Commentary

Prediction of ventilation weaning outcome: children are not little adults

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See related research by Leclerc *et al*. in this issue [http://ccforum.com/content/9/6/R798]

Abstract

Prediction of ventilation weaning outcome in children is important, as unsuccessful extubation increases both morbidity and mortality. Adult weaning criteria are poor predictors of weaning outcome in children for several possible reasons: the length of mechanical ventilation is generally much shorter, and the weaning failure rate is lower in children (thus larger patient numbers are required); integrated weaning indices, such as the rapid shallow breathing index, do not account for normal developmental changes in respiratory function; and the heterogeneity of mechanically ventilated children is greater than in adults. The challenge remains to find universal weaning outcome predictors in children.

In this issue of *Critical Care*, Leclerc and colleagues [1] report on whether mechanical ventilation weaning predictors proposed by the Task Force of the American College of Chest Physicians (ACCP) are useful to predict weaning outcome in children. Determination of predictors of weaning from mechanical ventilation in children is important, not only to reduce the risk of re-intubation and avoid delaying weaning resulting in longer paediatric intensive care unit (PICU) stay, but also to provide clearer weaning guidelines, especially as there is an increasing trend for weaning and extubation to be carried out by nursing staff. In addition, unsuccessful extubation increases both morbidity and mortality. Kurachek *et al*. [2] found that PICU patients failing extubation had longer length of PICU stay (17 versus 7 days), and a significantly higher mortality (4% versus 0.8%).

In adult intensive care, there are established indices predicting the outcome of trials of weaning from mechanical ventilation, such as the rapid shallow breathing index [3]. These were established to identify the earliest time that a patient can resume spontaneous breathing [3] and they also appear to apply if performed immediately pre-extubation [4]. Major efforts have been made to identify parameters that can predict extubation failure in children, but a clearly defined set of risk factors has not yet been established. Leclerc *et al*. [1] also found that the ACCP adult criteria were poor predictors of weaning outcome in children.

There are several possible reasons for this discrepancy between adult and paediatric studies. In the adult studies, the length of mechanical ventilation and failed weaning rate are higher than in children, thus possibly allowing identification of risk factors using smaller numbers of patients. In the adult studies, the median length of ventilation was 8 to 11 days [3,4], and weaning failure rates were 40% [3]. In paediatric studies, the length of mechanical ventilation is generally much shorter, being two days or less in most children [5]. In the study by Leclerc *et al*. [1], the median length of ventilation was 4 days, and the weaning failure rate was 20%, indicating that much larger numbers of paediatric patients may be required to detect a significant difference.

The timing of the studies is also important. Most of the adult studies were carried out when the patients were clinically stable and the primary physician considered them ready to undergo a weaning trial. In the current study [1], patients had already been weaned to pressure support ventilation <15 cmH_2O, a positive end expiratory pressure (PEEP) of <5 cmH_2O and inspired oxygen fraction (FiO_2) of <0.4 and only patients who passed a spontaneous breathing trial were included. Thus, the authors may have pre-selected a group of patients who had already met all the clinical criteria for weaning, and were at low risk of weaning failure, thereby reducing the power of their study measurements. Farias *et al*.

ACCP = American College of Chest Physicians; f = rapid spontaneous respiratory rate; FiO_2 = inspired oxygen fraction; PEEP = positive end expiratory pressure; PICU = paediatric intensive care unit; Vt = low spontaneous tidal volume.

[6] studied 418 children also with $FiO_2 < 0.4$ and PEEP < 5 who underwent a spontaneous breathing trial with T-piece or low level pressure support, and even when the 95 patients who failed the spontaneous breathing trial were included, they found that the ability of traditional weaning indices to discriminate between patients who could be extubated and those who could not was still very poor. In contrast, Venkataraman *et al*. [7] studied 312 children immediately prior to extubation, but did not have a minimum ventilation requirement prior to extubation, and they were able to establish threshold values for a low (<10%) and high (>25%) risk of extubation failure. A spontaneous tidal volume <3.5 ml/kg due to low respiratory drive or increased load, and patients extubated from a higher level of ventilator support (FiO_2 >0.4, mean airway pressure >8.5 cmH_2O) were more likely to fail extubation [7]. Thus, the low patient numbers (56 patients) and a requirement for FiO_2 <0.4, PEEP <5 cmH_20 and a passed spontaneous breathing trial may have contributed to the difficulty in detecting a significant difference in Leclerc *et al*.'s study [1].

Adult weaning indices are designed to quantify the extent of rapid shallow breathing (rapid spontaneous respiratory rate (f), low spontaneous tidal volume (Vt) and poor inspiratory effort (inspiratory occlusion pressure)) as this is a common finding in adult patients who fail weaning [3]. When these indices are applied to children, however, they have a very poor predictive power. Venkataraman *et al*. [7] and Farias *et al*. [6] found that integrated indices such as f/Vt and the compliance rate oxygenation and pressure index do not account for normal developmental changes in respiratory function, including mechanics and gas exchange and, therefore, are poor predictors of extubation success in infants and children. Leclerc *et al*. [1] again found that they performed poorly, even when the paediatric adjusted version of rapid shallow breathing (tidal volume and dynamic compliance corrected for the patient's body weight) [8] is used. This still does not take into consideration age related changes in spontaneous respiratory rate, and that not all paediatric patients develop tachypnoea prior to weaning failure. In some children, bradypnoea occurs, especially if oversedation is the primary reason for a low inspiratory drive [7].

Another possible factor to account for the difficulty in predicting weaning outcome in children is the heterogeneity of mechanically ventilated children. In Leclerc *et al*.'s [1] study, the causes of re-intubation included respiratory failure due to spinal amyotrophy, myopathy, and mucopolysaccharidosis, three patients with pulmonary oedema, and two with bronchial obstruction. Thus, the reason for weaning failure may be disease specific in some of these children [2], and may be difficult to detect using respiratory function measurements alone.

It is thus unlikely that a single parameter or index predicting weaning outcome will be found, although larger studies may determine a 'universal set' of extubation failure predictors. For example, low spontaneous tidal volume has been found to be predictive of extubation failure in the majority of published paediatric studies where it was measured [6,7,9,10]. Multiple studies have also noted that young age, prolonged ventilation support and prolonged use of sedative/analgesic drugs are risk factors for re-intubation [2,5,10,11]. Our challenge still remains to find simple easy to measure risk factors that will accurately define the group of paediatric patients at high risk of extubation failure.

Competing interests

The author(s) declare that they have no competing interests.

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