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Chest Physiotherapy and Post-Extubation Atelectasis in Infants

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Summary. We investigated the role of chest physiotherapy (CPT) in preventing post-extubation atelectasis (PEA) in infants. Sixty-three infants who were admitted to the neonatal intensive care unit and intubated for more than 24 hours and who showed no evidence of atelectasis by chest x-ray prior to extubation were enrolled in the study. Infants were randomly assigned to 2-hourly CPT, 4-hourly CPT, or a no CPT group. Chest physiotherapy began immediately after extubation and consisted of postural drainage, bilateral chest vibration, and suctioning. A second chest x-ray was obtained on all infants 24 hours following extubation. The three groups were comparable in birth weight, gestational age, and duration of intubation. In the 24-hour period following extubation, the incidence of PEA was not statistically significant in the three groups ($P = 0.33$). Two infants in the 2-hourly CPT group were placed on nasal continuous positive airway pressure; two in each of the 2-hourly and the no CPT groups required re-intubation and intermittent positive pressure ventilation to treat symptomatic atelectasis. We conclude that post-extubation chest physiotherapy as used in this study did not prevent atelectasis in extubated infants. **Pediatr Pulmonol. 1996; 21:227–230.**

Key words: Chest physiotherapy, atelectasis, mechanical ventilation, infants.

INTRODUCTION

The precise incidence of post-extubation atelectasis (PEA) in neonates is unknown. Significant atelectasis following extubation probably reaches 30–50%.[1–4] However, in spite of this high incidence, the exact mechanism of post-extubation atelectasis has not been fully determined. Several factors may play an important role in the process that causes alveolar collapse.[5] Neonates are sensitive to the obstructing effects of accumulating airway secretions, most likely because of small airway size and a less effective cough secondary to muscle weakness. Endotracheal tubes complicate this problem by impairing mucociliary clearance and by inhibiting an effective cough. In addition, neonates have a decreased number of pores of Kohn, which limits collateral ventilation.[6] The secretions can cause bronchial obstruction and lung collapse as air beyond the obstruction is absorbed. Chest physiotherapy (CPT), however, has been used as a method of moving obstructing secretions, enhancing mucociliary clearance, and re-expanding the atelectatic regions of the lung. Moreover, its use has been promoted as a method of preventing PEA, although this practice has not been evaluated by controlled studies on a large number of patients. We therefore decided to evaluate the efficacy of CPT in preventing post-extubation atelectasis in infants.

MATERIALS AND METHODS

All infants admitted to the neonatal intensive care unit (NICU) at King Faisal Specialist Hospital and Research Center, Riyadh, Saudi Arabia between February 1993 and April 1994, who required intubation for more than 24 hours and who were electively extubated, were considered candidates for the study. Infants with meconium aspiration or bacterial pneumonia were excluded. A chest radiograph was obtained prior to extubation, and only those with no evidence of atelectasis were included in the study. Birth weight, gestational age, age at intubation, duration of intubation, and fraction of inspired oxygen (FiO_2) before extubation were recorded. Thirty-three infants in the study group were diagnosed as having respiratory distress syndrome (RDS). Other indications for intubation included thoracoabdominal surgery (19), sepsis (3), hydrops fetalis (2), birth asphyxia (4), and apnea of prematurity (Table 1). None of the infants in the study group received steroid therapy during their hospital course. Oral tracheal intubation was performed with a Portex polyvinyl chloride endotracheal tube (Sims Industries, Keene, NH). The position of the endotracheal tube was confirmed by chest radiograph and was maintained below the first thoracic

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TABLE 1—Types of Underlying Diseases in the Three Chest Physiotherapy (CPT) Groups

Type of disease	No CPT	CPT every 2 hr	CPT every 4 hr
Respiratory distress syndrome	14	9	9
Thoracoabdominal surgery	4	7	8
Others	5	3	5
Total	23	19	22

vertebra and at least 0.5 cm above the carina. Routine endotracheal tube care consisted of instillation of 0.5 mL of normal saline followed by suctioning with a no. 6F, or larger, catheter every 2 to 4 hours.

Weaning from the ventilator was accomplished by a standard protocol adopted in our NICU. This protocol consisted of weaning peak inspiratory pressures and respiratory rates to a minimum, reducing the FiO_2 to 35% or less, and maintaining an oxygen saturation between 88 and 94%. Lower saturations were accepted for infants with congenital heart diseases due to right to left shunting. Prior to extubation infants were randomly assigned to one of three chest physiotherapy protocols: *2-hourly, 4-hourly,* or *no physiotherapy* by selection from sealed and shuffled envelopes. Feeding was suspended for at least 2 hours before and 4 hours after extubation. Infants were extubated when the rate of mechanical ventilation had fallen to 6 cycles/min or when continuous positive airway pressure (CPAP) support had decreased to 3 cm H_2O.

All CPT was performed by trained respiratory therapists. CPT began immediately after extubation and consisted of postural drainage and bilateral chest vibration. A Neo-cussor (General Physiotherapy, St. Louis, MO) was used to perform vibration on each side of the chest with infants lying in a lateral decubitus position for 5 minutes. Following this, infants received oral suctioning and nasotracheal suctioning if required. A chest radiograph was obtained on all infants 24 hours following extubation. When there was evidence of atelectasis, CPT was continued for a further 24–48 hours. CPT was initiated every 2–4 hours for a 24–48 hour period in those infants who had received no physiotherapy group but developed atelectasis. Each chest radiograph was reviewed by a pediatric radiologist who was unaware of study group assignment.

Statistical Analysis

Analysis of variance (ANOVA) and the Kruskal-Wallis test were used to compare birth weight, gestational age, duration of ventilation, age at intubation, and FiO_2 required before extubation in the three groups. The Chi-square test was used to compare the incidence of atelectasis among the three groups. To adjust for the effect of the disease process, the patients were classified into three different groups, i.e., primary respiratory disease, thoracoabdominal surgery, and others. The Cochran-Mentel-Haenszel test[7,8] was used to compare the incidence of post-extubation atelectasis in the three study groups. The effect of age at intubation on outcome (post-extubation atelectasis) was adjusted for in the following manner: A comparison for the primary outcome was made by including only those babies with an intubation age of 20 days or less. In a further analysis, all babies were divided into various intubation age groups, and the Cochran-Mentel-Haenszel technique was used to adjust for the effect of this age factor. The statistical analysis was performed to detect a significant difference, but the result was negative. The power was recomputed and found to be low (less than 50%), as is common when the trial is inconclusive. Statistical significance was determined by a P value of <0.05.

RESULTS

Of the 64 infants enrolled in the study, data were collected in 63. One infant was excluded because of reintubation due to apnea of prematurity 16 hours after extubation. Post-extubation atelectasis was documented in three (13%) of the no CPT group, in six (31.5%) of the 2-hourly group and in six (27.2%) of the 4-hourly group. There were no statistically significant differences among the groups ($P = 0.30$; Table 2). Atelectasis was localized to the right lower lobe in 3 and to the right upper lobe in 12 infants. RDS was the primary diagnosis in all three infants who were found to have atelectasis post-extubation in the no CPT group. Of the six infants in the 2-hourly group who developed PEA, four had RDS, one had hydrops fetalis, and the other underwent thoracoabdominal surgery. Of the six infants who developed PEA in the four-hourly group, three had undergone thoracoabdominal surgery; each of the other infants had either apnea of prematurity, hydrops fetalis, or sepsis. Analysis of the data using disease process as a factor showed no statistically significant difference ($P = 0.22$). This finding suggests that there was no difference in the incidence of atelectasis among those infants with primary lung disease, those who underwent thoracoabdominal surgery, or those who suffered from other disease processes. Infants who developed atelectasis experienced excessive pulmonary secretions during their clinical course. Desaturation was observed in most of the infants during the CPT procedure. These episodes of desaturations were

TABLE 2—Characteristics of Infants on Three Chest Physiotherapy (CPT) Protocols[1]

Characteristic	No CPT (n = 23)	2-hourly CPT (n = 19)	4-hourly CPT (n = 22)	*P* value
Birth weight (g)	1,965 ± 0.85	2,240 ± 1.02	2,200 ± 0.94	NS
Gestational age (wk)	33.04 ± 5.36	34.3 ± 5.49	34.7 ± 5.66	NS
Age at intubation (day)	1.7 ± 3.33	7.6 ± 13.66	11.3 ± 16.8	< 0.05
Duration of intubation (day)	8.3 ± 12.22	11.2 ± 16.72	11.4 ± 13.76	NS
FiO_2 before extubation	0.24 ± 0.04	0.25 ± 0.05	0.24 ± 0.04	NS
Post-extubation atelectasis [no. (%)]	3 (13)	6 (31.5)	6 (27.2)	NS

[1]Data are presented as mean ± SD.
FiO_2, fraction of inspired oxygen.

self-limited and bagging was not required. Concern was raised by NICU nurses regarding frequent disruption of the infant's sleep pattern and interference with feeding schedules, particularly in the 2-hourly CPT groups.

Analysis of birth weight, gestational age, duration of intubation, and FiO_2 requirement before extubation showed no statistically significant relation among the three groups. Age at intubation was, however, statistically different among the three groups. The longest period of intubation for group 1 (no CPT) was 17 days. We only considered the babies with intubation for less than 20 days and made a comparison of the three groups. The three groups were not different irrespective of the length of intubation. In a further analysis, the infants were divided into groups with different durations of intubation; the Cochran-Mentel-Haenszal technique showed no significant difference in the incidence of PEA among the three groups ($P = 0.43$). The numbers of infants extubated following CPAP were nine, four, and two in the no CPT, 2-hourly, and 4-hourly groups, respectively. Two infants in the 4-hourly CPT group and two from the no CPT groups developed atelectasis and required reintubation. Two infants from the 2-hourly CPT group developed atelectasis and required nasal CPAP.

DISCUSSION

Chest physiotherapy is generally thought to be useful in preventing post-extubation atelectasis. We found no statistically significant difference in the incidence of atelectasis after extubation among the groups that received post-extubation physiotherapy and those that did not receive such therapy. The only prospective study examining PEA is that of Finer et al.,[4] who studied 42 infants in 1979. They found no PEA in the CPT group compared with a 38% incidence of PEA in the no CPT group. In their study, postural drainage with percussions and vibrations using a manual finger technique depressing the infant's chest 1–2 cm was started 1 hour prior to extubation. Immediately following extubation an intensive physiotherapy routine was instituted, consisting of hourly and 2-hourly treatments for the first 24 hours, and 3 hourly treatments for an additional 24 hours. Following extubation, postural drainage was performed in one of the standard positions for the segments of the right upper lobe. The position was changed hourly. Chest vibrations were performed for a minimum of 5 minutes out of each hour over the area of the lung being drained and was followed by oral suctioning. Their study differed from ours in that they included infants with meconium aspiration and bacterial pneumonia (the former having been reported to cause long-term pulmonary function abnormalities).[9] Our protocol also differed in that all of our infants were orally intubated, whereas Finer et al.'s[4] infants were nasally intubated. This may explain the lower incidence of PEA (13%) in our control group compared with theirs (38%). Previous investigations found a decreased risk of PEA in infants intubated with oral endotracheal tubes compared with nasotracheal tubes, after standardizing the endotracheal tube care.[2,3] The CPT used in their study was intense and more frequent than ours; however, they did not report whether it was well tolerated. Even when using a Neo-cussor in which the infant's head was supported, we observed frequent desaturations among infants receiving CPT. We also found that the 2-hourly CPT did interrupt the routine care provided for these infants.

CPT has been implicated in an increased incidence of atelectasis in pediatric and adult patients after cardiovascular surgery.[10] Interestingly, the smallest number of patients with PEA in our study occurred in the no CPT group, although it was not statistically different from the other two groups. This most likely was due to splinting the chest cage during the CPT procedure with subsequent decrease in the functional residual capacity. A number of studies have reported significant complications due to CPT including intraventricular hemorrhage,[11] multiple rib fractures,[12] and generalized periosteal reaction.[13] Recent reports have suggested a link between CPT techniques, such as percussion that caused head movement, and brain damage or even death.[14] A New Zealand nursery reported that percussion physiotherapy was suspected to have caused the death of five babies and brain damage in eight others and that CPT on newborn low-birth-weight babies had been banned.

In our study we tried to minimize complications by using vibration instead of percussion. We have found that percussion was frequently associated with an increase in heart rate and desaturation. Others have reported similar findings. Duara et al.[15] studied percussion time intervals of 0.5, 1.5, and 2.5 minutes. Six neonates with RDS were enrolled in a program of six postural drainage positions per session, at 2-hourly intervals for three sessions. The results of the three sessions showed a decrease in transcutaneous oximetry. Holloway et al.[16] reported a decrease in arterial oxygen tension (PaO_2) in 51 neonates immediately after receiving CPT. Similarly, Fox et al.[17] reported hypoxia following treatment with percussion and suctioning, without improvement in pulmonary functions.

A large variation in CPT protocols is seen in NICUs.[18] The results have shown that there are large differences in the post-extubation treatment protocols used in NICUs, ranging from no treatment to half hourly treatment over 24–48 hours. The same study[18] also pointed out that studies recommending CPT for prevention of PEA were limited by small sample size; therefore, data obtained from these studies should be interpreted with caution. Since different techniques and protocols have been used, objective comparison between these studies is difficult.

In conclusion, our study has shown that CPT (vibrations and postural drainage) is not effective in preventing post-extubation atelectasis. In view of the complications associated with CPT, the benefits of post-extubation CPT for newborn infants is questionable and should be reviewed.

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REFERENCES

1. Engelke SC, Roloff DW, Kuhns LR. Post-extubation nasal continuous positive airway pressure. Am J Dis Child. 1982; 136: 359–361.
2. Spitzer AR, Fox WW. Post-extubation atelectasis—the role of oral versus nasal endotracheal tubes. J Pediatr. 1982; 100:806–810.
3. McMillan DD, Rademaker AW, Buchan KA, Reid A, Machin G, Sauve RS. Benefits of orotracheal and nasotracheal intubation in neonates requiring ventilatory assistance. Pediatrics. 1986; 77: 39–44.
4. Finer NN, Moriartey RR, Boyd J, Philips HJ, Stewart AR, Ulan O. Post-extubation atelectasis: A retrospective review and a prospective controlled study. J Pediatr. 1979; 94:110–113.
5. Mellins R. Pulmonary physiotherapy in the pediatric age group. Am Rev Respir Dis. 1979; 110:137–142.
6. Murray JF (ed). The Normal Lung: The Basis for Diagnosis and Treatment of Pulmonary Disease. Philadelphia: WB Saunders, 1976:51 p.
7. Cochran WG. Some methods for strengthening the common χ^2 tests. Biometrics. 1954; 10:417–451.
8. Mantel N, Haenszel W. Statistical aspects of the analysis of data from retrospective studies of disease. J Natl Cancer Inst. 1959; 22:719–748.
9. Marshall R, Tyrala E, McAlister W, Sheehan M. Meconium aspiration syndrome: Neonatal and follow-up study. Am J Obstet Gynecol. 1978; 131:672–676.
10. Iverson LIG, Ecker RR, Fox HE, May IA. A comparative study of IPPB, the incentive spirometer and blow bottle: The prevention of atelectasis following cardiac surgery. Ann Thorac Surg. 1978; 25:197–200.
11. Ravel D, Cuevas A, Mora A, Yeh TF, Pildes RS. The efficacy of chest physiotherapy (CPT) on the first postnatal day in infants with RDS (abstract). Pediatr Res. 1985; 19(Suppl):359A.
12. Purohit DM, Caldwell C, Levkoff AH. Multiple rib fractures due to physiotherapy in a neonate with hyaline membrane disease. Am J Dis Child. 1975; 129:1103–1104.
13. Wood B. Infant ribs: Generalized periosteal reaction resulting from vibrator chest physiotherapy. Radiology. 1987; 162:811–812.
14. Coney S. Physiotherapy technique banned in Auckland. Lancet. 1995; 345:510.
15. Duara S, Bessard K, Kezzler L, Artes D, Batzer K. Evaluation of different percussion time intervals of chest physiotherapy on neonatal pulmonary function parameters. Pediatr Res. 1983; 17: 310A (Abstr.).
16. Holloway R, Adams E, Desai S, Thambiran A. Effect of chest physiotherapy on blood gases of neonates treated by intermittent positive pressure respiration. Thorax. 1969; 24:421–426.
17. Fox W, Schwartz J, Shaffer T. Pulmonary physiotherapy in neonates: Physiological changes and respiratory management. J Pediatr. 1978; 92:977–981.
18. Lewis JA, Lacey JL, Henderson-Smart DJ. A review of chest physiotherapy in neonatal intensive care units in Australia. J Pediatr Child Health. 1992; 28:297–300.