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Management of infants with bronchopulmonary dysplasia in North America

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Abstract The in-hospital management of infants with BPD includes minimizing the duration of mechanical ventilation and avoiding the use of high inspired oxygen concentrations while maintaining adequate oxygenation. Fluid restriction, bronchodilators, and diuretic therapy can improve lung function and reduce the need for supplemental oxygen and high ventilator settings, but do not change the ultimate course of these infants. Corticosteroids also improve lung function and accelerate weaning from oxygen and mechanical ventilation, but their use during the first weeks of life is associated with worse neurological outcome. Adequate nutrition plays an important role in lung injury protection and recovery. Infants with severe BPD frequently develop pulmonary hypertension and may benefit from the use of pulmonary vasodilators.

Outpatient management must be carefully planned and carried out by experienced multidisciplinary teams. Social and financial issues must be addressed with the family and caregivers. Home oxygen and mechanical ventilation therapy are used frequently after discharge and require specialized staff and equipment.

Maintenance of oxygenation and proper nutritional support are critical aspects in the post-discharge management of these infants.

Immunizations and RSV prevention are also important to prevent infections in these vulnerable immunocompromised patients.

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1. In-hospital management

The management of the infant with established BPD is aimed at maintaining adequate gas exchange but at the same time avoiding the progression of the disease by reducing the factors that predispose to lung damage. The challenge in the management of these infants is that the main therapies used to maintain gas exchange are the same factors implicated in the pathogenesis of the lung damage. These include oxygen therapy and mechanical ventilation.

1.1. Respiratory support

1.1.1. Mechanical ventilation

The use of positive pressure ventilation is one of the factors closely associated with the pathogenesis of BPD. For this reason it is essential to use the minimal settings necessary to maintain gas exchange and reduce the duration of mechanical support to a minimum. The lowest peak airway pressure necessary to obtain adequate tidal volumes must be applied, using inspiratory times between 0.3 and 0.5 s with flow rates between 5 and 10 l/min. Shorter inspiratory times and higher flow rates may exaggerate the maldistribution of the inspired gas while longer inspiratory times may increase the risk of alveolar rupture and negative cardiovascular side effects. The end-expiratory pressure is adjusted between 2 and 6 cm H_2O to maintain lung volume so that the minimum oxygen concentration necessary to keep oxygen saturation above 90% (PaO_2 above 50 mm Hg) is used. In infants with severe airway obstruction, especially those with bronchomalacia, the use of higher PEEP levels between 5 to 8 cm H_2O may help reduce expiratory airway resistance and improve alveolar ventilation. The duration of mechanical ventilation must be limited as much as possible to reduce the risk of volume-induced lung injury and infection. Weaning these patients from mechanical ventilation is difficult and has to be accomplished gradually. When the patient is able to maintain an acceptable PaO_2 and $PaCO_2$ with low peak inspiratory pressures (lower than 15 to 18 cm H_2O) and an FiO_2 lower than 0.3 to 0.4, the ventilator rate is gradually reduced to allow the infant to perform an increasing proportion of the respiratory work. The use of patient-triggered ventilation and pressure support of the spontaneous breaths can accelerate the process of weaning and reduce the total duration of mechanical ventilation [1,2].

Frequently, during the process of weaning, it is necessary to increase the FiO_2 to maintain oxygen saturation within an acceptable range. Concurrently the $PaCO_2$ may rise to values in the 50—60 mm Hg or higher. As long as the pH is within acceptable limits, certain degree of hypercapnia must be tolerated to wean these patients from the ventilator. In small infants with poor central respiratory activity, aminophylline or caffeine can be used as respiratory stimulants during the weaning phase. When the patient is able to maintain acceptable blood gas levels for several hours on low ventilator rate (10 to 15 breaths/min), extubation can be attempted. During the days after the extubation, it is important to provide chest physiotherapy to prevent airway obstruction and lung collapse caused by retained secretions. In smaller infants with soft chest wall and frequent apneic episodes the use of nasal CPAP can stabilize respiratory function and reduce the need for reinstitution of mechanical ventilation.

1.1.2. Oxygen therapy

Although it is important to reduce the FiO_2 as quickly as possible to avoid oxygen toxicity, it is critical to maintain the PaO_2 at a level sufficient to ensure adequate tissue oxygenation and to avoid the pulmonary hypertension and cor pulmonale that can result from chronic hypoxemia. In addition, infants with BPD may respond with increased airway resistance to episodes of acute hypoxemia. Although there is no sufficient information to recommend a specific range of oxygen saturation in these infants, there is sufficient evidence that suggests that oxygen saturations above 95% and PaO_2 above 70 mm Hg are associated with higher incidence of ROP and worse respiratory outcome [3—5]. Because of this we recommend maintaining the saturations between 90% and 95% and the PaO_2 between 50 and 70 mm Hg to minimize the detrimental effects of hypo and hyperoxemia. In extubated infants, oxygen can be administered through a hood, tent, or a nasal canula. In many cases, oxygen therapy is required for several months or even years and many of these patients are discharged with oxygen therapy at home.

Adequacy of gas exchange is monitored by determining arterial blood gas levels at intervals dictated by the child's clinical condition. Blood gas determinations obtained by arterial puncture are usually not reliable because the infant responds to pain with crying or apnea. Transcutaneous PO_2 electrodes are also inaccurate in these infants because they frequently underestimate the true PaO_2. Pulse oximeters offer the most reliable estimate of arterial oxygenation and have the advantage of simplicity of usage and the possibility of assessing continuous oxygenation during different behavioral states. For this reason, we use