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Rationing ventilatory support for the newborn with respiratory distress

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Respiratory distress of the newborn continues to account for significant morbidity in the neonatal intensive care unit. The spectrum of disease ranges from mild distress to severe respiratory failure requiring varying degrees of support. The current modalities of ventilatory assistance range from the more benign but somewhat less effective continuous positive airway pressure (CPAP) to conventional mechanical ventilation, and on to high-frequency ventilation. It is a reasonable supposition that the type of ventilatory assistance provided to these infants should be graded according to the severity of disease. However, there is no consensus regarding the most appropriate means of support that results in minimum barotrauma to the infant.

At Babies' and Children's Hospital of New York, infants born with respiratory distress are placed on CPAP within minutes in an attempt to prevent progression to more severe respiratory failure. This institution's experience with early intervention since 1973 and that of others [1] have suggested a resultant change in the severity and duration of illness. In many cases the treatment has avoided the subsequent need for intubation and more traumatic mechanical ventilation (Table 1). The equipment required for CPAP is simple to use, has a greater cost benefit, and has a more universal application, which is of help to smaller units including those in developing parts of the world. Nursing support is not as labor intensive for those infants on CPAP, and the patient: nurse ratio can be increased from 2:1 ventilated patients per nurse to 3:1 for infants on CPAP support. Indications for starting CPAP include tachypnea, inspiratory retractions, and grunting. CPAP is maintained at 5 cm H_2O and the FiO_2 is adjusted to keep the PaO_2 above 50 mmHg. Usually, following the correct application of CPAP, the infant breathes more easily and the respiratory rate and retractions improve. If CPAP of 5 cm H_2O is not sufficient to achieve a satisfactory PaO_2 of 50–70 mmHg while breathing 80–100 % oxygen, the infant requires mechanical ventilation. Other indications for mechanical ventilation include marked retractions or frequent apnea while on CPAP, a $PaCO_2$ greater than 65 mmHg, intractable metabolic acidosis, severe cardiac disease, or neuromuscular disorders. Other strategies have been employed with mixed success in other institutions, such as intubation and introduction of surfactant followed by extubation to CPAP [2]. Such manipulations of the airway of small infants in respiratory failure must be performed with caution.

Endotracheal intubation and mechanical ventilation are invasive and impose harm on the infant. The potential complications of mechanical ventilation primarily involve the cardiovascular and pulmonary systems, with abolition of the thoracic pump mechanism leading to subsequent decrease of venous return and cardiac output. Tamponade of the heart and interference with pulmonary blood flow also occur. Pulmonary complications are mainly those of barotrauma or "volotrauma", including air leaks and bronchopulmonary dysplasia (BPD). High stretching force applied repeatedly to even the normal lung increases permeability, leading to pulmonary edema [3–5]. Animal studies have shown that ventilation of healthy, paralyzed, and anesthetized sheep with peak inspiratory pressure of up to 50 cm H_2O results in death from respiratory failure in 2–35 h [6]. Uneven ventilation, acid-base imbalance, cerebral vascular effects, and local complications from intubation are also seen.

Although modern infant respirators have been available since the late 1970s, functional characteristics of respirators and ventilation techniques are seldom taught to the professional staff who care for the newborns. Among institutions, or even within the same institution, there is little uniformity in the selection of the ventilator settings for even "standard conventional mechanical ventilation". Most ventilator manipulations are performed by staff with varying degrees of training

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Table 1. Respiratory distress of the newborn: outcome of 330 infants weighing 501–1500 g at birth without routine mechanical ventilation born at Babies and Children's Hospital, January 1990–October 1992

Birth wt. (g)	*n*	Survivors (*n*)	Mechanical ventilation (*n*)	CPAP (*n*)	PTX (*n*)	BPD[a] (*n*)	Surfactant (*n*)
501–600	13	5	8	3	1	4	2
601–700	26	19	17	9	4	10	3
701–800	29	22	11	18	2	5	2
801–900	35	29	10	25	1	3	2
901–1000	35	32	7	27	3	3	2
1001–1250	97	93	7	85	6	1	0
1251–1500	95	91	6	82	6	1	2
Total	330	291	66	249	23	27	13

[a] Number of infants who developed BPD and required oxygen supplement for more than 28 days.
CPAP, Continuous positive airway pressure; *PTX,* pneumothorax; *BPD,* bronchopulmonary dysplasia

and experience, and many clinicians are concerned primarily with maintenance of normal blood gases, with somewhat less regard to barotrauma. These factors might account for the considerable variability in both the success of ventilation and the incidence of complications seen in clinical practice [7].

The fundamental goal of mechanical ventilation is to assist ventilation in providing adequate tissue oxygenation and eliminating carbon dioxide, with minimal cardiovascular depression and barotrauma. Protocols emphasizing modest but adequate ventilator settings should logically result in a lower incidence of complications. The intermittent mandatory ventilation (IMV) mode allows spontaneous breathing to continue during the expiratory phase of the respirator cycle and permits the gradation of ventilator support depending on the degree of respiratory failure. The ventilator cycling frequency can therefore be set at a lower rate for the same level of minute ventilation as long as the infant responds with an increase in spontaneous breathing. Using the IMV mode in conjunction with permissive hypercarbia [8] and a judicious but tolerable hypoxemia will reduce the danger of barotrauma and cardiovascular compromise. Weaning is also facilitated.

The use of muscle relaxants should be discouraged for the following reasons: First, spontaneous ventilation should be preserved, as it allows a better match between ventilation and perfusion [9]; ventilator settings can thus be lowered. Second, the infant's well-being can be assessed from spontaneous movements. Third, the cause of agitation, such as mechanical obstruction of the endotracheal tube or pneumothorax, can be identified earlier in the nonparalyzed infant. For the rare patient who is agitated without a definable reason, mild sedation with phenobarbital or a narcotic may be sufficient. Finally, long-term paralysis can result in atrophy of respiratory muscles, ultimately making weaning more difficult.

Surfactant replacement therapy has been shown to improve gas exchange and is a valuable adjunct in treating infants with RDS. However, increased incidences of patent ductus arteriosus and pulmonary hemorrhage have been reported, and there is stress associated with the instillation of 4 ml fluid per kg body wt. directly into the trachea. It is worth remembering that before the introduction of surfactant many premature infants with RDS survived without developing BPD. Furthermore, not all premature infants have RDS, and not all infants with RDS will respond to surfactant therapy. Moreover, the financial cost (US $ 580 per 8-cc vial) attached to the use of surfactant should be taken into consideration. The necessity for routine liberal use of surfactant for all premature babies is questionable. Future research could be directed toward better and earlier identification of those infants most likely to die from RDS or develop BPD, so that surfactant can be given early and judiciously to the population of sick infants most needful of this therapy.

At our institution, exogenous surfactant replacement therapy is reserved for infants with severe RDS who require high ventilator settings and a FiO_2 of greater than 80 % and who appear most likely to develop BPD or other respiratory complications. From January 1990 to October 1992, utilizing the strategies of ventilatory support described before [10], 330 inborn premature infants weighing 500–1500 g were treated (Table 1): 291 infants survived (88.2 %), 249 infants (75.5 %) required CPAP only, and 66 infants (20 %) required mechanical ventilation. Thirteen patients were given surfactant. Thirty-nine patients died (11.8 %), ten of respiratory failure. Twenty-seven patients required oxygen supplementation for more than 28 days.

Much investigation remains to be done in order to better define the ideal ventilatory management for infants with respiratory distress, particularly in view of the disturbing trend toward more expensive, invasive, and hazardous treatments. While we await the optimal therapy, the following approach is suggested:

1. Neonates with less severe respiratory distress should be treated with early CPAP.
2. If adequate oxygenation or acceptable $PaCO_2$ cannot be achieved, IMV is instituted and settings are graded according to degree of respiratory failure.
3. Surfactant replacement therapy is limited to infants with severe RDS.
4. High-frequency ventilation is reserved for infants who fail IMV, and the more expensive and labor-intensive extracorporeal membrane oxygenation (ECMO) should be maintained as a last resort.

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