What’s new in pediatric mechanical ventilation: NAVA NIV

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Acute Respiratory Failure (ARF) is a leading cause of admission in Pediatric Intensive Care Unit (1-2). Traditional treatment includes endotracheal intubation and mechanical ventilation, that are invasive and not free from risks (3). Recent experiences from pediatric studies showed that Non-Invasive Pressure Support Ventilation (NIV-PS) has been associated with lower intubation rate, adverse events and mortality compared to mechanical ventilation delivered by an endotracheal tube (4-6). Nonetheless, in pediatric ARF the application of a well-synchronized NIV-PS is technically challenging due to the presence of leaks and the age-specific characteristics of pediatric respiratory pattern (high respiratory rate, short inspiratory/expiratory time and weak inspiratory effort) (7). Consequently, NIV-PS often results in difficult patient-ventilator interaction, with a failure rate up to 43% (8-9). Data from previous studies report a higher Asynchrony Index (AI) in children than in adults, with values largely exceeding the 10% cut-off currently defining severe dyssynchrony (10, 14-15). This may be explained by the typical pediatric breathing pattern, the large leaks around the interface and the technical characteristics of ventilators. Pediatric breathing pattern is characterized by low tidal volume, weak inspiratory effort, high respiratory rate and short neural timings. In this condition, the current ventilator technology is often unable to detect the small variation in tidal volume and flow generated by small children and to allow a fast response. From this point of view, NAVA represents an attractive technology to deliver NIV while optimizing synchronization and interaction in preterms, neonates and small children. Neurally Adjusted Ventilatory Assist (NAVA) is a new form of ventilatory assistance wherein the ventilator applies positive pressure throughout inspiration synchronously and proportionally to the Electrical Diaphragm activity (Edi). The acquisition of the diaphragm electromyography (Edi signal) represents the critical point of NAVA technology, because ventilator activation and cycling off are under direct control of Edi signal. The
major concern is the acquisition of a selected diaphragmatic electrical signal and to discriminate signals originating from tissues surrounding the diaphragm (heart, lung and muscles) and from PICU electrical environment.

Specific signal processing algorithms (double subtraction technique) are now incorporated in NAVA technology to achieve the highest signal to noise ratio to trigger the ventilator, to compensate for electrodes-muscle distance, to remove interferences generated from PEEP variations in intra-abdominal pressure, activity from intercostal or abdominal muscles and signals from ICU devices. Thus, NAVA is not influenced by large leaks around uncuffed endotracheal tubes or noninvasive interfaces (10-13). Studies in intubated children found that NAVA improved interaction by reducing asynchronies and optimizing ventilator cycling (12,13). Two recent studies showed that the application of Non-Invasive NAVA (NIV-NAVA) in children with ARF is feasible and may reduce asynchronies as compared to NIV-PS (14,15). Previous randomized studies investigated the effects of NAVA both in invasively and noninvasively ventilated neonates and children showing a reduction in peak and mean airway pressure (12-15). In a recent paper by our groups we conducted a prospective randomized crossover physiological study on eighteen children with ARF needing noninvasive ventilation. Enrolled children were allocated to receive two 60-min NIV-PS and NIV-NAVA trials in a crossover randomized sequence. Primary end-point was the Asynchrony Index (AI). Parameters describing patient-ventilator interaction and gas exchange were also considered as secondary end points. In our paper NIV-NAVA compared to NIV-PS: 1) reduced AI ($p=0.001$) and the number of asynchronies/min for each type of asynchrony studied (Ineffective Efforts, Double Triggering, Autotriggering, Figure 1,2), mainly Ineffective Efforts; 2) it increased the Neuroventilatory Efficiency Index ($p=0.001$), suggesting better neuroventilatory coupling; 3) reduced inspiratory and expiratory delay times ($p=0.001$) as well as lower peak and mean airway pressure ($p=0.006$ and $p=0.038$, respectively); 4) lowered oxygenation index ($p=0.043$). No adverse event was reported. In conclusion, NIV-NAVA delivered as first-line noninvasive respiratory support in children with infectious ARF was found to be effective in
reducing asynchronies and improving patient-ventilator interaction, as depicted in Figure 3. Further
studies are warranted to evaluate the clinical impact on intubation rate, PICU morbidity and
mortality.

REFERENCES

   acute respiratory failure in the developing world: literature review and and implementation

2. Murthy S, Kissoon N. Management of severe viral infections in the pediatric intensive care

3. Bontemps STH, van Woensel JB, BOS AP. Acute viral lower respiratory tract infections in

   with severe bronchiolitis is associated with decline in intubation rates over a decade.
   *Intensive Care Medicine* 2012; 38: 1177-1183

5. Tassiou I, Papazoglou K, Patsoura A et al. Non invasive ventilation in a pediatric intensive
   care unit. *Pediatric Critical Care Medicine* 2011 12:3 Suppl. 1 (A129)

   noninvasive ventilation in pediatric acute respiratory failure. *Pediatric Critical Care
   Medicine* 2008 9:484-489

7. Alander M, Peltoniemi O, Pokka T, et al: Comparison of Pressure-, Flow-, and NAVA-
   Triggering in Pediatric and Neonatal Ventilatory Care. *Pediatric Pulmonology* 2012; 47:76-
   83


Figure 1. Asynchrony Index

Figure 2. Type of Asynchronies

Figure 3. Typical traces of NIV-PS and NIV-NAVA