Postextubation Nasal Continuous Positive Airway Pressure

A Prospective Controlled Study

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• **Nasal continuous positive airway pressure (N-CPAP), applied immediately after extubation, was prospectively evaluated in 18 neonates recovering from respiratory distress syndrome. Patients were randomly assigned to N-CPAP (group 1, N = 9) or a control group given oxygen by hood (group 2, N = 9). Groups were comparable in birth weight and duration of intubation. In the 24-hour period following extubation, group 1 showed a significantly lower mean respiratory rate (46 ± 2 vs 74 ± 4), alveolar-arterial oxygen gradient (94 ± 9 vs 134 ± 12 mm Hg), Pco_2 (45 ± 1 vs 50 ± 1 mm Hg), higher pH (7.33 ± 0.01 vs 7.30 ± 0.01), and less atelectasis by roentgenographic scores. This was associated with considerably better clinical courses in group 1 when compared with group 2, in which six patients required a late trial of N-CPAP because of respiratory deterioration and two patients needed reintubation. Postextubation N-CPAP has a striking beneficial effect on respiratory function and prevention of atelectasis.**

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Atelectasis or other evidence of respiratory failure is common after extubation of mechanically ventilated newborns despite the use of vigorous chest physiotherapy.[1-6] Since nasal continuous positive airway pressure (N-CPAP) might facilitate extubation by a number of mechanisms,[7-9] a study was undertaken to evaluate this mode of therapy.

METHODS

A randomized, prospective investigation of the use of postextubation N-CPAP was carried out in all neonates intubated for more than 72 hours but less than 14 days. We excluded patients with multiple or traumatic intubations, tracheal stenosis, chronic lung changes, neurological conditions, congestive heart failure, birth weight less than 1.0 kg, surgical conditions, or major congenital anomalies. The protocol was approved by the hospital's Human Use Committee, and parental consent was obtained.

The timing of extubation was determined by the clinical staff after the patient demonstrated respiratory stability on a ventilator frequency of 0 to 4 breaths per minute and endotracheal CPAP of 3 to 4 cm H_2O. Anemia, abnormalities of blood glucose, electrolyte, and calcium values, and extensive atelectasis by chest roentgenogram were corrected before extubation. The patients were then randomly assigned by shuffled envelopes to N-CPAP at 6 cm H_2O (group 1) or to the control group given oxygen by hood (group 2).

After extubation, fraction of inspired oxygen was initially raised 0.05 over the previous concentration. Vigorous chest physiotherapy, using percussion, mechanical vibration, postural drainage, and oropharyngeal suctioning, was begun before extubation and continued every two hours afterward. Tracheal suctioning, mask bagging, initiation of feedings, aminophylline, and corticosteroids were avoided during the 24-hour study period.

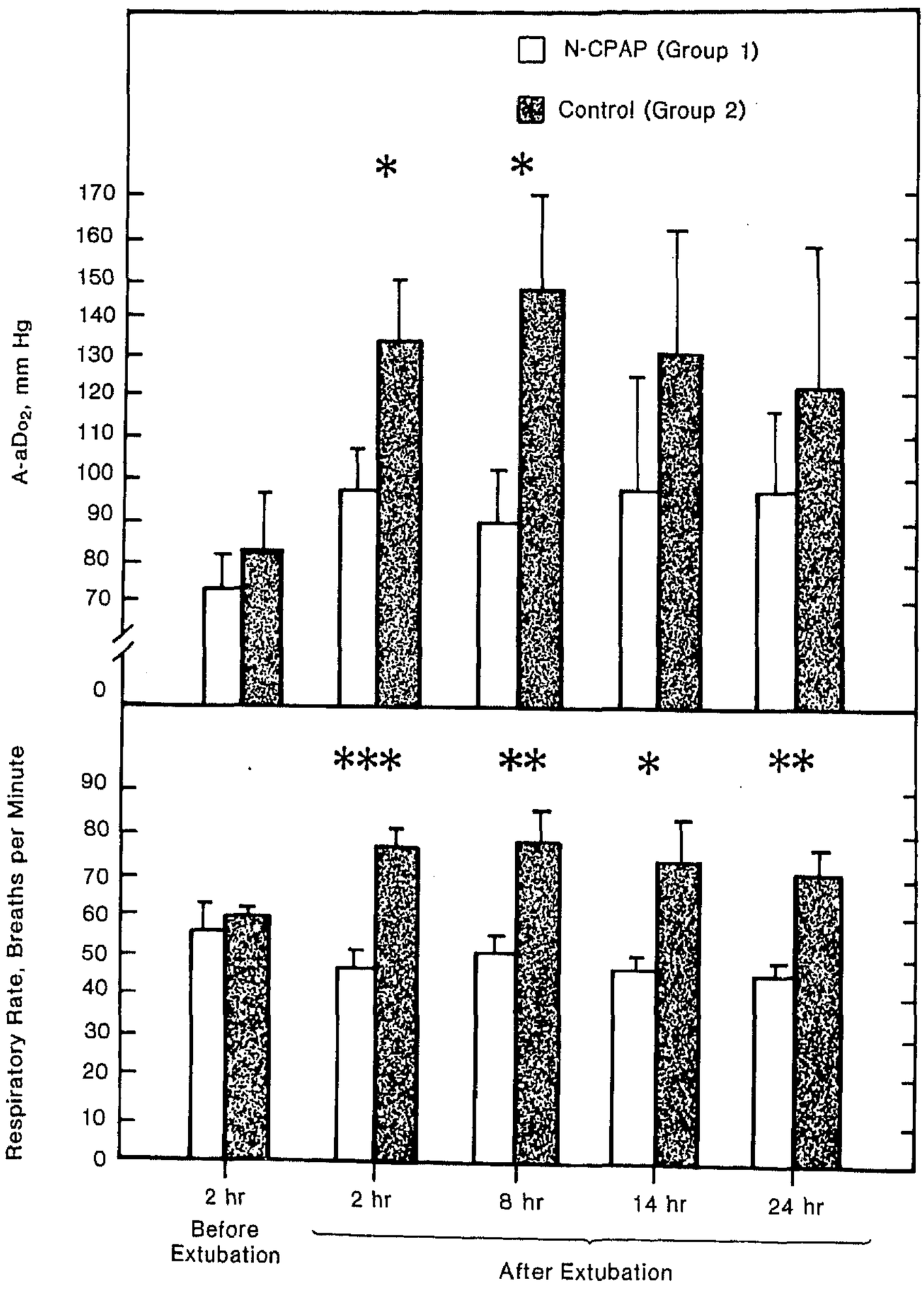
Heart rate, respiratory rate, blood pressure, and respiratory and neurological activity were recorded every four hours. Blood glucose levels (measured by cellulose paper strip impregnated with glucose oxidase and chromagen indicator system [Dextrostix]) and arterial blood gas values were measured 2, 8, 14, and 24 hours after extubation; chest roentgenograms were taken by protocol 2, 12, and 24 hours after extubation. Roentgenograms were scored by a radiologist (L.R.K.) without knowledge of group assignment. A score of 1 to 7 for each lung was based on increasing degrees of atelectasis, from diffuse subsegmental involvement through severe lobar collapse.

Extubation failure was judged by the investigators (S.C.E. or D.W.R.) on the basis of (1) progressive atelectasis and respiratory distress; (2) worsening pul-

Clinical Data			
	Group 1 (N = 9)	Group 2 (N = 9)	*P*
No. with extubation failure	0	6	< .005*
No. reintubated	0	2	NS
Respiratory rate,† breaths per minute	46 ± 2	74 ± 4	< .005‡
Alveolar-arterial oxygen gradient,† mm Hg	94 ± 9	134 ± 12	< .005‡
Pco_2,† mm Hg	45 ± 1	50 ± 1	< .005‡
pH†	7.33 ± 0.01	7.30 ± 0.01	< .01‡
Chest roentgenogram score†	4.7 ± 0.4	6.1 ± 0.05	< .05‡

*Fisher's exact test.
†Postextubation means (±SEM) for first 24 hours.
‡Unpaired Student's *t* test.

Effect of nasal continuous positive airway pressure (N-CPAP) on respiratory rate and alveolar-arterial oxygen gradient (A-aDo_2) measured before and at standard intervals after extubation (values given are mean ± SEM). Asterisk indicates $P < .05$; double asterisk, $P < .01$; and triple asterisk, $P < .005$ (unpaired *t* test).



monary status, defined by a Pco_2 greater than 60 mm Hg with a pH less than 7.20; or (3) inspired oxygen requirement increasing by greater than 0.15 to 0.2. Group 2 patients judged as having extubation failure received a crossover trial of late N-CPAP.

RESULTS

Eighteen patients were assigned to N-CPAP (group 1, N = 9) or control (group 2, N = 9) treatment protocols. Groups were comparable in gestational age (mean ± SEM, 33.2 ± 0.7 vs 33.8 ± 1.4 weeks), birth weight (2.07 ± 0.19 vs 2.06 ± 0.26 kg), and duration of intubation (6.1 ± 1.0 vs 6.0 ± 1.0 days). Diagnoses included respiratory distress syndrome (often associated with perinatal asphyxia) in 16 patients and pneumonia in two patients. There were no group differences in diagnosis, birth weight, indication for intubation, or age at extubation. No complications attributable to N-CPAP were noted. Preextubation respiratory rate, alveolar-arterial oxygen gradient (A-aDo_2), Pco_2, and chest roentgenogram score did not differ between the groups.

Results are given in the Table. The study was discontinued after considerably better postextubation courses and no extubation failures were found in those patients treated with N-CPAP, while six of the patients treated with hood oxygen had definite deterioration and two required reintubation. Evidence of deterioration was defined by progressive respiratory acidosis (3/6 patients), hypoxemia (3/6), or atelectasis (3/6) associated with progressive tachypnea and retractions. The two patients requiring reintubation weighed 1.1 and 1.4 kg at birth; however, there were no differences within group 2 in duration intubated, age at extubation, degree of atelectasis, pulmonary disease, or other factors to account for extubation failure, and one successfully extubated control patient weighed 1.06 kg.

There were statistically significant differences between groups in mean postextubation respiratory rate, A-aDo_2, pH, and chest roentgenogram score during the initial 24-hour period. This represented significant deterioration from preextubation val-

ues within group 2 ($P < .01$, paired t test), while group 1 remained unchanged except for a slight rise in A-aDo_2. Segmental or lobar atelectasis developed in four control patients (right upper lobe in two, right middle lobe in one, right lower lobe in one, and left lower lobe in two), but in none of the N-CPAP group.

When group 1 patients were weaned from N-CPAP after an average of 32 ± 6 hours, there was no change in mean A-aDo_2, pH, or roentgenogram score. There was a slight rise in mean Pco_2 (+4 ± 1.5 mm Hg) and respiratory rate (+24 ± 4). Group 2 failures, treated with N-CPAP after a mean interval of 27 ± 13 hours, showed significant improvement only in respiratory rate, although further deterioration requiring intubation did not occur in four of the six patients.

Results for A-aDo_2 and respiratory rate for the initial 24-hour postextubation period are graphically illustrated in the Figure.

COMMENT

These results demonstrate that use of N-CPAP after extubation greatly improves respiratory function, reduces morbidity from progressive atelectasis and respiratory failure, and decreases the need for reintubation in neonates intubated for more than three days. In contrast, patients weaned to hood oxygen are more tachypneic and are more apt to have CO_2 retention and acidosis, larger A-aDo_2 gradients, and atelectasis. Extubation failure does not seem to be related to any specific factor such as weight, duration of intubation, or presence of pulmonary disease, although the two smallest control patients did not respond to N-CPAP and required reintubation.

Atelectasis is a commonly recognized complication after tracheal extubation. In the report by Gregory et al[1] of endotracheal CPAP for respiratory distress syndrome, five of 18 patients had atelectasis develop after extubation. It usually affects the right upper lobe[2] and increases in frequency with duration of intubation.[3] Wyman and Kuhns[4] demonstrated a considerable increase in atelectasis after 90 hours of intubation. They pointed out that "7 of the 11 neonates who developed post-extubation opacification required reintubation and positive pressure ventilation for 1 to 30 additional days." Others have confirmed this observation.[5,6]

Multiple factors may contribute to the occurrence of atelectasis in the extubated patient, including inadequate cough reflex,[7] inability to suction increased bronchial secretions resulting from prior catheter irritation,[8] and tracheal stenosis due to prolonged intubation.[9] It has been emphasized that in the relatively smaller airway of the newborn, even a small encroachment on the diameter of the upper airway can drastically reduce the cross-sectional area. Transient subglottic edema might strikingly exacerbate the normal narrowing of the extrathoracic airway that occurs during inspiration.[10,11]

Nasal continuous positive airway pressure might act through maintenance of the compromised extrathoracic airway during inspiration. Use of an expiratory resistance after extubation has been shown to substantially increase functional residual capacity and Pao_2.[12] In addition, CPAP may increase the strength and duration of inspiratory effort,[13] regularize periodic breathing, and reverse the progressive decrease in thoracic gas volume after birth.[14]

In conclusion, this study demonstrates that N-CPAP applied immediately after extubation has considerable beneficial effects on respiratory function and prevention of atelectasis. It may facilitate earlier and more successful withdrawal of ventilatory support in newborns recovering from respiratory distress.

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