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Extubation failure in the very preterm infant

Keith J. Barrington*

Many very preterm infants require assisted ventilation. After resolution of their initial pulmonary dysfunction, when extubated they are at risk of failure due to poor respiratory drive, atelectasis, residual pulmonary function abnormalities, or intercurrent illness. Keeping such infants extubated will decrease lung injury and improve long-term pulmonary and perhaps even neurologic outcomes. On the other hand, if failure of extubation could be accurately predicted, then extubation could be deferred and the trauma of reintubation after a brief failed extubation, with increased work of breathing, hypoventilation, and respiratory acidosis, could be avoided.

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Prediction of extubation failure

Several studies have examined factors associated with failure of extubation. The contribution in this issue of Jornal de Pediatria from Hermeto et al.[1] confirms that infants with lower gestational ages are more likely to fail extubation; other factors which they investigated did not independently predict extubation failure. They also showed an association between extubation failure and both severe intracranial hemorrhage and patent ductus arteriosus. As the authors point out, the causal relationship between these findings is uncertain; in both cases the abnormal finding could be caused by, or could cause, failure of extubation. Their finding confirms that attempts to prevent extubation failure should be focused on the most immature infants. Other studies have examined physiologic or clinical measurements as a means of predicting successful extubation in individual infants, unfortunately there is no clear evidence that any specific test or physiologic measurement can adequately predict a successful extubation.

The maximal inspiratory force, that is, the most negative pressure that an infant can generate during an airway occlusion, has been suggested as a way of determining the capacity of an infant to tolerate extubation. However, this measure, like many others, is very dependent on the state of arousal of the infant, thus it varies from one minute to the next and has not proved helpful in predicting extubation failure.[2]

More sophisticated measurements, such as a low post-extubation functional respiratory capacity, have been shown to be statistically associated with extubation failure,[3] but in that study low gestational age was in fact a better predictor.

The test which appears to have the greatest potential currently is the minute ventilation test of Gillespie et al,[4] a measurement of minute ventilation during complete ventilator support followed by a repeat during 10 minutes of continuous positive airway pressure (CPAP). If the infant is capable of maintaining a minute ventilation at least 50% as high during CPAP, then successful extubation is likely. A randomized controlled trial showed that the use of this test significantly decreased the duration of assisted ventilation,[4] although the very early extubations were associated with a higher rate of extubation failure.

Kamlin et al.[5] evaluated another test of the ability to breathe spontaneously, the spontaneous breathing test, in which there is a short trial period of endotracheal CPAP. A failed test is defined as a bradycardia (< 100/min) for > 15 seconds or SpO_2 below 85% despite a 15% increase in FiO_2.

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They also demonstrated that minute ventilation falls by a greater amount during this 3-minute test for infants who fail extubation than among those who succeed.[5] Further confirmation of the utility of this test will probably require a randomized controlled trial.

Prevention of extubation failure

An evidence-based review of strategies to reduce extubation failure shows the following:

- Immature infants are more likely to be successfully extubated if they are not weaned to endotracheal CPAP prior to extubation, but extubated from low ventilator settings.
- It is uncertain whether weaning using synchronized intermittent mandatory ventilation (SIMV) and reducing the rate, or using assist control and weaning the pressure is preferable. Similarly, it is unclear whether newer modes of volume ventilation or pressure support ventilation improve the chances of successful extubation.
- Nasal CPAP after extubation is preferable to no pressure support.
- The method for generating the positive pressure appears to be unimportant, specifically the infant flow device is no better than other means of generating a positive pressure, it is possible that bubble CPAP is preferable to the infant flow device,[6] but this requires confirmation.
- Nasal ventilation using the Infant Star® ventilator with peak inspiratory pressures greater than 14 cmH_2O is preferable to CPAP,[7] in contrast, bi-level positive airway pressure (BiPAP) using the infant flow device is no better than CPAP.[8]
- The infant should probably have binasal prongs rather than a single nasal prong.
- Immature infants receiving methylxanthines prior to extubation have reduced extubation failure; more specifically, caffeine has been shown to decrease bronchopulmonary dysplasia[9] and to improve long-term outcomes[10] and should probably be the methylxanthine of choice.
- Additional respiratory stimulants, such as doxapram, do not further improve extubation success.[11]

Extubating the very immature infant

These considerations lead to the following recommendations: very preterm infants should be extubated as early as possible, since the maneuver is likely to be successful, perhaps using the minute ventilation test, with infants receiving more than 40% oxygen, and those who already have a low lung volume prior to extubation are unlikely to be successful. Apart from these limitations, most infants deserve an attempt to extubate as long as a reintubation can be achieved with little trauma, with experienced intubators and good premedication. Infants should receive a loading dose of 20 mg/kg of caffeine citrate prior to extubation, followed by a maintenance dose of 5 mg/kg/day and should be extubated from low ventilator settings. After extubation, they should be supported with nasal ventilation. As the Infant Star® ventilator is no longer available, and there is no other method of reliably synchronizing nasal ventilation, non-synchronized nasal ventilation with pressures of at least 14 cmH_2O peak and 6 cmH_2O positive end-expiratory pressure (PEEP) and a rate of 20 per minute should be initiated. In general, 72 hours of nasal ventilation would be a minimum, followed by CPAP or a trial of unsupported breathing depending on the clinical condition.

Conclusion

Early extubation of very preterm infants holds promise for reducing lung injury. Unfortunately, as Hermeto et al. showed, the infants most at risk are those most likely to fail. Selection of those individuals who are most likely to be successful is currently unsatisfactory and further research is required. Application of evidence-based interventions, as described above, will give all babies the greatest chance to remain extubated after the initial attempt and the opportunity to minimize the long-term consequences of lung injury.

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Prevalence of congenital heart defects in patients with Down's syndrome

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Down's syndrome (DS) is the most frequent chromosomal aberration among newborns, with an incidence of 1/660 live births; trisomy 21 occurs in 95% of cases due to maternal meiosis I non-disjunction, resulting in three full copies of chromosome 21 in each cell. Of these cases, 4% are due to parental/de novo translocation and 1% is due to mosaicism. Frequency of congenital heart defects (CHDs) in children with DS varies greatly in the literature, from 20 to over 60%.[1,2]

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In this issue of Jornal de Pediatria, Vilas Boas et al.[3] publish a study aimed at determining the prevalence of CHDs in patients with DS in the municipality of Pelotas, Brazil, describing the most frequent types and assessing associated factors. The authors' cross-sectional study included children with DS who were born and lived in Pelotas from January 2000 to December 2005. Data were collected by means of home interviews with mothers or guardians. There is no surprise in their findings with regard to the prevalence of DS and CHD in DS.

Bivariate analysis between the outcome CHD and the predicting factors maternal age, paternal age, parents' and child's skin color, presence of other malformations, and child's sex showed that the associations were not statistically significant. These finding correlated with 532 affected children found in the Atlanta project.[4]

The most frequent heart defect in the study by Vilas Boas et al.[3] was interatrial communication (17%); atrioventricular septal defect (AVSD) affected five patients. Complete AVSDs are one of the most common cardiac defects in DS, but the distribution of CHDs in children with DS may vary according to geographical location.[5,6] In epidemiological studies carried out in the United States and Europe, a complete form of AVSD reached the highest rate, affecting up to 60% of patients.[7,8] Alternately, in Asia, isolated ventricular septal defects have been reported to be the most common defects, observed in about 40% of patients.[9] In Latin America, a secundum type of atrial septal defect (ASD) was reported to be the most common lesion (40%).[5] This data correlated with Latin American studies.

Age at evaluation of CHD was low in the study by Vilas Boas et al.[3]: 63.8% of the patients were evaluated during the first 6 months of age, and most of them had echocardiograms (93.6%). This striking finding is the

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