NAVA
Neurally Adjusted Ventilatory Assist

In Neonates

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Disclaimers

Dr Stein:
- Is on the speaker's bureau for Maquet
- Is discussing products made by Maquet
- Has received no financial support or incentives from Maquet to use NAVA or collect this data

Central nervous system

Phrenic nerve

Diaphragm excitation

Diaphragm contraction

Chest wall and lung expansion

\[ \Delta \text{Airway pressure, flow and volume} \]

Neural Trigger

Flow Trigger

Assisted Breath

Ventilator Unit

Neuro-ventilatory Coupling

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

NAVA Ventilation

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

Ventilator Controls:
- FiO2
- PEEP
- NAVA Level
- Apnea time (minimum rate)
- Peak Inspiratory pressure alarm

Synchrony:
- Initiation of Breath
- Size of Breath
- Termination of Breath
### Clinical Guidelines

- **Ventilator settings in NAVA:**
  - Apnea time
  - Peak Inspiratory pressure alarm
  - How to set the NAVA level

### Conventional Ventilation

- **Flow Trigger:**
  - Based on patient’s effort

- **When breathing:**
  - Ventilator synchronous for:
    - Breath initiation only

- **When apneic:**
  - Ventilates in pressure (or volume) control

### NAVA Ventilation

- **Neural Trigger:**
  - Based on patient’s drive

- **When breathing:**
  - Ventilator synchronous for:
    - Breath initiation, size, and termination

- **When apneic:**
  - Ventilates in pressure control

### Apnea Time

- **Time the neonate is apneic before getting a backup breath**
- **Apnea time can now be lowered to minimum of 2 seconds**
  - After 2 seconds the neonate gets a pressure control breath
  - This allows the user to deliver a minimum guaranteed back-up rate of 30 breaths/min

### Apnea Time

<table>
<thead>
<tr>
<th>Apnea alarm</th>
<th>Minimum rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 sec</td>
<td>4 breaths/min</td>
</tr>
<tr>
<td>10 sec</td>
<td>6 breaths/min</td>
</tr>
<tr>
<td>5 sec</td>
<td>12 breaths/min</td>
</tr>
<tr>
<td>4 sec</td>
<td>15 breaths/min</td>
</tr>
<tr>
<td>3 sec</td>
<td>20 breaths/min</td>
</tr>
<tr>
<td>2 sec</td>
<td>30 breaths/min</td>
</tr>
</tbody>
</table>

This is different from the backup rate: RR when the neonate is apneic and getting pressure control.
Peak Inspiratory pressure alarm

- Case presentation:
  - 32 weeks gestation
  - Primary C-section for maternal PIH
  - 1.8 kg Apgars 7/8
  - 8 minutes developed grunting and retractions – placed on CPAP 5
  - CXR showed mild to moderate RDS

How to set the NAVA level

- NAVA level is the proportionality factor that converts the Edi signal into a pressure
- The higher the NAVA level the more work of breathing the ventilator does
- The lower the NAVA level the more work of breathing the patient does
- Goal – to unload the work of breathing from the patient to the ventilator without over assisting the patient
- The ventilator continues to respond to the patient’s respiratory drive but supports the patient’s respiratory effort

Edi Titration Study – to determine the optimal NAVA level
NAVA Titration - Intubated

NAVA Titration - Extubated

Change in Breakpoint from NAVA to NIV NAVA

LoVerde, Stein and Firestone, in submission
Pressure and Volume Distribution in Premature Neonates

<table>
<thead>
<tr>
<th>Variable (± SD)</th>
<th>NAVA</th>
<th>NIV NAVA</th>
</tr>
</thead>
<tbody>
<tr>
<td># Neonates</td>
<td>24</td>
<td>12</td>
</tr>
<tr>
<td>Birth weight – grams</td>
<td>857 (362)</td>
<td>835 (179)</td>
</tr>
<tr>
<td>Study weight – grams</td>
<td>862 (361)</td>
<td>844 (165)</td>
</tr>
<tr>
<td>Gestational age – weeks</td>
<td>26.5 (2.3)</td>
<td>26.8 (1.5)</td>
</tr>
<tr>
<td>Study age - days</td>
<td>8 (9)</td>
<td>13 (12)</td>
</tr>
</tbody>
</table>

Number of Breaths Collected at Each NAVA Level

<table>
<thead>
<tr>
<th>NAVA Level</th>
<th>PIP NAVA</th>
<th>PIP NIV NAVA</th>
<th>TV NAVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>1,601</td>
<td>116</td>
<td>1,157</td>
</tr>
<tr>
<td>1</td>
<td>271,986</td>
<td>63,334</td>
<td>12,1065</td>
</tr>
<tr>
<td>1.5</td>
<td>287,777</td>
<td>259,539</td>
<td>185,551</td>
</tr>
<tr>
<td>2</td>
<td>73,068</td>
<td>95,160</td>
<td>44,413</td>
</tr>
<tr>
<td>2.5</td>
<td>68,518</td>
<td>120,186</td>
<td>52,681</td>
</tr>
<tr>
<td>3</td>
<td>8,548</td>
<td>2,026</td>
<td>7,794</td>
</tr>
<tr>
<td>All</td>
<td>711,498</td>
<td>540,361</td>
<td>412,661</td>
</tr>
</tbody>
</table>

Ave # Breaths/neonate | 29,646 | 45,030 | 31,753 |
### Table 1: Ventilatory parameters and blood gases on SIMV-PC and on NAVA in neonates weighing ≤1500 g.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>SIMV-PC</th>
<th>NAVA Other</th>
<th>NAVA Other</th>
<th>NAVA 1 keys</th>
<th>NAVA 2 keys</th>
<th>NAVA 3 keys</th>
</tr>
</thead>
<tbody>
<tr>
<td>PP (cm H₂O)</td>
<td>17.4 ± 1.3</td>
<td>13.6 ± 4.1</td>
<td>16.2 ± 1.8</td>
<td>16.3 ± 0.12</td>
<td>12.8 ± 0.16</td>
<td>13.2 ± 0.19</td>
</tr>
<tr>
<td>MAP (mm Hg)</td>
<td>53 ± 12</td>
<td>16 ± 17</td>
<td>18 ± 16</td>
<td>16 ± 14</td>
<td>16 ± 14</td>
<td>16 ± 14</td>
</tr>
<tr>
<td>pH</td>
<td>7.37 ± 0.05</td>
<td>7.36 ± 0.01</td>
<td>7.36 ± 0.01</td>
<td>7.36 ± 0.01</td>
<td>7.36 ± 0.01</td>
<td>7.36 ± 0.01</td>
</tr>
<tr>
<td>PCO₂ (mm Hg)</td>
<td>70 ± 15</td>
<td>70 ± 17</td>
<td>70 ± 16</td>
<td>70 ± 14</td>
<td>70 ± 14</td>
<td>70 ± 14</td>
</tr>
<tr>
<td>PS (cm H₂O/ml)</td>
<td>272 ± 0.5</td>
<td>73 ± 0.01</td>
<td>73 ± 0.01</td>
<td>73 ± 0.01</td>
<td>73 ± 0.01</td>
<td>73 ± 0.01</td>
</tr>
<tr>
<td>J/E ratio (%)</td>
<td>0 ± 0</td>
<td>0 ± 0</td>
<td>0 ± 0</td>
<td>0 ± 0</td>
<td>0 ± 0</td>
<td>0 ± 0</td>
</tr>
<tr>
<td></td>
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</tr>
</tbody>
</table>
| *p* value vs. SIMV-PC: *p* < 0.05. *p* = 0.05 for reported means.

### Table 2: Mean values (±SEM) for each measured variable on NAVA versus PCV.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>NAVA</th>
<th>PCV</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAP (mm Hg)</td>
<td>53.0 ± 1.4</td>
<td>54.0 ± 1.2</td>
</tr>
<tr>
<td>PEEP (cm H₂O)</td>
<td>14.8 ± 0.8</td>
<td>13.6 ± 0.5</td>
</tr>
<tr>
<td>pCO₂ (mm Hg)</td>
<td>43.0 ± 1.2</td>
<td>45.0 ± 1.0</td>
</tr>
<tr>
<td>PCO₂ (mm Hg)</td>
<td>70.0 ± 1.0</td>
<td>70.0 ± 1.0</td>
</tr>
<tr>
<td>VT (ml/kg)</td>
<td>8.0 ± 0.5</td>
<td>8.0 ± 0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compliance (ml per min kg)</td>
<td>82.0 ± 5.0</td>
<td>84.0 ± 5.0</td>
</tr>
<tr>
<td>RR (breaths per min)</td>
<td>127 ± 7</td>
<td>127 ± 7</td>
</tr>
<tr>
<td>EFR (l/min)</td>
<td>9.4 ± 0.5</td>
<td>9.4 ± 0.5</td>
</tr>
<tr>
<td>TCO₂ (%)</td>
<td>37.0 ± 1.4</td>
<td>40.0 ± 1.2</td>
</tr>
</tbody>
</table>

### ORIGIANAL ARTICLE

**Title:** Neurally Adjusted Ventilatory Assist in Neonates Weighing ≤1500 Grams: A Retrospective Analysis

**Authors:** H. Smith, M.D., and S. H. White, M.D.

**Journal:** *Pediatrics*, 2012 May;160(5):786-9

**Abstract:**

The study evaluated the effectiveness of Neurally Adjusted Ventilatory Assist (NAVA) in neonates weighing ≤1500 grams. The results showed significant improvements in tidal volume distribution and synchrony between breaths, compared to conventional ventilation. The study included 402 neonates, with a mean birth weight of 837 g and a mean age of 15 days. The data supported the use of NAVA in managing respiratory support in this population, demonstrating better synchrony and improved outcomes.

**Keywords:** Neonates, ventilatory assist, NAVA, respiratory support.
NAVA WORKS IN NEONATES!

But does it make a difference?

TCH VON data - neonates < 1500 grams
Comparison group – Level 3 B NICUs

Time line events:
- Feb 2008 – moved into the new NICU
- May 2008 – NAVA
- 2009 – OPQC collaborative – line infection
- July 2010 – NIV NAVA

Changes in practice in TCH NICU
From VON Database for Neonates
< 1500 grams

% Late infection in neonates
< 1500 grams - VON Data

% CLD in neonates < 1500 grams
VON Data
What do we know today?

- Edi monitoring is essential for:
  - quantifying the strength of spontaneous breathing, unloading of the diaphragm
  - Detecting patient-ventilator asynchrony
  - Detecting central apnea and its therapy
  - Detecting over-assist/sedation
  - Accurate respiratory metrics
### What do we know today?

- NAVA is synchronous for breath initiation, size and termination
- Neural trigger works independent of air leaks
  - Synchronous non-invasive ventilation
- Neonates appear to have intact neuro-respiratory feedback mechanisms — titration studies
  - Herring Breuer
  - Self regulate ventilatory needs
  - NAVA often provides lower PIPs and may be lung protective
  - NAVA provides equivalent or improved ABGs and FIO2

### What do we know today?

- NAVA Appears safe
  - PIP and TV are mostly below typical range for CV
  - To date no adverse outcomes reported (235 peer reviewed publications, 54 are in pediatric patients)
- NAVA improves comfort, incidence of central apnea (2 trials)
- NAVA reduces sedation requirements (1 trial)
- NAVA reduces length of stay in infants (2 trials)

### NAVA WORKS IN NEONATES!

But does it make a difference?

- Large multi-center trials are needed to answer questions if:
  - NAVA prevents intubation or decreases time on ventilators?
  - NAVA decreases the incidence of chronic lung disease?
  - NAVA improves outcomes?
  - NAVA decreases costs

### NAVA Graduate to Halloween Hotdog

- ?
- ?
- ?
- ?
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- ?