

Continuous oscillation therapy improves the pulmonary outcome of intubated newborns: Results of a prospective, randomized, controlled trial

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Objectives: To determine the effects of continuous postural changes produced by an oscillating bed on cardiopulmonary function and on the duration of endotracheal intubation and oxygen supplementation with large premature and term infants.

Design: A prospective, randomized, controlled trial.

Setting: Neonatal intensive care unit.

Patients: Nineteen 1-day-old newborns weighing >1500 g with various respiratory diseases.

Interventions: The treatment group received continuous postural therapy on an oscillating bed; the control group received conventional frequency of manual postural changes. Both groups received physiotherapy. Patients were studied until they were extubated and oxygen supplementation was stopped.

Measurements and Main Results: Selected cardiopulmonary variables and ventilator settings during the first 6 hrs of study and the overall duration of endotracheal intubation and oxygen supplementation were determined.

Oscillation therapy significantly decreased the duration of oxygen supplementation and had no adverse effects on cardiopulmonary variables.

In a subgroup of infants with respiratory distress syndrome from prematurity or asphyxia, oscillation therapy also significantly shortened the duration of oxygen supplementation; a trend toward reduced duration of intubation was observed.

Conclusions: Continuous postural changes using an oscillating bed reduced the duration of oxygen supplementation in infants with various respiratory disorders. Furthermore, this oscillation therapy was not associated with adverse cardiopulmonary or thermal complications. (Crit Care Med 1994; 22:1147-1154)

KEY WORDS: posture; infant, premature; physiotherapy; respiratory distress syndrome; hospital bed; critical illness; respiratory insufficiency; physical therapy; pulmonary emergencies

Pulmonary physiotherapy is a common adjunct to the care of the intubated infant (1). The components of physiotherapy include postural drainage, percussion, vibration, tracheal suctioning, and hyperventilation (2, 3). Although physiotherapy with tracheal suctioning improves oxygenation, increases the volume of secretions collected, decreases airway resistance, reduces infections, and decreases the incidence of post-extubation atelectasis (4-9), the degree of benefit from each specific component of physiotherapy is not clearly known (1, 10). Furthermore, despite these beneficial aspects, suctioning may lead to significant injury and adverse changes in cardiopulmonary and cerebral vascular function (5, 11-15). These problems are more likely to occur with deep bronchial suctioning (16-20). However, since a major objective of physiotherapy is to clear the lungs of secretions (1, 2), tracheal suctioning is necessary because endotracheal intubation reduces the effectiveness of the cough and mucociliary functions (2, 21-26). A procedure that would safely facilitate the movement of these secretions from small airways to the trachea could reduce the need for deep bronchial suctioning techniques with its associated adverse effects and ultimately decrease the need for prolonged endotracheal intubation. Postural therapy may reduce the necessity for deep bronchial suctioning by facilitating gravity drainage of thickened pulmonary secretions and by promoting their accumulation in the trachea. Postural therapy would thereby facilitate aspiration of

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secretions from the trachea (27). Moreover, while conventional postural therapy (12 to 24 changes/day) has accepted beneficial effects (27-36), more frequent postural changes (24 to 48 changes/day) further improve pulmonary function (32). Thus, it is conceivable that even greater benefits in pulmonary function may be observed with continuous postural changes (411 changes/day). These improvements would be expected to facilitate the resolution of newborn respiratory diseases and to reduce the need for prolonged endotracheal intubation and oxygen supplementation.

Therefore, we tested the following hypotheses: intubated neonates receiving postural therapy on a continuously oscillating bed: a) will have a reduced duration of mechanical ventilation and supplemental oxygen therapy; b) will have a lower occurrence of atelectasis, pneumonia, and sepsis; c) will not manifest any immediate adverse cardiopulmonary functions.

MATERIALS AND METHODS

This study was approved by the Institutional Review Board of the University of Texas Health Science Center at San Antonio, TX. All parents of subjects provided written informed consent for study participation.

Infants were eligible for enrollment if they weighed >1500 g, were mechanically ventilated at 24 hrs of age, and had a prediction of continued ventilator requirements for an additional 24 hrs. The prediction of a prolonged intubation was used to select the population of infants with significant respiratory illness. Based on our experience, large preterm and term infants with an F_{iO_2} of 0.25, ventilator peak inspiratory pressure of <20 cm H_2O , positive end-expiratory pressure of <4 cm H_2O , and frequency of <15 breaths/min with spontaneous respiratory efforts were ready for extubation. We reasoned that randomization after enrollment would reduce the bias of group selection. We excluded infants with documented infections, congenital anomalies (documented pleural effusions due to the possibility of pulmonary hypoplasia), or those patients who were extubated before 48 hrs of life.

Standard care for all infants with acute respiratory distress requiring endotracheal intubation included: nursing care while on a radiant warmer unit; fluid and electrolyte management to permit 1% to 3% weight losses per day during the first 3 to 7 days of life with maintenance of urine output of >1 mL/kg/hr; parenteral alimentation to provide protein, carbohydrate, and fats at ~50 to 70 kcal/kg/day by the end of the first week of life; maintenance of normal mean arterial pressure with the use of blood transfusions or dopamine infusions; maintenance of hematocrit concentrations

>40%; and the use of time-cycled, pressure-limited mechanical ventilators. In all cases, the temperature of the inspired gases was maintained at 34° to 35°C at 80% relative humidity. Arterial blood samples (0.2 mL) were obtained from indwelling arterial catheters. Arterial pH and blood gas tension values were measured in the neonatal satellite laboratory with a blood gas analyzer (CIBA Corning Diagnostic, Park Ridge, IL; or Instrumentation Laboratories, Lexington, MA). In addition, continuous oxygen saturation was assessed, using a pulse oximeter (Nellcor, Hayward, CA), and transcutaneous P_{CO_2} was assessed with a skin electrode (SensorMedics, Anaheim, CA).

The standard procedures for pulmonary physiotherapy (if tolerated without hypoxemia, bradycardia) included chest percussion to all areas of the chest for 5 to 10 mins every 2 to 4 hrs. Percussion was immediately followed by instillation of normal saline (0.25 to 0.5 mL) into and suctioning of the endotracheal tube. The suction catheter was passed to no more than 1 cm beyond the end of the endotracheal tube and the negative pressure applied was no less than -50 mm Hg. Hand ventilation with supplemental oxygen concentrations similar to those concentrations administered during mechanical ventilation followed the suctioning procedures. After several sequences of the above procedure, the infant was reconnected to the ventilator.

At 24 hrs of age, physiotherapy and suctioning of endotracheal tubes were started. Using a random number generator and sealed envelopes, infants were randomized to receive the standard care with one of two treatment protocols for postural drainage. The infants were not stratified by diagnoses. The infants in the control group had their lying posture rotated from one side to the other every 2 hrs (12 changes/day). The treatment group infants were continuously rotated from one side to the other every 3.5 mins (411 changes/day). The treatment group received this continuous oscillation therapy on a P-30 Pediatric Kinetic Treatment Table with an overhead radiant warmer (Kinetic Concepts, San Antonio, TX).

The sides of the treatment table tilt from 40° below to 40° above a horizontal plane in ~3.5 mins (one cycle in 7 mins) (Fig. 1). With the exception of the continuous oscillation therapy, these infants received the same percussion and suctioning procedures as did the control infants. Movement of the oscillating bed was stopped for these and other nursing procedures.

The study began when the infant was 24 hrs of age and was completed when the infant was extubated and no longer required supplemental oxygen.

The primary dependent variables were the duration of endotracheal intubation (during mechanical venti-

lation or continuous positive airway pressure alone) and the duration of supplemental oxygen therapy (with or without endotracheal intubation) for each group. The criteria for extubation were left to the discretion of the individual attending physicians. Typically, infants were extubated with ventilator peak inspiratory pressures of <20 cm H_2O , positive end-expiratory pressures of <4 cm H_2O , and frequency of <15 breaths/min with spontaneous respiratory efforts. Reintubation or prolonged duration of oxygen supplementation would have suggested premature extubation. Termination of supplemental oxygen was based on the infant maintaining oxygen saturations of $>95\%$ and P_{O_2} of >50 torr (>6.7 kPa) while breathing an F_{IO_2} of 0.21. The secondary dependent variables were the vital signs, ventilator and oxygen requirements, arterial pH, and blood gas tensions after 6 hrs of treatment for each group. These variables were determined during the pretreatment period and then hourly for 6 hrs immediately after the start of oscillations or the start on the conventional bed.

Additional secondary dependent variables were the occurrence of atelectasis, pneumonia, and sepsis. Daily chest radiographs were used to determine the occurrence of atelectasis. Atelectasis associated with malposition of the endotracheal tube (i.e., right mainstem bronchus intubation) was not considered to be related to posture or secretions and was not included in the analysis. Pneumonia was defined as an episode of clinical respiratory deterioration with new

chest radiograph abnormalities that did not resolve in 24 hrs, a positive blood culture, and Gram stain of tracheal aspirate suggestive of an inflammatory process. Sepsis was defined as an episode of clinical deterioration with a positive blood or cerebral spinal fluid culture.

To obtain a more homogeneous subgroup of infants, we stratified and analyzed separately only the infants with respiratory distress syndrome caused by either prematurity or perinatal asphyxia. This retrospective stratification was felt justified because, from a pathophysiologic basis, the subgroup separated infants with pulmonary compliance disorders from those infants with airway resistance disorders. Thus, the infant with meconium aspiration syndrome was excluded as were those infants with hydrops fetalis because of the possibility of pulmonary hypoplasia. In addition, the lung pathology of the subgroup would more closely reflect the pathology of premature infants with birthweights <1500 g (respiratory distress syndrome of surfactant deficiency), a group with a higher risk of prolonged ventilation.

All values are mean \pm SD and analyses were by two-tailed unpaired *t*-test, Mann-Whitney test when the data failed the Kolmogorov-Smirnov test of normality, or Fisher exact test for nominal scale data. We selected $p < .03$ to determine statistical significance because of multiple comparisons. The Bonferroni correction (0.0008) was considered excessively conservative.

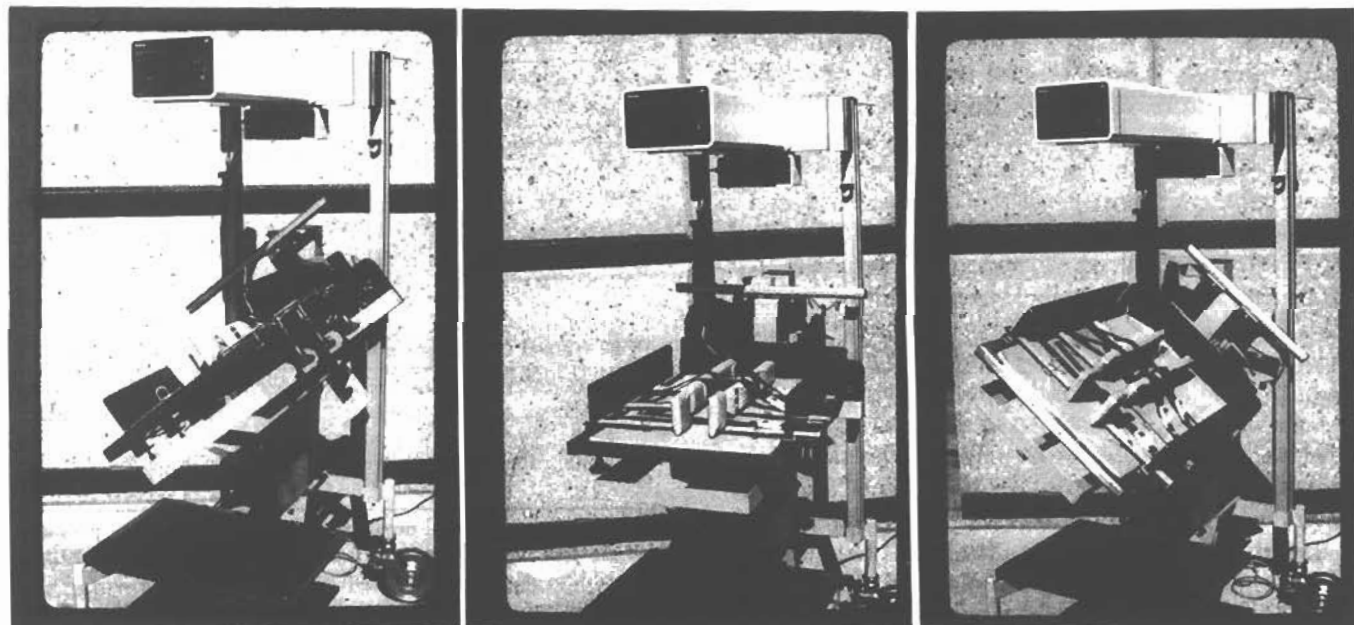


Figure 1. P-30 oscillating bed rotating from side to side, 40° above (left), level (middle), to 40° below (right) the horizontal plane in 3.5 mins.

RESULTS

Nine controls and ten treated infants were enrolled in the study. One patient had meconium aspiration syndrome and two patients had hydrops fetalis without pleural effusions. The remaining patients had respiratory distress syndrome (Table 1). Although the treated group was slightly heavier than the control group, none of these differences was statistically significant. Although there appeared to be a trend of clinically important differences between groups, the pretreatment vital signs (heart rate, $p = .86$; respiratory rate, $p = .17$; mean blood pressure, $p = .36$), ventilatory variables (F_{IO_2} , $p = .22$) and arterial pH and blood gas tensions (P_{O_2} , $p = .21$; alveolar-arterial oxygen tension ratio, $p = .23$) were not statistically significant (Table 2). During the first 6 hrs of the study (from the start of oscillations), there were no significant differences in the mean vital signs nor respiratory variables (Table 3). No infant received corticosteroid treatment.

Continuous oscillation therapy significantly reduced the need for respiratory support. The treated group of infants with various pulmonary disorders required fewer hours of supplemental oxygen treatment than did the control group ($p = .017$). However, there was no significant ($p = .096$) difference in the duration of mechanical ventilation/intubation (Table 4). One infant (control) was reintubated 9 hrs after extubation. There were no differences in the occurrence of pulmonary complications between the groups (Table 4).

In the subgroup of infants with respiratory distress syndrome from prematurity or perinatal asphyxia, the group characteristics, the pretreatment vital signs and respiratory variables, and the mean changes in vital signs and respiratory variables after 6 hrs were similar (Tables 5, 6, and 7). Continuous oscillation therapy significantly decreased the duration of oxygen supplementation ($p = .01$); the decrease in the

Table 1. Characteristics of infants with various lung conditions

	Controls (n = 9)	Treated (n = 10)
Birth weight (kg)	2.3 ± 0.7 ^a	2.5 ± 0.9
Gestation age (wk)	34.5 ± 3.2	35.2 ± 3.2
Entry age (hr)	25.3 ± 1.9	27.4 ± 7.2
Sex (male/female)	5/4	5/5
Diagnoses		
RDS	6	6
Asphyxia	1	3
Meconium aspiration	1	0
Hydrops fetalis	1	1

RDS, respiratory distress syndrome.

^aMean ± SD values.

duration of ventilation/intubation was nearly statistically significant ($p = .035$). No effects on the occurrence of pulmonary complications were observed (Table 8).

DISCUSSION

The results of this study support the view that continuous postural change using an oscillating bed

Table 2. Pretreatment vital signs and respiratory variables of infants with various lung conditions (mean ± SD)

	Controls (n = 9)	Treated (n = 10)
Heart rate (beats/min)	147.1 ± 16.6	142.8 ± 13.3
Respiratory rate (breaths/min)	54.9 ± 13.0	45.6 ± 14.4
MAP (mm Hg)	40 ± 7	46 ± 5
F_{IO_2}	0.64 ± 0.23	0.51 ± 0.22
PIP (cm H ₂ O)	23 ± 6	22 ± 5
PEEP (cm H ₂ O)	4 ± 1	4 ± 1
f (breaths/min)	37 ± 15	36 ± 19
P_{aO_2}/P_{aO_2}	0.19 ± 0.11	0.29 ± 0.22
P_{aO_2} (torr)	67 ± 28	74 ± 31
pH	7.32 ± 0.12	7.34 ± 0.06
P_{aCO_2} (torr)	42 ± 10	37 ± 8

MAP, mean arterial pressure; PIP, peak inspiratory pressure; PEEP, positive end-expiratory pressure; f, frequency; P_{aO_2}/P_{aO_2} , arterial/alveolar oxygen tension ratio.

Conversions of standard pressures to kPa: mm Hg and torr × 0.133 = kPa; cm H₂O × 0.098 = kPa.

Table 3. Mean changes in vital signs and respiratory variables after the first 6 hrs of continuous oscillation therapy of infants with various lung conditions (mean ± SD)

	Controls (n = 9)	Treated (n = 10)
Heart rate (beats/min)	-2 ± 11	2 ± 11
Respiratory rate (breaths/min)	1 ± 11	3 ± 12
Temperature (°C)	-0.1 ± 3	0.1 ± 3
MAP (mm Hg)	1 ± 5	-2 ± 8
F_{IO_2}	0.02 ± 0.14	-0.03 ± 0.03
PIP (cm H ₂ O)	1 ± 2	-0.2 ± 1
PEEP (cm H ₂ O)	0.2 ± 0.4	-0.1 ± 0.3
f (breaths/min)	7 ± 14	-3 ± 5
P_{aO_2}/P_{aO_2}	0.02 ± 0.06	0.05 ± 0.06
P_{aO_2} (torr)	5 ± 27	11 ± 25
P_{aCO_2} (torr)	0.1 ± 4	0.4 ± 4
pH	-0.03 ± 0.06	0.01 ± 0.05

MAP, mean arterial pressure; PIP, peak inspiratory pressure; PEEP, positive end-expiratory pressure; f, frequency; P_{aO_2}/P_{aO_2} , arterial/alveolar oxygen tension ratio.

Values are 6-hr value less baseline value. A negative value indicates a decrease at 6 hrs from baseline.

Conversions of standard pressures to kPa: mm Hg and torr × 0.133 = kPa; cm H₂O × 0.098 = kPa.

Table 4. Effects of continuous oscillation therapy on duration of intubation and oxygen requirements and on pulmonary complications of infants with various lung conditions

	Controls (n = 9)	Treated (n = 10)
Intubation (hr)	137.1 ± 52.5 ^a	97.7 ± 45.0 ^b
O ₂ supplement (hr)	261.3 ± 170.3	110.3 ± 58.3 ^c
Atelectasis (n)	1	0
Pneumonia (n)	0	0
Sepsis (n)	0	0

^aMean ± SD values; ^bp = .096; ^cp = .017.

Table 5. Characteristics of infants with respiratory distress syndrome (RDS) from prematurity or perinatal asphyxia

	Controls (n = 7)	Treated (n = 9)
Birth weight (kg)	2.1 ± 0.5 ^a	2.5 ± 0.9
Gestational age (wk)	34.6 ± 1.3	35.1 ± 3.3
Entry age (hr)	25.5 ± 2.1	27.7 ± 7.5
Sex (male/female)	4/3	4/5
Diagnoses		
RDS	6	6
Asphyxia	1	3

^aMean ± SD values.

Table 6. Pretreatment vital signs and respiratory variables of infants with respiratory distress syndrome from prematurity or perinatal asphyxia (mean ± SD)

	Controls (n = 7)	Treated (n = 9)
Heart rate (beats/min)	142 ± 12	142 ± 14
Respiratory rate (breaths/min)	57 ± 16	44 ± 18
Temperature (°C)	36.8 ± 2.4	36.7 ± 3.2
MAP (mm Hg)	41 ± 7	46 ± 5
F _{IO₂}	0.63 ± 0.19	0.52 ± 0.22
PIP (cm H ₂ O)	22 ± 6	22 ± 5
PEEP (cm H ₂ O)	4 ± 2	4 ± 2
f (breaths/min)	39 ± 16	36 ± 20
PaO ₂ /PAO ₂	0.16 ± 0.05	0.28 ± 0.22
PaO ₂ (torr)	66 ± 32	72 ± 32
Paco ₂ (torr)	45 ± 8	37 ± 8
pH	7.27 ± 0.06	7.33 ± 0.06

MAP, mean arterial pressure; PIP, peak inspiratory pressure; PEEP, positive end-expiratory pressure; f, frequency; PaO₂/PAO₂, arterial/alveolar oxygen tension ratio.

Conversions of standard pressures to kPa: mm Hg and torr × 0.133 = kPa; cm H₂O × 0.098 = kPa.

reduces the morbidity of respiratory distress in the large premature and term infant. In a selected group of neonates with lung disease from prematurity or asphyxia, continuous postural changes via an oscillating bed decreased the duration required for oxygen

Table 7. Mean changes in vital signs and respiratory variables after the first 6 hrs of continuous oscillation therapy of infants with respiratory distress syndrome from prematurity or perinatal asphyxia (mean ± SD)

	Controls (n = 7)	Treated (n = 9)
Heart rate (beats/min)	3 ± 8	2 ± 11
Respiratory rate (breaths/min)	5 ± 4	4 ± 13
Temperature (°C)	-0.6 ± 0.3	0.8 ± 0.3
MAP (mm Hg)	-0.7 ± 2.9	-0.3 ± 7.3
F _{IO₂}	0.08 ± 0.22	-0.03 ± 0.04
PIP (cm H ₂ O)	2 ± 3	-0.2 ± 2
PEEP (cm H ₂ O)	0.3 ± 0.5	-0.1 ± 0.4
f (breaths/min)	9 ± 16	-3 ± 5
PaO ₂ /PAO ₂	0.01 ± 0.06	0.05 ± 0.06
PaO ₂ (torr)	0.2 ± 25	13 ± 26
Paco ₂ (torr)	0.1 ± 5	0.1 ± 4
pH	-0.02 ± 0.04	0.01 ± 0.03

MAP, mean arterial pressure; PIP, peak inspiratory pressure; PEEP, positive end-expiratory pressure; f, frequency; PaO₂/PAO₂, arterial/alveolar oxygen tension ratio.

Values are 6-hr value less baseline value. A negative value indicates a decrease at 6 hrs from baseline.

Conversions of standard pressures to kPa: mm Hg and torr × 0.133 = kPa; cm H₂O × 0.098 = kPa.

Table 8. Effects of continuous oscillation therapy on duration of intubation and oxygen supplementation of infants with respiratory distress syndrome from prematurity or perinatal asphyxia

	Controls (n = 7)	Treated (n = 9)
Intubation (hr)	119.9 ± 33.6 ^a	85.7 ± 25.4 ^b
O ₂ supplement (hr)	210.0 ± 113.6	90.2 ± 27.4 ^c
Atelectasis (n)	0	0
Pneumonia (n)	0	0
Sepsis (n)	0	0

^aMean ± SD values; ^bp = .035; ^cp = .01.

supplementation (p = .01), the duration of intubation (p = .035, not significant), and were not associated with detrimental changes in cardiovascular variables, or with an increased incidence of pulmonary complications.

The introduction of continuous positive airway pressure breathing, intermittent mandatory ventilation, and new approaches to mechanical ventilation significantly improved the survival and reduced the morbidity of newborn infants (37–40). Despite these advances, infants with respiratory diseases still develop morbidities related to both the disease and/or the treatment (41). Of considerable concern are those complications associated with endotracheal tubes and tracheal intubation. Acute complications of tracheal intubation include trauma to tissues (5, 42–44) and adverse

cardiorespiratory physiologic changes (5, 11–15). Greater care and improvements in technique may decrease these complications. However, the complications associated with long-term intubation are more difficult to prevent and treat, and present a continuing challenge to those individuals caring for these infants (43). The duration of intubation and mechanical ventilation significantly contributes to nosocomial respiratory infections (45–48) and chronic lung diseases in newborns (41). Hemorrhage, mucosal erosions, and granulomatous lesions of the tracheobronchial tree associated with endotracheal intubation and suctioning impair the clearance of secretions from the lungs (16, 17, 25, 49–51). The retention of secretions may lead to an increased occurrence of atelectasis (9, 52) and the higher risk for developing pneumonia and sepsis (53, 54). Furthermore, during the acute illness, the clearance of secretions is further impaired from relative immobilization and decreased postural changes.

Although physiotherapy increases the volume of secretions collected and has other beneficial effects (4–9), the contribution from each component remains unclear. In this study, we have shown a large, beneficial contribution from frequent postural changes since chest percussion/vibration and suctioning were similar in both groups. This finding is consistent with the observation that increasing the frequency of postural changes to twice the conventional frequency further improves pulmonary function in dogs (32). In the present study, continuous postural changes on an oscillating bed occurred ~17 to 34 times that of conventional rates.

The mechanisms of these benefits have been studied in adults and animals. The increased frequency of postural changes may reduce regional pulmonary edema, atelectasis (32, 55), and the effects of high lung closing volumes (56, 57). The reduction of pulmonary edema could reverse the impairment of antibacterial activity of alveolar macrophages (58). Theoretically, intermittent increases in gravity-dependent perfusion *may improve the immunologic function with the delivery of leukocytes and antibiotics* (59). Furthermore, continuous postural changes could enhance gravity drainage of secretions (60), regional distribution of ventilation, increase lung volumes (61), and ultimately improve alveolar-bronchial gas flow (56).

In the subgroup analysis, the duration of oxygen supplementation was significantly shorter with the treated group. There was only a trend toward a significant difference for duration of intubation. However, the suggestion that oscillation may shorten the duration of intubation must be made with caution because bias cannot be eliminated due to the undefined

extubation criteria. Nonetheless, prolonged oxygen supplementation was not observed in the treatment group as would be expected if hypoventilation or atelectasis occurred with premature extubation. This finding suggests that the treated group was not prematurely extubated.

The absence of any observed difference in the occurrence of atelectasis or infections between the groups is due to the low frequency rates in both groups. This finding is consistent with the duration of intubation of only 4 to 6 days for both groups of infants. In adults, the occurrence of infections increases with the duration of endotracheal intubation and mechanical ventilation (45–48). Therefore, because of the longer durations of endotracheal intubation with very low birth weight (<1500 g) premature infants, it is conceivable that additional benefits may be observed from oscillation therapy by reducing infectious complications.

Regardless of the mechanisms proposed, the small size of this study should suggest caution in generalizing our conclusions to other pediatric or more premature neonatal patients. Nonetheless, this study is the first to demonstrate improvements in neonatal patients similar to those improvements found in adult patients in prospective, randomized trials (34, 35, 62, 63). Fink et al. (34) reported on 99 patients with blunt trauma. Patients on the treatment bed had a significantly lower occurrence of lower respiratory tract infections and fewer days of intubation and hospitalization. The risk of developing pneumonia in the treatment group was approximately one third of the group on a conventional bed. Kelley et al. (62) also found that continuous oscillation reduced the occurrence of infections and pneumonia to ~45% that of patients with stroke who were treated conventionally. Gentilello et al. (63) reported a 50% reduction in the occurrence of atelectasis or pneumonia with continuous oscillation. Although Summer et al. (35) did not find a significant difference in the overall mortality rate or occurrence of pneumonia, continuous oscillation did shorten the duration of mechanical ventilation and hospitalization in patients with pneumonia and chronic obstructive pulmonary disease. Furthermore, continuous oscillation in adult patients with head trauma had no significant effect on intracranial pressure (64).

Concerns have been raised regarding techniques that are fairly well tolerated by adults, may be poorly tolerated by infants. Moreover, excessive stimulation and handling of infants may be detrimental and have led to the adoption of "minimal stimulation" policies in many nurseries (65). Nonetheless, in this study, oscillation was not associated with cardiopulmonary deterioration. Furthermore, although the direct neurodevelopmental effects of medical procedures are

not known, some types of supplemental stimulation may be beneficial to premature infants (66-70). Specifically, several studies (71-74) of oscillations (10 to 30 cycles/min) from water- and airbeds have reported beneficial effects compared with controls; others (75, 76) have not reported benefits. More importantly, no known adverse effects have been reported when compared with controls. Although it is conceivable that the kinesthetic/vestibular stimulation of infants in this study would have similar results, the effects of slower (0.3 cycle/min) and regular oscillations await further study.

In conclusion, we have shown that frequent and standardized application of postural therapy, using a continuously oscillating bed, improves pulmonary outcomes of a selected group of large preterm and term infants. Furthermore, we have shown that continuous oscillation does not have adverse cardiopulmonary effects on these infants. Finally, as the risks of long-term pulmonary complications from lung diseases and their therapy increase with decreasing birth weights (77), it appears that greater benefits could be achieved with continuous postural therapy for infants weighing <1500 g. The lack of any complications in thermal and cardiovascular function suggests that such a study could be safely conducted.

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