Postextubation atelectasis: A retrospective review and a prospective controlled study

To determine the role of chest physiotherapy in the prevention of postextubation atelectasis in neonates intubated for greater than 24 hours, a retrospective survey compared the incidence of this complication in a newborn intensive care unit prior to and following the institution of a routine of chest physiotherapy. Eight of 23 infants extubated developed atelectasis in the "pre-physio" period, whereas only one collapse occurred in 20 infants treated with a routine of physiotherapy at extubation ($P < 0.025$). Subsequently a prospective controlled trial compared the use of a routine of physiotherapy at extubation with no physiotherapy. Eight of 21 infants not receiving physiotherapy developed postextubation atelectasis and none of 21 infants receiving physiotherapy developed atelectasis ($P < 0.01$). Seventy-six percent of the collapses involved the right upper lobe. A vigorous program of chest physiotherapy, including postural drainage emphasizing the positions of the right upper lobe and chest vibrations, will significantly reduce the incidence of postextubation atelectasis.

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POSTEXTUBATION PULMONARY ATELECTASIS is a frequent complication of endotracheal intubation in neonates and, in a recent study, occurred in 41% of all intubated infants.[1] Fox et al[2] have reported that 50% of intubated neonates weighing less than 1,250 gm require reintubation for this complication. Reports describing this condition recommend the use of chest physiotherapy to reduce its frequency or to treat the atelectasis when it has occurred, but do not detail the method of physiotherapy to be utilized. There has been no objective documentation of the value of a routine of chest physiotherapy for the prevention or treatment of postextubation atelectasis. A retrospective survey was carried out to compare the experience with postextubation atelectasis in our intensive care unit prior to and following the appointment of a full-time physiotherapist. Upon completion of the retrospective review, a prospective controlled trial was undertaken to evaluate the role of chest physiotherapy.

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METHODS AND MATERIALS

In March, 1975, a uniform approach toward the intubation, stabilization, maintenance, and removal of endotracheal tubes, as well as the technique of mechanical ventilation, was instituted in the Intensive Care Unit of the Royal Alexandra Hospital and continues unchanged to the present time.

All tracheal intubations were performed by an attending neonatologist or by a house officer with a neonatologist in attendance. Nasotracheal intubation was performed in all circumstances, using only a No. 3.0 or larger polyvinyl chloride non-tapered endotracheal tube. Endotracheal tubes were positioned by suprasternal palpation[3] and the position was confirmed by chest roentgenogram. The tubes were secured with a circumferential tape around the head with suturing of the endotracheal tube to the tape.

Routine endotracheal tube care consisted of the instillation every one to two hours of 0.25 to 0.5 ml of isotonic saline using the technique of Gregory,[4] with the head turned 90 degrees to the right followed by suctioning with a No. 8 French or larger suction catheter with multiple end and side holes.[5] This procedure was repeated with the head turned 90 degrees to the left.

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Table I. Retrospective study: Comparison between infants receiving physiotherapy vs no physiotherapy

	No physiotherapy (N = 23)		*Physiotherapy (N = 20)*		
	Mean	*Range*	*Mean*	*Range*	P
Birth weight (gm)	2,098	1,140-4,600	2,256	1,010-3,820	NS*
Gestation (wk)	33.4	29-41	33.8	28-40	NS*
Age at intubation (hr)	19.9	0.1-81	14.6	.1-53	NS*
Duration of intubation (hr)	184.3	36-420	225.1	29-830	NS*
Duration $FI_{O_2} > 0.6$ (hr)	35.6	0-192	32.2	0-120	NS*
Postextubation atelectasis	8		1		< 0.05†
Reintubated for postextubation atelectasis	3		1		

*Analysis by nonpaired Student t test.
†Analysis by chi-square with Yates correction; $\chi^2 = 4.08$.

Table II. Prospective study: Comparison between infants receiving physiotherapy vs no physiotherapy

	No physiotherapy (N = 21)		*Physiotherapy (N = 21)*		
	Mean	*Range*	*Mean*	*Range*	P
Birth weight (grn)	2,339	1,020-3,960	2,400	1,460-4,190	NS*
Gestation (wk)	35	30-42	35.9	31-43	NS*
Age at intubation (hr)	63	0.1-422	15.8	0.1-96	< 0.05*
Duration of intubation (hr)	159.3	30-409	144.6	37-406	NS*
Duration $FI_{O_2} > 0.6$ (hr)	8.7	0-48	24.7	0-124.5	< 0.05*
Postextubation atelectasis	8		0		< 0.01†
Reintubation for postextubation atelectasis	7		0		

*Analysis by nonpaired Student t-test.
†Chi-square analysis with Yates correction: $\chi^2 = 7.56$.

All extubations were performed between 9 and 10:30 AM. All infants received 1 mg/kg of dexamethasone intravenously one hour prior to extubation, and all feedings were discontinued six hours prior to extubation.

All infants who were studied required mechanical ventilation with a Baby Bird ventilator and received low pressure ventilation as described by Herman and Reynolds[6] and Reynolds,[7] Initial settings on the ventilator were a peak inspiratory pressure of 18 cm H_2O, end expiratory pressure of 4 cm H_2O, and a respiratory rate of 20 to 25 breaths/minute with an inspiratory time of 1.2 to 1.4 seconds as measured from a Bourns LS 160 ventilator monitor (Riverside, Calif.). Subsequent alterations were based on blood gas analysis.

Retrospective study. From March, 1975, until November, 1975, there was no established routine of physiotherapy during the postextubation period (the "pre-physio era"). On November 1, 1975, a chest physiotherapist (J. B.) was appointed to the intensive care area and a rigid routine of physiotherapy was established for the extubation period. All records were reviewed for infants intubated for more than 24 hours and successfully extubated from March, 1975, until June, 1976. Since there was a continuing evaluation of mechanical ventilation of the neonate during this period, all infants had a prospective data sheet completed during their course in the nursery, which included the times and numbers of intubations, extubations, pre- and postextubation blood gas determinations, and results of chest roentgenograms. These data forms were consulted and the roentgenograms were reviewed by a pediatric radiologist, (H. P.) without knowledge of the diagnosis or treatment. Additional information was obtained from the charts when necessary. Birth weight, gestation, age at intubation, duration of intubation, and duration of exposure to greater than 60% oxygen are shown in Table I. Twenty-six infants had hyaline membrane disease. The remaining 17 infants had a variety of diagnoses including meconium aspiration (2), bacterial pneumonia (5), asphyxia (2), thoracoabdominal surgery (6), hydrops (1), and congenital laryngeal stridor (1).

Prospective study. All infants intubated for greater than 24 hours and who were subsequently extubated from

September, 1976, until September, 1977, were studied. The birth weight, gestation, age at intubation, duration of intubation, and duration of exposure to greater than 60% oxygen are shown in Table II. Fifteen infants in the prospective study had hyaline membrane disease, other diagnoses included meconium aspiration (5), bacterial pneumonia (6), asphyxia (5), thoracoabdominal surgery (7), and apnea (4). A chest roentgenogram was obtained on the day prior to the extubation; only infants with no evidence of atelectasis at that time were included in the study. On the evening prior to the planned extubation, the infants were randomly assigned to receive either a routine of chest physiotherapy or no physiotherapy by selecting from a group of sealed and shuffled envelopes.

The routine of chest physiotherapy for both the retrospective and prospective study began one hour prior to extubation and consisted of postural drainage for the lower lobes in conjunction with percussions and vibrations. Immediately following extubation, postural drainage was performed in one of the standard positions for the segments of the right upper lobe, the position being changed hourly, with chest vibrations performed for a minimum of five minutes out of each hour over the area of the lung being drained. The technique of vibrations consisted of placing the index and second fingers of one hand over the index and second finger of the other hand at right angles to each other and applying anteroposterior oscillatory movements in direct contact with the chest wall. Pressure was applied along the middle and distal phalanges and not with the fingertips in an attempt to achieve a thoracic displacement of 1 to 2 cm. These were performed during expiration when possible, lasting for 3 to 4 seconds with a 3 to 4-second pause between vibrations. Following chest vibrations, oral suctioning was performed to remove accumulated secretions. The physiotherapy was performed by a physiotherapist for the first eight hours and subsequently by nurses trained in these techniques.

A chest roentgenogram was obtained eight and 24 hours following extubation. If there was no evidence of atelectasis, physiotherapy was continued every two hours from eight to 24 hours post-extubation and then every three hours for a further 24 hours.

Those infants who received no physiotherapy were nursed in the supine and alternate-side lying positions with head elevated at a 30 degree angle; these positions were changed each hour.

If on the eight- or 24-hour postextubation roentgenogram there was evidence of atelectasis, those infants not receiving chest physiotherapy initially were begun with a routine of physiotherapy as described above. All roentgenograms for all patients studied were independently reviewed by a pediatric radiologist (H. P.) without knowledge of the diagnosis or treatment.

Statistical evaluation was by chi square analysis with the Yates correction and by the Student t test.

RESULTS

Retrospective study. In the retrospective study there were eight instances of atelectasis, all involving the right upper lobe, in the 23 infants not receiving chest physiotherapy. In the 20 infants receiving chest physiotherapy, there was one collapse. This difference was significant ($\chi^2 = 4.08$ $P < 0.05$, Table I). Fifteen infants had endotracheal tube changes prior to the planned extubation (a maximum of four intubations). Five of these infants developed postextubation atelectasis compared to four of 28 infants requiring a single intubation. The association of postextubation atelectasis with multiple intubations was not significant ($P > 0.25$, $\chi^2 = 1.22$).

Prospective study. In the prospective controlled study, eight of the 21 infants receiving no physiotherapy developed evidence of postextubation atelectasis, seven of whom required re-intubation for re-expansion of the collapsed lobes.[8, 9] Five of the eight collapses involved the right upper lobe, and three involved the right lower lobe. In the group of infants receiving physiotherapy, there was no evidence of postextubation atelectasis. This difference was significant ($P < 0.01$, $\chi^2 = 7.56$, Table II). Nine infants had multiple intubations (maximum of three) prior to their planned extubation. Three of these infants, as opposed to five of 33 infants intubated once only, had evidence of postextubation atelectasis. The difference was not significant ($P > 0.25$, $\chi^2 = 0.59$).

Combined results. Combining the results of both studies, there were 17 instances of atelectasis postextubation, 16 of which occurred in infants not receiving a routine of physiotherapy, compared to one instance of collapse in the infants who received physiotherapy ($P < 0.001$, $\chi^2 = 14.86$). Overall, eight of 24 infants with multiple intubations and nine of 61 infants with single intubations developed postextubation atelectasis; this difference was not statistically significant ($P > 0.1$, $\chi^2 = 2.65$). All instances of atelectasis in this study were diagnosed within 24 hours of extubation; there was no significant association between any specific diagnosis and the occurrence of postextubation atelectasis.

DISCUSSION

Lobar collapse following extubation of the trachea occurs as a result of retained secretions and mucosal edema.[10] Frequent intubation may traumatize the airway, leading to further damage and a higher incidence of postextubation complications.[11]

Physiotherapy, including postural drainage, may promote improved clearance of accumulated secretions and prevent airway obstruction that leads to lobar collapse. Since the right upper lobe is the most frequent area of atelectasis following extubation (76% in our study), our routine has emphasized this area.

In the prospective study, infants not receiving a routine of phsyiotherapy were nursed in positions of drainage for the upper lobes. In spite of the use of postural drainage, 38% of these infants had postextubation atelectasis. Thus, postural drainage alone is not effective in reducing the incidence of this complication. In the infants receiving physiotherapy, postural drainage was combined with chest vibrations following extubation. Vibrations alone were used as it was felt that these would adequately loosen secretions. We have previously demonstrated that postural drainage with chest percussions are effective in improving oxygenation in a group of distressed neonates.[12] It would appear that percussions or vibrations coupled with postural drainage are effective forms of therapy in the neonate. Further studies will be required to determine if the combination of chest percussions and vibrations is superior to the use of either one alone.

Dexamethasone was used empirically in all infants in an attempt to reduce tracheal and laryngeal edema after extubation, although we are not aware of any controlled study which documents the benefit of such therapy. All studied infants survived and no instances of postextubation stridor or subglottic stenosis were documented[13]; this may be related to decreased frequency of intubation. The only indications for endotracheal tube changes in our unit are tube blockage or accidental extubation.

By instituting rigid routines for intubation, extubation, and endotracheal tube care, and applying a specific technique of chest physiotherapy prior to and following extubation, we were able to significantly reduce the incidence of postextubation atelectasis.

REFERENCES

1. Wyman ML, and Kuhns LR: Lobar opacification of the lung after tracheal extubation in neonates, J PEDIATR **91**:109, 1977.
2. Fox WW, Berman LS, Dinwiddie R, and Shaffer TH: Tracheal extubation of the neonate at 2 to 3 cm H_2O continuous positive airway pressure, Pediatrics **59**:257, 1977.
3. Bednarek FJ, and Kuhns LR: Endotracheal tube placement in infants determined by suprasternal palpation: A new technique, Pediatrics **56**:224, 1975.
4. Gregory G: Respiratory care of newborn infants, Pediatr Clin North Am **19**:311, 1971.
5. Sackner MA, Landa JF, Greeneltch N, and Robinson MJ: Pathogenesis and prevention of tracheobronchial damage with suction procedures, Chest **64**:284, 1973.
6. Herman S, and Reynolds EOR: Methods for improving oxygenation in infants mechanically ventilated for severe hyaline membrane disease, Arch Dis Child **48**:612, 1973.
7. Reynolds EOR: Management of hyaline membrane disease, Br Med Bull **31**:18, 1975.
8. Ehrlich R, and Arnon RG: Intermittent endotracheal intubation technique for the treatment of recurrent atelectasis, Pediatrics **50**:144, 1972.
9. Galvis AG, White JJ, and Oh KS: A bedside washout technique for atelectasis in infants, Am J Dis Child **127**:824, 1974.
10. Banacalari E: Mechanical ventilation, *in* Iatrogenic problems in neonatal intensive care, Columbus, Ohio, 1976, Ross Laboratories, pp 70.
11. Strong RM, and Passy V: Endotracheal intubation: Complications in neonates, Arch Otolaryngol **103**:329, 1977.
12. Finer NN, and Boyd J: Chest physiotherapy in the neonate: A controlled study, Pediatrics **61**:282, 1978.
13. Stewart AR, Moriartey RR, and Finer NN: Nasotracheal intubation: Absence of long-term morbidity, Pediatr Res **12**:569, 1978.