NAVA-korzyści dla noworodka

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DISCLOSURE

• No conflict of interest related to this topic

POZNAŃ and WIELKOPOLSKA REGION

• 4 mln level III center (7 level II and 24 level I)
• 7300 deliveries
• 400 outborn admissions
• 900 NICU admissions
• 37 NICU beds

Poznan Univ of Med Sciences NICU
• Intro/basics
• How it looks/how it works?
• Status quo in the literature
• How to tune-up NAVA ventilation
• Ventilation Induced Diaphragm Dysfunction

### Comparison of Triggering Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impedance</td>
<td>No added dead space, noninvasive</td>
<td>Poor sensitivity, many artifacts</td>
</tr>
<tr>
<td>Pneumatic Capsule</td>
<td>Rapid response, no extra dead space, leak tolerant</td>
<td>Positioning is critical, no longer commercially available</td>
</tr>
<tr>
<td>Pressure</td>
<td>No added dead space, leak tolerant</td>
<td>Poor sensitivity, long trigger delay, high WOB</td>
</tr>
<tr>
<td>Airflow</td>
<td>Very sensitive, rapid response</td>
<td>Added dead space, leak sensitive</td>
</tr>
<tr>
<td>Diaphragm EMG - Edi</td>
<td>Sensitive, most rapid response, leak tolerant</td>
<td>Requires careful positioning of probe</td>
</tr>
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State of the art in mechanical ventilation, Keszler, J of Perinatology (2009) 29, 262-75

### NAVA
neurally adjusted ventilatory assist

### How NAVA works

The ventilator generates the peak inspiratory pressure based on the amount of electrical activity generated by the diaphragm.

The PIP is generated until the electrical activity decreases by 40 to 70% and then the breath is terminated.

The baby therefore determines the peak inspiratory pressure, the inspiratory and termination time for each breath and the respiratory rate.
**NAVA Terminology**

**EADi** – **Electrical Activity of the Diaphragm**  
– Abbreviated as Edi

**Edi Peak** - peak electrical activity tells you about the neural inspiratory effort

**Edi Min** – tonic electrical activity believed to play a role in preventing de-recruitment of the lung (Allo 2006, Emeriaud, Beck 2008)

**Edi trigger** – the change in Edi needed to trigger the ventilator to deliver a breath

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**NAVA Terminology**

**NAVA level** - Conversion factor that translates the Edi from an electrical signal to a peak inspiratory pressure (PIP)

Calculated by:

\[
\text{PIP} = \text{NAVA level} \times (\text{Edi peak} - \text{Edi min}) + \text{PEEP}
\]

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**NAVA Terminology**

\[
\text{PIP} = \text{NAVA level} \times (\text{Edi peak} - \text{Edi min}) + \text{PEEP}
\]

- **NAVA level 2**  
  Edi peak = 12  
  Edi min = 2  
  PEEP = 5

\[
\text{PIP} = 2 \times (12 - 2) + 5 = 2 \times (10) + 5 = 25 \text{ mmHg}
\]

Brainstem senses decreased pH or increased pCO2 – wants to increase tidal volume – increases the electrical signal to the diaphragm

- **NAVA level 2**  
  Edi peak = 15  
  Edi min = 2  
  PEEP = 5

\[
\text{PIP} = 2 \times (15 - 2) + 5 = 2 \times (13) + 5 = 31 \text{ mmHg}
\]

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**NAVA Terminology**

\[
\text{PIP} = \text{NAVA level} \times (\text{Edi peak} - \text{Edi min}) + \text{PEEP}
\]

- **NAVA level 3**  
  Edi peak = 12  
  Edi min = 2  
  PEEP = 5

\[
\text{PIP} = 3 \times (12 - 2) + 5 = 3 \times (10) + 5 = 35 \text{ mmHg}
\]

Brainstem senses increased pH or decreased pCO2 – wants to decrease tidal volume – decreases the electrical signal to the diaphragm

- **NAVA level 3**  
  Edi peak = 8  
  Edi min = 2  
  PEEP = 5

\[
\text{PIP} = 3 \times (8 - 2) + 5 = 3 \times (6) + 5 = 23 \text{ mmHg}
\]
Conventional Ventilation

Patient Controls using Flow Trigger:
- Initiation of Breath
- Rate (in some modes)

Ventilator Controls:
- Peak Pressure or Tidal Volume
- Inspiratory Time
- Termination of Breath
- PEEP
- Minimum Rate
- FiO2

Synchrony:
- Only for Initiation of Breath
- Asynchronous for Many Breaths
- False Triggering

NAVA Ventilation

Patient Controls using Neural Trigger:
- Initiation of Breath
- Inspiratory Time
- Rate
- Peak Pressure
- Termination of Breath

Ventilator Controls:
- FiO2
- PEEP

Synchrony:
- Initiation of Breath
- Size of Breath
- Termination of Breath

NAVA is not only about triggering

Neuroventilatory coupling

Health ———————————> Disease

Neural Control of Ventilatory Assist (NAVA)

Central Nervous System ————> Phrenic Nerve ————> Diaphragm Excitation ————> Diaphragm Contraction ————> Chest Wall and Lung Expansion ————> Airway Pressure, Flow and Volume

Ideal Technology
New Technology
Current Technology
Edi Catheter

1. Connection to Edi cable
2. Nutrition feed
3. Evacuation (only 12 and 16 Fr)
4. Reference electrode
5. Electrodes (9)
6. Holes for nutrition/evacuation
7. Inter Electrode Distance (IED)
8. Lumen for electrodes
9. Sump lumen (only 12 and 16 Fr)
10. Feeding lumen
11. Barium strip for X-ray identification
12. Coating for easier insertion and better electrical conductivity (indicated in the picture with light blue)
13. Scale in centimeters from the tip

Fr (French) = circumference of the catheter in mm
Catheter positioning 2

NAVA ventilation tuning

NAVA ventilation tuning
How does it work in real life?

**Status quo in the literature**

- 235 peer reviewed manuscripts
- Clinical studies on newbrons:
  - Invasive NAVA: 6 studies (n=106 babies); GA=24 weeks, bw=728g
  - Non-invasive NAVA: 2 studies (n=17 babies); GA=24 weeks, bw=812g
- Results:
  - Limits PIP and TV
  - Superior patient-ventilator interaction

Electrode Array in Neurally Adjusted Ventilatory Assist (NAVA)

Mechanical ventilation induces prolonged neural expiratory time

- 14 patients with ARDS
- Draeger Babylog 8000
  - Trigger setting @1
  - Flow 10 L/min
- Ead measured with esophageal electrodes
- CONCLUSIONS:
  - No reflex deactivation of the diaphragm during SIMV
  - 53% infant-ventilator asynchrony of the total breath
  - Asynchrony associated predominantly with expiratory asynchrony
  - Online monitoring of diaphragm activation during IMV


NAVA improves synchrony and respiratory unloading

- 12 New Zealand rabbits
  - (ARDS lung lavage model)
  - Servo I (VT=6 mL/kg, RR=20, FiO₂=0.5, PEEP=2 cmH₂O)
  - Incremental PSV and NAVA run for each animal
- CONCLUSIONS:
  - NAVA requires small increase in airway pressure to unload the diaphragm
  - NAVA interferes less with natural breathing pattern than PSV

NAVA in LBW infants

- 7 premature infants < 36 weeks ga
  - 5F oro-gastric tube
  - Conventional ventilation group: Babylog Draeger, PSV
  - NAVA group: Servo300 with NAVA:
    - Intubated – ET tube, NAVA matched PIP
    - Non-intubated – SNP tube, NAVA adjusted to reach this same delta IP

CONCLUSIONS:
- Patient-ventilator synchrony not affected by the presence of leak
- Interface with less leak would increase the efficiency of non-invasive ventilation with NAVA

Edi Catheter positioning procedure

- Four ECG waveforms for Edi catheter position
- Edi waveform
- Scale and sweep speed settings
- Freeze function
- Numerical values of Edi peak and Edi min

Fine-tune the settings in Pressure Support

Trigger Edi

- Trigger Edi zawsze na 0.5 uV

NAVA estimation
NAVA titration

• Starting at NAVA=0.5 => every 3 minutes increases until NAVA=4

Edi from 1 premie

Edi from all premies

NAVA number (cmH2O/μV)

NAVA optimization

• Optimize the NAVA level according to Edi max, which should be targeted between 5-15 μV.
  - If Edi max is < 5 μV, decrease the NAVA level.
  - If Edi max is > 15 μV, increase the NAVA level.
• The changes in NAVA level should be 0.1-0.2 cmH2O/μV at a time. The changes in NAVA level are mediated in a few breaths to Edi max. The usual NAVA level is 0.5 – 2.0 cmH2O/μV.
### Setting up PEEP

- Initially, set the same PEEP as in the previous ventilator settings. If Edi min is constantly > 1 μV (as a sign of tonic diaphragmatic activity to maintain FRC), increase PEEP.

### Setting up apnea time

- Set the initial apnea time at 5 seconds. If breathing is irregular and the patient unstable, you may decrease apnea time down to 2 seconds. This will result in backup breaths after each 2-second apnea until next spontaneous breath indicated by Edi signal occurs. However, make sure that the backup ventilation does not hyperventilate the patient preventing spontaneous breathing efforts (which would keep the patient unnecessarily on backup ventilation).

### Back-up settings

- A shorter apnea time (<5 seconds) increases the significance of backup ventilation, as there is a risk for hyperventilation. This does not usually occur with NAVA ventilation.
- Adjust the backup settings appropriately taking into account the pre-NAVA settings and the recovery process of the patient.

### Weaning patients from NAVA

- Decrease the NAVA level as the patient’s pulmonary status improves. Usually, the patient is ready to be extubated when the NAVA level is ≤ 0.5 cmH2O/μV.
NIV NAVA in practice

- The NAVA levels in NIV NAVA are usually lower than in invasive NAVA (0.5 – 1.0 μV/cmH2O). Higher NAVA levels may increase the amount of gas entering the stomach/intestine and cause abdominal distention.
  - If Edi max is < 5 μV, decrease the NAVA level.
  - If Edi max is > 20 μV, increase the NAVA level.
- The changes in NAVA level should be 0.1-0.2 μV/cmH2O at a time. Usually, patient can be switched to nCPAP, when the NAVA level is < 0.5 cmH2O/μV.
When using nCPAP NAVA set-up NAVA=0
2d of life, 750g, 1 dose of Survanta

PIP decreases when on NAVA

Dynamic Compliance improves on NAVA

Neonates with Acidosis - on SIMV/PC and then on NAVA
Neonates with Alkalosis - on SIMV/PC and then on NAVA

Neonates with normal pH and pCO2 - on SIMV/PC and then on NAVA

NAVA allows neonates to wean their own PIP over time

Improved Compliance over time on NAVA
Diaphragm activity

**Respiratory Muscle Dysfunction**

Mechanical ventilation should reverse diaphragmatic fatigue or encourage greater "Ventilation Induced Diaphragmatic Dysfunction (VIDD)?"
Summary

- Neonates appear to have intact neuro-ventilatory coupling with functional feedback pathways.
- Patient selection is important – not all neonates are candidates for NAVA and, some may not be candidates all the time (sedation, PPHN, IVH, CNS).
- Many neonates ventilate on NAVA with lower PIP (TV) and FiO2 than on conventional ventilation.

Summary

- Many neonates improve their blood gases on NAVA despite ventilating with lower pressures.
- Many neonates decrease their own PIP (TV) over time while on NAVA – “auto weaning”.
- Many neonates have improved compliance on NAVA.
- In this small number of patients no significant complications or side effects were noted while on NAVA.

NAVA WORKS IN NEONATES!

But does it make a difference to outcomes?

- Large multi-center trials are needed to answer questions if:
  - NAVA decreases time on ventilators?
  - NAVA decreases the incidence of chronic lung disease?
  - Is it helpful for MIST/INSURE?

Thank you