2 Update on Clinical Management of Neonatal Chest Conditions

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2.1 Introduction

The period of the past three decades has been marked by extraordinary advances in the treatment of critically ill neonates. With the advent of intensive care coupled with advances in modern technology, the face of neonatal medicine has changed forever. This has resulted in improved survival and decreased morbidity among term and preterm infants. Nowhere is this more clearly seen than in the fact that the limits of viability have now extended to lower gestational ages. Most of these improvements are directly related to the better management of neonatal lung conditions, such as respiratory distress syndrome in preterm infants and meconium aspiration syndrome and persistent pulmonary hypertension of the newborn in term infants. In addition, a better understanding of various congenital abnormalities of the chest, such as congenital diaphragmatic hernia, has allowed us to manage these infants better in the immediate postnatal period and also to consider novel new ways of treating the condition, such as fetal intervention. This chapter will outline the recent key advances that have impacted on the management of neonatal lung conditions. First the area of mechanical ventilation will be discussed, including newer modes of ventilation, such as high-frequency ventilation, liquid ventilation and extracorporeal membrane oxygenation. Attention will then be turned to two new drug therapies: with surfactant, which has become established as a standard part of the management of preterm infants and, more recently, with nitric oxide, which is being used in the management of hypoxic respiratory failure in term infants. Lastly, mention will be made of the role of prenatal diagnosis and fetal surgery in the treatment of selected neonatal chest conditions.

2.2 Ventilatory Support

Without doubt, the ability to support and treat various respiratory disorders in the neonate has led to an increase in survival among lower gestational age infants and critically ill term infants. Continuous positive airway pressure (CPAP) and conventional mandatory ventilation (CMV) remain the mainstays, although more recently high-frequency ventilation (HFV) and liquid ventilation (LV) have been in evaluation as alternative ventilatory modes.

2.2.1 Continuous Positive Airway Pressure

CPAP has proved an important tool in the treatment of neonates with respiratory distress syndrome (RDS). The mechanisms by which CPAP produces its beneficial effects include an increase in alveolar volumes and functional residual capacity (FRC), better alveolar recruitment and stability and redistribution of lung water. The result is an improvement in ventila-
tion–perfusion matching. However, high CPAP levels can lead to side effects, including overdistension, an increased risk of air leaks, carbon dioxide retention, cardiovascular impairment, decreased lung compliance and possibly an increase in pulmonary vascular resistance. Multiple clinical trials have evaluated the use of CPAP in neonates with respiratory disorders. Meta-analyses have generally yielded the conclusion that CPAP is most beneficial if used early on in the treatment of neonates with established RDS. Prophylactic CPAP in preterm infants does not decrease the incidence or severity of RDS or reduce the rate of complications or death that RDS carries (Subramaniam et al. 2001). However, once the diagnosis of RDS is established, the administration of CPAP decreases oxygen requirements and the need for mechanical ventilation, and it may reduce mortality (Ho et al. 2000). One notable side effect, however, is that the incidence of air leaks is increased (Ho et al. 2000). The optimal time to start CPAP is still under discussion and appears to depend on the severity of RDS. “Early” CPAP, when the arterial-to-alveolar ratio is higher than 0.20, was found to decrease the subsequent need for CMV and the duration of respiratory assistance (Carlo and Ambalavanar 1999). This suggests that CPAP should be initiated in newborns with RDS when the PaO2 is around 6–7 kPa (50 mmHg) with an inspired oxygen concentration of 40% or more. A meta-analysis of studies performed to determine whether CPAP facilitates successful extubation suggests a benefit in preterm infants (Davis and Henderson-Smart 2000). Now that surfactant is widely used in the treatment of RDS, the role of CPAP in the management of RDS needs to be revisited. The questions to be addressed include whether intubation and administration of surfactant early in the course of RDS will shorten the clinical course and improve outcome. Equally, if infants are intubated to receive surfactant, we need to ask whether they should be extubated immediately for CPAP or gradually weaned from mechanical ventilation, with all the consequent risks associated with the latter. Verder et al. (1994) reported that in infants with moderate to severe RDS (as defined by an arterial-to-alveolar ratio of less than 0.22) treated with nasal CPAP, a single dose of surfactant significantly reduced the need for subsequent mechanical ventilation from 85% to 43%. Lastly, safe ranges need to be established for PaO2 and PaCO2 in preterm infants on assisted ventilation, as the use of CPAP and the acceptance of higher PaCO2 and lower pH have been reported to improve outcome with a reduction in the incidence of chronic lung disease (CLD) (Avery et al. 1987). More studies are clearly needed in this area.

2.2.2 Continuous Mandatory Ventilation

CMV has a critical role in the care of neonates. The mode most frequently used is pressure-limited intermittent mandatory ventilation. With the increasing survival of premature infants, CMV is being used on smaller and sicker infants for longer durations. There is evidence to suggest that mechanical injury from ventilation plays a part in the pathogenesis of CLD. Ventilator-associated lung injury was traditionally thought to have been due to the use of high pressures; hence the name “barotrauma”. However, recent laboratory-based and clinical research has raised questions about this purported mechanism. Experimentally, investigators have used high and low lung volumes and pressures in an attempt to determine whether volume or pressure is the major culprit responsible for lung injury in the immature animal. By using negative pressure ventilation and chest strapping, investigators have been able to dissociate the magnitudes of volumes and pressures. These studies have consistently demonstrated that markers of lung injury (pulmonary oedema, epithelial injury and hyaline membrane) are present with the use of high volume and low pressure, but not with the use of low volume and high pressure. Thus, many investigators and clinicians prefer the term “volutrauma” to the more classic term of “barotrauma” (Dreyfuss and Saumon 1993, 1998; Hernandez et al. 1989).

Armed with this information, attempts are now being made to optimise particular ventilatory strategies in certain lung diseases in an effort to minimise barotrauma and volutrauma. This offers the theoretical advantage of improving gas exchange with the smallest amount of lung injury. These strategies have been derived by the application of basic concepts of pulmonary mechanics, gas exchange, and control of breathing to the particular lung disease in question. To demonstrate a benefit of adopting any particular ventilatory strategies, it is necessary to show an improvement in blood gases and/or a decrease in morbidity. Not surprisingly, the complexities of the multiple patient presentations along with the myriad of available ventilatory changes mean that definitive conclusions are hard to reach. Suffice it to say is that more research is needed.

RDS is characterised by low compliance and low FRC. An optimal CMV strategy would include con-