Spontaneous Breathing Trials in Children: Putting the 'T' in SBT

The use of invasive mechanical ventilation is a life-saving and essential component of pediatric intensive care. However, prolonged intubation can be associated with an increased risk of ventilator-induced lung injury, nosocomial infections, airway irritation or trauma, and sedative dependence.[1,2] A spontaneous breathing trial (SBT) is typically performed in children to gauge readiness for extubation because gradual weaning may not be required to be successfully liberated from the ventilator.[3] Although SBTs are utilized in the vast majority of pediatric ICUs, the optimal formulation and interpretation of results has yet to emerge in the literature.

In the current issue of RESPIRATORY CARE, Mortamet et al[4] report observations made in a cohort of mechanically ventilated children during an SBT. This is an important area of pediatric mechanical ventilation, and the authors should be applauded for focusing their work on this topic. They collected a number of important respiratory and hemodynamic factors, including but not limited to esophageal pressure (P_{es}), electrical activity of the diaphragm (EA_{di}), and oxygen consumption ($\dot{V}_{O_2}$). These data were recorded over the course of 90 min: 30 min before, 30 min during, and 30 min after an SBT in CPAP. None of the variables recorded in the study reached statistical significance. The minute-to-minute pressure-time product of P_{es} increased from 23 during baseline ventilation to 83 cm $H_2O \times s$ during the SBT, but this was not statistically significant ($P = .75$). A trend was noted for peak EA_{di}, which increased from 7.5 to 15.9 μV ($P = .059$) before and during the SBT. $\dot{V}_{O_2}$ was 3.6, 3.8, and 3.8 mL/kg/min before, during, and after the SBT, respectively ($P = .98$).

In general, the study is adequately designed from a methodological perspective to report changes in parameters during the peri-SBT time period. However, the study is underpowered to detect *statistically significant* changes among the main outcome variables of P_{es}, EA_{di}, and $\dot{V}_{O_2}$. The pressure-time product of P_{es} more than tripled, but the *P* value did not approach significance. Rightfully so, the authors anticipated only modest increases in $\dot{V}_{O_2}$ because the diaphragm has been reported to account for only 1–3% of the total $\dot{V}_{O_2}$ during breathing.[5] Interestingly, the authors report a 5.5% increase in $\dot{V}_{O_2}$ before and during the SBT, which may be associated primarily with increased work of the diaphragm during CPAP/SBT. This may be one of the most interesting findings of the study. The authors also point out that the absolute values for $\dot{V}_{O_2}$ and CO_2 elimination ($\dot{V}_{CO_2}$) are very low compared to data published by my group.[6] Also of concern are the values for the respiratory quotient ($RQ = \dot{V}_{CO_2}/\dot{V}_{O_2}$) obtained during the study. The average RQ of a cohort of children in the PICU is typically 0.89–0.91,[6-8] and the physiologic range for RQ is 0.67–1.3.[9] An RQ that is very low, as in the findings by Mortamet et al[4] (ie, approximately 0.71), is most likely to occur from either the nearly exclusive metabolism of lipid by the child or by measurement error from a leak, gas sensor, or flow sensor on the indirect calorimeter itself. Given either of these scenarios, it is difficult to say whether the findings for $\dot{V}_{O_2}$ can be extrapolated to other populations.

SEE THE ORIGINAL STUDY ON PAGE 509

Based on these comments, it is difficult to make any specific generalizations about how these data can be incorporated into practice at this point in time. Ignoring *P* values and $\dot{V}_{O_2}$ for a moment, however, I believe the work by Mortamet et al[4] is both thought-provoking and hypothesis-generating. If one is able to accurately measure factors during baseline ventilation, and then during an SBT, what is the acceptable magnitude of a change in P_{es}, EA_{di}, or $\dot{V}_{O_2}$? At what threshold shall we set these variables to adequately detect those who are likely to fail extubation? Can we use other factors that are readily obtained on the ventilator as a surrogate for the more difficult to obtain measurements of P_{es} and $\dot{V}_{O_2}$?

In the future, findings from the study by Mortamet et al may serve as pilot data to design a larger study powered to detect changes in P_{es}, EA_{di}, and $\dot{V}_{O_2}$. Importantly, this work should be expanded to detect differences in the data between

Dr Smallwood has disclosed relationships with Mallinckrodt Pharmaceuticals, Bernoulli Health, and Ventec Life Systems.

Correspondence: Craig D Smallwood PhD RRT, 300 Longwood Ave., Bader Building 634, Boston, MA 02115. E-mail: craig.smallwood@childrens.harvard.edu.

DOI: 10.4187/respcare.07057

those subjects who were successfully extubated and those who failed or required noninvasive respiratory support.

Craig D Smallwood
Division of Critical Care Medicine
Department of Anesthesia, Critical Care and Pain Medicine
Boston Children's Hospital, Boston, MA, and
Harvard Medical School
Boston, MA

REFERENCES

1. Rivera R, Tibballs J. Complications of endotracheal intubation and mechanical ventilation in infants and children. Crit Care Med 1992; 20(2):193-199.
2. Chomton M, Brossier D, Sauthier M, Vallieres E, Dubois J, Emeriaud G, et al. Ventilator-associated pneumonia and events in pediatric intensive care: a single center study. Pediatr Crit Care Med 2018;19(12): 1106-1113.
3. Randolph AG, Wypij D, Venkataraman ST, Hanson JH, Gedeit RG, Meert KL, et al. Effect of mechanical ventilator weaning protocols on respiratory outcomes in infants and children: a randomized controlled trial. JAMA 2002;288(20):2561-2568.
4. Mortamet GNN, Groleau V, Essouri S, Fauroux B, Jouvet P, Emeriaud G. Impact of spontaneous breathing trial on work of breathing indices derived from esophageal pressure, electrical activity of the diaphragm, and oxygen consumption. Respir Care 2019;64(5):509-518.
5. Field S, Kelly SM, Macklem PT. The oxygen cost of breathing in patients with cardiorespiratory disease. Am Rev Respir Dis 1982; 126(1):9-13.
6. Smallwood CD, Walsh BK, Bechard LJ, Mehta NM. Carbon dioxide elimination and oxygen consumption in mechanically ventilated children. Respir Care 2015;60(5):718-723.
7. Hulst JM, van Goudoever JB, Zimmermann LJ, Hop WC, Buller HA, Tibboel D, et al. Adequate feeding and the usefulness of the respiratory quotient in critically ill children. Nutrition 2005;21(2): 192-198.
8. Mouzaki M, Schwartz SM, Mtaweh H, La Rotta G, Mah K, Herridge J, et al. Can Vco2-based estimates of resting energy expenditure replace the need for indirect calorimetry in critically ill children? JPEN J Parenter Enteral Nutr 2017;41(4):619-624.
9. Mehta NM, Smallwood CD, Graham RJ. Current applications of metabolic monitoring in the pediatric intensive care unit. Nutr Clin Pract 2014;29(3):338-347.