse are shown in Table 1. All

Table 3. Changes in outcome variables across the sessions (n = 42).

Variable	Day 1, Session 1 (min)				Day 1, Session 2 (min)				p
	Pre PT	Post (10)	Post (30)	Post (45)	Pre PT	Post (10)	Post (30)	Post (45)	
Dynamic compliance	31.3 ±5.7	32.0±5.5	32.3±5.6	32.1±5.5	31.4±5.6	31.7±5.4	32.1±5.5	32.5±5.2	0.003
Inspiratory resistance	58.0±7.8	50.5±8.1	47.1±6.3	51.8±8.8	59.8±5.2	54.9±6.6	52.1±6.7	48.4±8.1	≤0.0001
Expiratory resistance	87.0±5.8	82.6±7.4	82.7±6.9	83.9±6.1	88.2±8.5	84.2±7.9	84.9±5.1	85.4±5.8	≤0.0001
	Day 2, Session 3 (min)				Day 2, Session 4 (min)				
Dynamic compliance	31.8±5.4	32.0±5.5	32.5±5.7	33.6±5.8	33.0±6.4	34.0±7.8	34.7±9.3	37.5±11.9	≤0.0001
Inspiratory resistance	58.7±8.5	55.7±6.4	50.3±6.7	49.3±8.4	58.0±8.2	58.0±7.4	58.0±7.6	58.0±7.1	≤0.0001
Expiratory resistance	88.1±4.9	79.9±9.1	82.8±8.6	80.6±10.1	83.0±10.5	80.2±8.4	81.6±9.5	78.9±11.2	≤0.0001

1. All the babies had a primary medical diagnosis which necessitated use of mechanical ventilation, and details of diagnoses is shown in Table 2. When dynamic compliance was recorded, pre and post CPT at 10th, 30th and 45th min yielded a significant difference in each session; however differences were more after the 3rd and 4th sessions on the second day ($p \leq 0.0001$). Inspiratory and expiratory resistances showed highly significant reduction after each session, and these differences are statistically ($p \leq 0.0001$) as well as clinically significant. The mean changes with standard deviations after each session with p values are mentioned in Table 3. Sessions required to show resolution of lobar collapse on chest x-ray (CXR) ranged from 2 to 3, and mean with standard deviation was 2.6 ± 0.78.

DISCUSSION

This study recruited 42 consecutive neonates who were mechanically ventilated due to primary medical diagnoses as shown in Table 2. Our study tested the efficacy of a full treatment protocol in neonates for the first time. Dynamic compliance improved from pre to post chest physiotherapy in all sessions. However, dynamic compliance improved more after second session on second day. This could be attributed to reinflation of collapsed lobes of the lungs and secretion clearance.

Inspiratory resistance reduced from pre to post in all sessions, which was clinically significant. There was no reduction or increase in inspiratory resistance after session 2 of the second day. This finding requires further investigation while one probable reason could be minimum stable resistance during the last session. Expiratory resistance also decreased from pre to post chest physiotherapy after all sessions on both days. This change was statistically and clinically meaningful. These positive changes could be due to secretion clearance and relieved bronchospasm which stabilizes the chest and improves compliance as well.

A study by Morrow et al. (2006) reported a reduction in compliance and increase in resistances post suction which could be attributed to the fact that readings were taken immediately upon post suction. Report on whether values stabilized or not over a long period of time was not done. We have taken readings at 10th, 30th and 45th min of post CPT sessions to see changes in values over a period. It is noteworthy that values showed more stability after 10 min. Another study reported an improvement in lung compliance and reductions in resistances after CPT and data was recorded past 10, 40 and 70 min. Findings of this study are in parallel with our study (Mara Lisiane et al., 2009).

In another study, patients were randomized into one of three treatment groups: Group 1 (suctioned only); Group 2 (positioned and suctioned); and Group 3 (positioned, manually hyperinflated and suctioned). Baseline and 10, 30 and 60 min post-treatment data were recorded for dynamic pulmonary compliance, arterial blood gases and haemodynamic variables. Derecruitment was an important finding reported by authors (Barker and Adams, 2002). Sessions required for reinflation of collapsed lung on chest X-ray was three, however this change was dependent on the number of lobes involved. More than one lobe involvement took more sessions for re-expansion than single lobe involvement.

Some studies reported adverse effects of CPT like hypoxemia, bruising, rib fractures and intracranial hemorrhage due to which efficacy of

CPT has been questioned. In our study, these adverse events did not occur. We believe that Neonatal intensive care unit (NICU) is a unique environment and requires the best skills and expertise before handling the neonate.

Three trials involving 106 infants were included in a Cochrane systematic review, which showed conflicting results (Hough et al., 2008). In one trial (n = 20), CPT was not better than standard care in clearing secretions. In the review, author has defined active CPT as vibration or percussion, with or without the use of devices such as face masks and electric vibrators, followed by suction, compared with standard care (that is suction with or without positioning). No increase in the risk of intraventricular haemorrhage was noted (Raval et al., 1987). The other trial (n = 30) showed that the use of percussion or 'cupping' resulted in an increased incidence of hypoxaemia (RR 0.53; 95% CI, 0.28 to 0.99) and increased oxygen requirements (MD -9.68; 95% CI -14.16 to -5.20) when compared with contact heel percussion. There was insufficient information to adequately assess important short and longer-term outcomes, including adverse effects (Peters, 1983). In another trial (n = 56), it showed that non-resolved atelectasis was reduced in more neonates receiving the lung squeezing technique (LST) when compared to postural drainage, percussion and vibration (RR 0.25; 95% CI, 0.11 to 0.57). No difference in secretion clearance or in the rate of intra-ventricular haemorrhage or periventricular leucomalacia was demonstrated (Wong and Fok, 2006).

Authors of the same Cochrane review have recommended that further well-designed trials are required to assess the risks and benefits of CPT in the treatment of respiratory diseases in ventilated neonates. Future trials should be adequately powered to address clinically important outcomes, particularly for the high risk population of infants < 30 weeks gestation. Clinically important outcomes which should be assessed include duration of ventilation, duration of oxygen therapy, length of hospital stay, and presence of intracranial lesions. Shorter-term outcomes such as resolution of atelectasis, oxygenation, and other lung function variables such as ventilation distribution should also be included. Costs also need to be considered. Some of the important clinical and economic outcomes that remain unmeasured by the current research are likely to require a very large sample size, therefore, a large multicentre trial would be recommended. We could not randomize our study but we have taken few recommended outcomes as our study outcomes (Hough et al., 2008).

In a study done by the same author, lung mechanics were recorded for five minutes before and five minutes after a standardized suctioning procedure in 78 patients intubated with endotracheal tubes (≤ 4.0 mm internal diameter). There was a significant overall decrease in dynamic compliance ($p < 0.001$) and mechanical expired tidal volume ($p = 0.03$) following suctioning, with no change in the percentage endotracheal tube leak ($p = 0.41$). The change in dynamic compliance was directly related to both endotracheal tube and catheter sizes. This study demonstrated that endotracheal suctioning frequently caused an immediate drop in dynamic compliance and expired tidal volume in ventilated children with variable lung pathology, intubated with small endotracheal tubes, probably indicating loss of lung volume caused by the suctioning procedure (Morrow et al., 2006). Our study showed no reduction in dynamic compliance while the changes in inspiratory and expiratory resistances were significant.

A review was done by Morrow and Argent (2008) to provide evidence-based review of pediatric endotracheal suctioning, its effects, indications, and clinical practice. One hundred and eighteen references were included in the final review. Despite the widespread use of endotracheal suctioning, very little high-level evidence was found. Authors concluded that suctioning should be performed when obstructive secretions are present, rather than routinely. Authors further recommended that routine saline instillation before suctioning should not be performed. In addition, recruitment maneuvers performed after suctioning have not been shown to be useful as a standard practice. They further recommended that controlled clinical studies are needed to develop evidence-based protocols for endotracheal suctioning of infants and children, and to examine the impact of different suctioning techniques on the duration of ventilatory support, incidence of nosocomial infection, and length of pediatric intensive care unit and hospital stay.

A previous study has reported that chest and motor physiotherapy improved cardiovascular parameters in respiratory distress syndrome newborns (Abreu et al., 2011a). Torigoshi et al. (2011) recommended the implementation of a specialized newborn health accompaniment after neonatal ICU discharge for proper and positive outcomes regarding their future growth and development, is of uttermost importance for proper and positive outcomes regarding newborns future growth and development in Brazil. A study reported that chest and motor physiotherapy acutely improves heart rate (HR), RR, symptom association probability (SAP), minute-to-minute mean arterial pressure (MAP) and SO_2% in newborns with Acute respiratory distress syndrome (ARDS), where comparisons of outcomes were made between six sessions on same day (Abreu et al., 2011b). Chest physiotherapy, along with motor physiotherapy treatment, acutely improved SO_2%, HR and RR in premature Peri-Intra-Ventricular Hemorrhage (PIVH) newborns. Authors recommended performing chest and motor physiotherapy in neonatal critically ill newborns (Abreu et al., 2011c).

Our study has examined few aspects of the recommendations by the authors. An important fact lying in neonatal study is who performs the intervention, and therapist's experience of working with neonates. A lot of misoccurrence can be avoided by proper handling and adequate monitoring while treating the baby. A rescue must be brought in at any point of intervention if there is consistent fall in SpO_2 or change in Electrocardiography (ECG) or other vitals. A multidisciplinary team for neonates in NICU comprises of supervising Neo-nathologist/ pediatrician, Cardiopulmonary physiotherapist therapist, Child psychologist, NICU nurses, and parents of the baby. Regular discussions about the baby among the team can fetch better results over the outcome of the baby.

There are several limitations of this study. This study is non-randomized with no control group, and sample size was not calculated. We recommend future researches based on randomized control trials, and also to understand whether chest physiotherapy during ventilation period minimizes the risk of post-extubation atelectasis. However, this study tried to explore the effects of chest physiotherapy in neonates, which is still a less researched area. This research also tried to explore important parameters which determine recovery of neonates with a systematic CPT approach.

Conclusion

Chest physiotherapy in ventilated neonates is a popular treatment choice but there is lack of evidence due to shortage of studies in this area. A well designed chest physiotherapy protocol and multidisciplinary approach may help ventilated neonates in improvement of lung dynamics and atelectasis.

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