NAVA and Edi monitoring

Year in Review

2013
The body of scientific publications for NAVA and Edi monitoring continues to grow, with over 180 peer-reviewed publications in total.

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In 2013, nearly the same number of peer-reviewed papers were published (33 articles in PUB MED) compared to 2012 (35 articles).

Over the last 20 years, the distribution of article type can be plotted as:
In 2013, the following articles were published:

**Scientific Papers (N=13)**

**NAVA and Sedation:**
Vascchetto et al. (CCM 2013), were the first to study the effects of sedation (Propofol) on patient-ventilator interaction during PSV and NAVA. In fourteen adult patients with ARF, they randomized 3 levels of PSV and 3 levels of NAVA, during wakefulness, light sedation and deep sedation. Reducing sedation caused an increase in (diaphragm electrical activity) Edi amplitude in both modes. Patient-ventilator interaction worsened (ineffective triggering) with increasing sedation in PSV, whereas with NAVA synchrony was present and not affected by sedation.

**NAVA and Ventilation Distribution:**
Blankman et al. (ICM 2013) examined ventilation distribution (measured with EIT) at varying levels of PSV and NAVA in 10 adult patients with acute lung injury. Their results demonstrated higher aeration of the dependent lung regions during NAVA and less over-assistance compared to PSV.

**Edi and Work of Breathing:**
Bellani et al. (CCM 2013) compared the amplitude (Edi peak) of the Edi waveform to the measured work of breathing (Pmusc) in 10 adult patients on mechanical ventilation at three levels of assist during both PSV and NAVA. Although the Edi/Pmusc ratio (an index of “neuro-mechanical coupling”) was found to be variable between patients, within a patient, the ratio was constant for different modes and levels of assist. The authors concluded that the Edi was a valid index of global inspiratory muscle force, which confirms the findings of Beck et al. from 2001 (Beck AJRCCM 2001).

**Neuro-ventilatory Efficiency and Weaning:**
From University of Göttingen Medical School, Barwing et al. (CC 2013) used the EAdi (combined with VT) as a monitoring parameter in eighteen adult patients that were having difficulty with weaning from the respirator. They performed a 30 min spontaneous breathing trial (SBT) with t-piece and 90% FiO2 and found a higher EAdipk (~26 μV) in the failure group, compared to the success group (13 μV). The neuro-ventilatory efficiency (NVE), calculated as ml/μV, was significantly lower in the failure group, compared to the success group. These findings confirm the results of two previous studies examining Edi and NVE as predictors of weaning success and failure (Liu CC 2012; Dres ICM 2012).

**Neuro-ventilatory efficiency and weaning:**
Rozé et al. in The British Journal of Anesthesia (2013), also reported ventilatory and Edi parameters in 12 adult patients, undergoing daily SBTs (with PSV = 7 cm H2O, ZEEP). If patients failed the 30-min SBT, they were placed on NAVA ventilation (NAVA level set to 60% of Edipk during SBT), and the SBT was repeated the subsequent day. The process was continued until successful weaning was achieved. Their analysis included the (daily) increase in Edi and the drop in NVE when patients were switched from NAVA to SBT. Edi increased by equal amounts when switched from NAVA to SBT, regardless of success or failure, however, the drop in NVE was less for the success group. Interestingly, looking at the change in Vt from NAVA to the SBT, Vt could be maintained in the success group, whereas it dropped significantly in the failure group.

**Edi and Tidal Volume Matching:**
Chiew et al. (Biomed Eng Online 2013) studied the relationship between the integrated Edi and VT, the so-called “Range90” index, during three different levels of non-invasive NAVA (NIV NAVAs) in 12 adult patients. A low Range90 index is suggestive of better “matching” between patient respiratory drive and delivery of assist. The NAVA level was set to the same peak pressure as during clinical PSV prior to the study (NAVA100), to 50% less (NAVA50) and 50% more (NAVA150). Globally, NAVA50 was found to have the best matching of Edi and VT (albeit only in 7 of the 12 patients). The authors also stated however, that NAVA level settings, based on their findings, are patient specific.
NAVA in prolonged weaning:
In thirteen tracheotomised patients with prolonged weaning, Vagheggini G et al (Respir Med 2013) compared the physiological response to four different levels of PSV and NAVA. As the assist increased, the peak Edi decreased in both modes, however VT in PSV increased from 4.5 ml/kg to >6 ml/kg, whereas in NAVA, the VT at the highest assist level was 5 ml/kg. Neural respiratory rate did not change during different NAVA levels, but decreased with increasing PSV. Ineffective triggering was the same in both modes.

Note: These findings (NAVA reduces risk of overdistension by down-regulation of Edi) confirm those of 14 other studies (e.g. Colombo 2008; Brander 2009; Terzi 2011; and others).

Note: 17 adult studies (in 240 patients) show mean Vt values of 6.5ml/kg (range 5.9-9.9 ml/kg) on NAVA (mean breathing frequency is 25 bpm, range 18-30). In 14 infant studies, mean Vt was 6.4 ml/kg on NAVA (range 3-8.7 ml/kg) with a mean breathing frequency of 46 bpm (range 35-59).

Edi values in neonates:
In the pediatric and neonatal literature, Stein and colleagues (J Perinatol 2013) were the first to publish Edi data in non-ventilated preterm neonates (n=17) (only highflow nasal cannula, nasal cannula or room air). Edi was collected weekly, up to 10 weeks. The average Edi peak was 10.8 uV (range 3.8 – 18.7) and the average Edi min was 2.8 uV (range 0.8-7.6) and did not change with postnatal maturation. No adverse events were reported with Edi catheter placement (similar to 6 other studies that specifically evaluated this, eg. Barwing, ICM 2009 or Duyndam, Nurs Crit Care 2013).

NAVA in neonatal RDS:
In a Chinese study (Zhongguo Dang Dai Er Ke Za Zhi. 2013), Chen et al studied 10 preterm neonates with RDS, and compared NAVA to SIMV (1 hour each). They showed improved patient-ventilator interaction, with lower PIP, lower respiratory rate, lower Edi and lower work of breathing with NAVA.

NAVA in PICU (invasive and non-invasive):
Improved patient-ventilator interaction with NAVA was also found in two separate papers by Vignaux et al (both in PCCM 2013) in pediatric patients undergoing invasive (19 infants) and non-invasive (6 infants) ventilation. Extensive manual analysis was performed on the airway pressure and Edi waveforms in these studies to reveal the asynchronies (wasted efforts, auto-triggering) and dys-synchronies (trigger and cycling-off delays).

Note: Interestingly, as of the end of 2013, 24 studies (PUBMED) in 329 patients of all ages have shown that NAVA improves synchrony compared to conventional ventilation modes. In the 17 studies (224 patients) that reported an Asynchrony Index, asynchrony was reduced with NAVA (26 to 5%, p<0.001). 19 studies in 301 patients of all ages report improved or equivalent physiological parameters.

NeuroSync index for patient-ventilator interaction:
As an alternative to tedious and time-consuming (limiting the time periods for reasonable analysis), Sinderby et al, in Critical Care (2013), described an automated method to use the EAdi waveform in detecting and quantifying poor patient-ventilator interaction in adult patients on PSV. They described algorithms and a “NeuroSync Index” which could quantify patient-ventilator interaction, and could separate “asynchrony” from “dys-synchrony”. The algorithms reported were standardized and correlated well with manual analysis.

NAVA in Pediatric ARDS and outcomes:
Piastra et al (J Crit Care 2013) performed a nested study to compare the clinical outcomes in children ventilated either with PSV (n=20) or NAVA (n=10) after a period of HFOV for severe ARDS. From HFOV, NAVA showed less of an increase in HR and blood pressure, showed an improved COMFORT score, lower PIP and PaCO2. Duration of NAVA was significantly lower than that of PSV.
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CASE REPORTS (N=3)

Use of Edi for detecting Congenital Central Hypoventilation Syndrome:
Both Rahmani et al (J Coll Physicians Surg Pak) and Szcapa et al demonstrated the use of monitoring Edi as a diagnostic tool in newborn infants suspected of having Congenital Central Hypoventilation Syndrome (CCHS), also known as “Ondine’s Curse”. In both cases, the infants had recurring hypoventilation and oxygen desaturation; they were admitted to the NICU and were intubated and mechanically ventilated. The Edi was measured in both children, and was found to be absent during sleep (and hypercapnia observed in the Szcapa study). Both centers subsequently performed genetic testing and confirmed CCHS.

Interference with Edi:
Somers et al (Minerva Anesthesiol) reported a technical note, where electrical equipment (intra-aortic balloon catheter, a pacemaker and a heating device) could interfere with the Edi signal in the ICU. The study demonstrated the importance of catheter positioning procedures. One of the interfering devices has since been taken off the market. Note that despite this single case of report of pacemaker-related problems, the use of pacemaker during measurements of Edi/NAVA has previously been reported as non-problematic in other studies. Rahmani A, Ur Rehman N, Chedid F.

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