Providence HEALTH CARE	Department: **Respiratory Services**	Date Originated: December 2009 Date Reviewed/Revised:
PROCEDURE	Topic: Critical Care – Neurally Adjusted Ventilatory Assist (NAVA) with the Servo-I Ventilator (Respiratory Therapy) Number: B-00-12-12067	Related Links:

APPLICABLE SITES:

St. Paul's Hospital
Mount Saint Joseph Hospital

GENERAL INFORMATION:

Neurally Adjusted Ventilatory Assist (NAVA) is a mode of ventilation which delivers ventilatory assist in ***proportion to*** and ***synchronized to*** the patient's respiratory effort as determined by the electrical activity of the diaphragm.

The Edi waveform can also be used in other ventilation modes as a tool for monitoring the patient's own breathing efforts.

DEFINITIONS:

Edi: Electrical activity of the diaphragm (μV)

Edi_{peak}: The highest value of the Edi signal during a single breath cycle (μV)

Edi_{min}: The lowest value of the Edi signal during a single breath cycle (μV)

Edi Catheter: A single-use feeding tube with measuring electrodes

IED: The distance between the Edi Catheter electrodes (16 mm)

NAVA: Neurally Adjusted Ventilatory Assist

NAVA Level: The "gain factor" by which the patient's Edi signal is multiplied to deliver assist in proportion to the patient's own breathing effort ($cmH_2O/\mu V$)

NEX: Measurement to help with the insertion and positioning of the Edi Catheter,

determined by the distance between the bridge of the nose, ear, and xyphoid process

NVT: Neuro Ventilatory Tool

Trigg. Edi: The level of Edi signal when inspiration is started (μV)

CAUTIONS:

The electrical signal from the brain to the diaphragm must be intact. Do not use NAVA ventilation if no Edi activity is observed.

There must be no contraindication for the insertion or exchange of a naso/oro gastric tube.

The feeding lumen of the Edi Catheter is slightly smaller compared to the lumen of a standard feeding tube of the same size, which may affect tube patency for smaller Edi Catheters (i.e. 8 Fr).

Do not touch the Edi Catheter or connector during defibrillation.

The Edi Catheter must be removed from the patient before an MRI examination due to the possibility of heat being generated in the electrodes, as well as to avoid potential artifact in the images.

DESCRIPTION AND OVERVIEW:

NAVA is a patient initiated breathing mode in which ventilatory support is triggered by the electrical activity of the diaphragm. When triggering is not detected, back-up ventilation is provided using Pressure Support mode, and for apnea by Pressure Control mode.

During NAVA ventilation the patient regulates their respiratory rate and tidal volume, with support from the ventilator.

The Respiratory Therapist will set the NAVA level, where an increase in the NAVA level will result in an increase in ventilatory support.

The NAVA level can be multiplied with the measured Edi minus the Edi_{min} to provide an approximation of the pressure support level required to deliver the gas for that particular breath.

$(Edi - Edi_{min})$ x NAVA level = pressure support equivalent delivered (above PEEP)

At the set trigger level, the ventilator will start to deliver assist in proportion to the Edi signal. NAVA is triggered by an increase in Edi from its lowest value (Edi_{min}).

The delivered pressure may vary during inspiration due to variation in the Edi, but is limited

to 5 cmH_2O *below* the set upper pressure limit. If three consecutive breaths are limited, an alarm message will be presented on the screen. **The high pressure alarm limit must be set appropriately.**

During the expiratory phase, Edi does not influence ventilation and an appropriate PEEP level should be set.

If the ventilator fails to trigger on Edi, but triggers pneumatically (i.e. pressure or flow) the ventilator will provide a guaranteed support level of 2 cmH_2O for these breaths.

After a few breaths without Edi activity, the set pressure support level will be used for subsequent pneumatically triggered breaths. If the ventilator does not trigger with either Edi or spontaneous pneumatic breaths and the set apnea time has elapsed, the ventilator will automatically switch to back-up ventilation in pressure control mode.

NOTE: Preset default settings are used in back-up ventilation **EXCEPT** for the pressure control level.

NAVA RESPIRATION CYCLE:

Inspiration:

- When the patient triggers a breath, gas flows into the lungs at a varying pressure proportional to the Edi of the patient
- The breath may be triggered either by the Edi or pneumatically (flow or pressure)
- The maximum time for inspiration is 2.5 seconds

Expiratory Phase Starts:

- When the Edi decreases below 70% of the peak value during inspiration (40% for low Edi signals)
- If the pressure increases 3 cmH_2O above the inspiratory target pressure
- If the upper pressure limit is exceeded
- When the maximum time for inspiration is exceeded (2.5 seconds)

A breath triggered by Edi is indicated by a pale pink colour in the Edi waveform on the ventilator monitor display, while a breath triggered by flow or pressure is coloured purple in the appropriate waveform.

MONITORING THE EDI SIGNAL:

The Edi signal including Edi_{peak} and Edi_{min} can be monitored in all modes of ventilation on a breath-by-breath basis, and can be used as a reference tool to help determine ventilator triggering and synchrony, as well as weaning readiness.

Edi values are also available while in Standby mode by pressing neural access. The values can also be trended and followed in the trend graphs.

EQUIPMENT:

- Servo-I ventilator
- Edi Module
- Edi Cable
- Edi Test Plug
- Edi Catheter
  - 16 Fr 125 cm

  or
  - 8 Fr 125 cm

PROCEDURE:

1. **Insert Edi Module into the Ventilator.**

   a. Insert the Edi Module into a free slot in the module compartment on the side of the Servo-I ventilator and ensure the module clicks into place.

2. **Test the Edi Module and the Edi Cable with the test plug.**

   a. Connect the Edi Cable to the Edi Module by holding the ribbed part of the connector with the white markings to the right and insert into the socket.

   b. Remove the cap from the test plug and connect the test plug to the other end of the Edi Cable. The **Edi Module test** will then start automatically.

   c. Wait until "**Edi Module Test Passed**" appears on the monitor display.

      NOTE: If the test fails, replace the Edi Cable and/or Edi Module and repeat the test.

   d. Press **OK**. Remove the test plug and replace cap.

3. **Select the correct Edi Catheter size for the patient and estimate the length of the Edi Catheter to be inserted.**

   a. Select the 16 Fr catheter for oral insertions. A 16 Fr or 8 Fr catheter may be used for nasal insertions. The nasal route is preferred for patients with a tracheostomy tube in place.

   b. Measure the distance from the bridge of the **Nose (N)** via the **Earlobe (E)** to the **Xiphoid process (X)**. This is referred to as the **NEX** measurement.

   c. Make note of the NEX measurement in centimeters, and use that value with the following calculations to determine insertion depth:

      Oral Insertion Calculation: (NEX x 0.8) + 18 = Insertion depth in centimeters

      Nasal Insertion Calculation: (NEX x 0.9) + 18 = Insertion depth in centimeters

d. Make note of the calculated value for the Edi Catheter insertion length.

4. Insert the Edi Catheter into the patient to the estimated length.

NOTE: The RN, intensivist, fellow, or resident will be responsible for insertion of the Edi Catheter.

a. Dip the Edi Catheter in water for a few seconds to activate its lubrication properties.

NOTE: Do not use lubricants as this may destroy the Edi Catheter coating and interfere with the measurement of the Edi signal.

b. Insert the Edi Catheter and advance it down the esophagus to the calculated insertion length.

5. Plug the Edi Catheter Cable connector into the Edi Cable.

a. Remove the cap from the Edi Catheter and plug it into the Edi Cable connector.

6. Position the Edi Catheter.

a. Open the Neural access menu using the soft key **Neural Access** and select **Edi Catheter Positioning**.

b. The Edi Catheter positioning window will appear with four electrode signal waveforms being displayed. The **blue segments** indicate the electrodes with the **strongest signals**.

c. Check the position of the Edi Catheter by analyzing the ECG waveforms.

- Verify that the P and QRS waves are visible in the top leads, and that the P waves disappear in the lower leads where QRS wave amplitude also decreases.
- Verify that the Edi scale is fixed and set to ≥ 5 μV. Set the high upper limit on the scale high enough so that the Edi signal is not cut off.
- If the Edi deflections are present, observe which leads are highlighted in blue.
- If the leads highlighted in blue are in the centre (i.e. second and third leads), then the Edi Catheter is aligned correctly and ready to secure. Make note of the final position distance in centimeters.

d. If not already aligned, then adjust the Edi Catheter position.

- If the **top leads** are highlighted in **blue**, the catheter is **too deep**. Withdraw the Edi Catheter in steps corresponding to the IED until the blue highlight appears in the centre. Do not exceed 4 IED steps.

- If the **bottom leads** are highlighted in **blue**, the catheter is **too high**. Insert the Edi Catheter further in steps corresponding to the IED, until the blue highlight appears in the centre. Do not exceed 4 IED steps.

  NOTE: The distance between the electrodes is 16 mm.

- If the Edi signal is very low, there will be no blue highlights.

7. Secure the Edi Catheter.

a. To avoid interference of Edi monitoring, care must be taken to minimize manipulation of the catheter.

b. Assess the Edi curve at the bottom of the positioning window post-catheter securement.

   If low or no Edi activity observed:

   - Verify that the effects of any administered muscle relaxants have worn off.

   - Verify the patient's sedation level. The apneic threshold might be higher due to CNS depressant drugs.

   - Verify that the patient is not hyperventilated or over supported and thus decreasing their respiratory drive.

   - A PEEP level which is too high may flatten the diaphragm due to hyperinflation, which may diminish the electrical activity of the diaphragm to a point where it is difficult to detect. In this case a gradual reduction of these levels may restore Edi and diaphragm activity.

   If possible, perform an expiratory hold and verify that the positive Edi deflection coincides with a negative deflection in the pressure waveform.

   NOTE: If the Edi signal is not synchronized with pressure and flow, this may indicate that the Edi Catheter is displaced and registering the electrical activity of another muscle. If this occurs it would be indicated by the Pneumatic-Edi Out Of Synch alarm.

8. Set the initial NAVA Level using the NAVA preview tool.

a. Press the **Neural Access** button and select **NAVA preview**.

b. On the uppermost waveform there are two curves presented simultaneously. The **gray curve** shows the **estimated pressure (P_{est})** based on Edi and the set NAVA level. The **yellow curve** is the patient's **current peak pressure**.

c. Press the **NAVA Level** button and use the main rotary dial to set the desired NAVA level. Press the **NAVA Level** button again to save the NAVA level. The NAVA level will be transferred to the NAVA Ventilation mode window.

NOTE: The first NAVA level to try should produce the same pressure or slightly lower than that used in the current ventilation mode.

d. To close and exit this window, press **Close**.

9. Set up NAVA mode and start NAVA ventilation.

a. Open the **Select Ventilation Mode** window and select **NAVA**. The **Set Ventilation Mode** parameters window opens.

b. Set the basic **NAVA parameters**:

1) NAVA level:

- The NAVA level displayed is the initial setting saved from the NAVA preview window
- Will vary for different patients
- May need adjustment over time on the same patient
- Typically set to between 1.0 – 4.0 $cmH_2O/\mu V$
- NAVA level should be adjusted in small steps (0.1 – 0.2 $cmH_2O/\mu V$)

2) PEEP:

- Set as per previous mode or patient condition

3) FiO_2:

- Set as per previous mode or patient condition

4) Trigg. Edi:

- Default setting of 0.5 µV (above Edi_{min} for variable background noise)
- The electrical threshold set to trigger the ventilator to assist inspiration

c. Set the **Pressure support** parameters NAVA (PS):

1) **Pneumatic trigger:**

- Set as per previous mode or patient triggering ability

2) **Insp. cycle off:**

- Set as to previous mode or patient comfort

3) **Pressure support level:**

- Set to achieve adequate ventilation when pneumatic triggering is active

d. Set the **Back-up ventilation** parameter:

1) **Pressure control level:**

- Set to achieve adequate ventilation in the event of apnea

e. Select **Accept** to confirm the settings and initiate NAVA ventilation. If **Cancel** is selected, the Set NAVA Ventilation Mode window will close without the changes being implemented.

NEURO VENTILATORY TOOL:

The **Neuro Ventilatory Tool (NVT)** can be used to study the change in breathing pattern and breathing related parameters during a change in the NAVA level.

To access the NVT, press the **Neuroventilatory Tool** button on the **Neural Access** menu.

Curves in the NVT window will be presented as follows:

a) First Graph:

- Peak pressure and NAVA level as waveforms with relating values
- PEEP as a numerical value

b) Second Graph:

- Edi peak and min. as waveforms with relating values
- RR as a numerical value

c) Third Graph:

- VTe and $etCO_2$ as waveforms with relating values
- P0.1 and SBI as numerical values

The scales can be set by accessing **NVT Scales** from the **Neural Access** menu.

To select which NAVA level to use, increase the NAVA level from a low to a high assist, and look for an inflection point (plateau) in the waveform. The assumption is that the NAVA level at the inflection point gives the optimal assist level in NAVA.

OPTIMIZING NAVA LEVEL:

1. Begin with the NAVA level such that the pressure delivered is equal to or slightly below the set pressure support level.

2. Set an upper pressure limit that is appropriate for the patient.

3. Open the Neuro Ventilatory Tool.

4. In order to increase the patient's respiratory drive while not provoking too much distress, reduce the NAVA level to a minimum setting of 0.0 $cmH_2O/\mu V$ or slightly higher, resulting in a minimal level of assist.

   Maintain at this level for a few minutes or until the Edi signal reaches its maximum. During this period, the patient should be carefully observed as discomfort or hemodynamic instability may occur.

5. Gradually increase the NAVA level in steps of 0.1 to 0.2 $cmH_2O/\mu V$, while observing the trend graphs for P_{peak}, Vt, and Edi.

6. As the NAVA level increases, the P_{peak} and Vt levels will also increase while the Edi will gradually decrease. Typically, an initial steep increase in airway pressure and Vt is followed by a less steep increase in the airway pressure and by a plateau in Vt, while the Edi signal continues to decrease. When the Edi reaches its minimum level, the increases in airway pressure and Vt may resume.

7. When a transition from a steep to a less steep increase in P_{peak} and Vt becomes visible, activate the cursor and note the NAVA level at the end of the transition zone.

8. The NAVA level at the end of the transition zone may represent an assist level that adequately unloads respiratory muscle, and should be set using the Nava Level quick access knob. If the patient fails to respond to an increase in the NAVA level, do not use this mode.

9. Check and readjust the NAVA level at regular intervals.

WEANING FROM NAVA:

1. When the patient is stable and the Vt is unchanged while the Edi signal is declining or unchanged, reduce the NAVA level in steps of 0.1 – 0.2 $cmH_2O/\mu V$.

   NOTE: An increase in sedation or a sedation bolus may cause a decline in the Edi signal. If an increase in sedation is NOT the cause of the decline, then a "spontaneous" wean has already been initiated by the patient, and they are independently using less support.

2. If the Vt is reduced, and the Edi signal increases disproportionately, return to the previous setting. This reaction may indicate one of the following situations:

   a. The patient is not yet ready to be weaned. Allow the patient to rest on the previous setting and try again later.

   b. The initial assist is too low (indicated by a slow rise in the Edi and flow curve). This is often seen in COPD patients who may require a higher initial gas delivery in order to overcome intrinsic PEEP. This may cause a higher P_{peak} and a high Edi_{peak}, with a lengthening of the inspiratory phase and a shortening of expiration, thus increasing intrinsic PEEP.

3. Weaning progress can be monitored by the decline in the Edi signal. When the P_{peak} (minus PEEP) has fallen to 10 cmH_2O, the patient is considered weaned and extubation may be considered.

CHARTING NAVA:

Monitoring and charting of NAVA parameters should include both the Nava Level and the Edi_{peak}. All other relevant ventilator parameters should continue to be recorded as per routine ventilator monitoring practices.

The size and type of Edi Catheter including the position in centimeters must also be recorded a minimum of once per shift.

ALARM CONDITIONS:

HIGH PRIORITY ALARMS

Asynchrony alarm:

In case of asynchrony, the ventilator will switch back and forth between NAVA mode and NAVA (PS) mode without triggering an alarm until one of the following conditions has been met:

1. The ventilator has been in NAVA (PS) for more than 2 minutes.
2. There have been 6 switches from NAVA to NAVA (PS) in the last 5 minutes.

In these two situations the asynchrony alarm will be activated and the message

Pneumatic-Edi Out Of Synch will appear, since the measured Edi signal is out of phase with the pressure and flow signals generated by the patient. There will also be an indicator message to check the Edi Catheter position. The following should be assessed:

- Edi signal
- Edi Catheter position
- Pneumatic trigger setting
- Edi trigger setting

As soon as synchrony is re-established, the message **Pneumatic-Edi synch restored** will be displayed. Press the **OK** button or select **Back to NAVA** to return to NAVA ventilation.

If asynchrony is still detected a message will appear followed by the question **Do You Really Want To Go Back To NAVA?**, which will require confirmation before returning to NAVA mode. The alternative is to change to a different mode of ventilation.

Back to NAVA:

a) Press **Back to NAVA** to change from NAVA (PS) to NAVA.
b) Select **Yes** to confirm change to NAVA.
c) Select **NO** to return to ventilation using NAVA (PS).

Change Mode:

a) Press **Change Mode** to open the Set Ventilation Mode window.
b) Select a new ventilation mode and press **Accept**.
c) Press **Previous Mode** to return to the mode in use prior to the initiation of NAVA.

No Edi Monitoring Alarm:

The message **Edi Monitoring Not Active** appears when the NAVA mode is activated without an Edi Module being connected. If this occurs, insert the Edi Module.

MEDIUM PRIORITY ALARMS

Edi Module Alarms:

- In case of disconnection or an improperly inserted Module, the message **Edi Module Disconnected** will appear.

- In case of a hardware error, the message **Edi Module Error** will appear. In this case, the Edi Module should be unplugged and reinserted. If this does not resolve the problem, the Edi Module should be changed and sent for a Biomedical inspection.

Edi Catheter Alarms:

- In case of connection failure, the message **No Edi Catheter Connected** will appear. When this happens, ensure the Edi Catheter is properly connected.

- In case of error, the message **Edi Catheter Error** appears. An Edi Module Test should then be performed, whereby a successful pass indicates that the Edi Catheter is faulty and should be replaced.

- If the Edi Catheter has been incorrectly positioned or has shifted position, the message **Edi Catheter Out Of Position** appears – the catheter position should be checked.

Low Edi Activity Alarm:

- The message **Low Edi Activity** appears when the measured Edi activity is low while using NAVA mode. When this happens, check the Edi Catheter position. It may also be necessary to adjust the Edi trigger setting. Failing this, change to another ventilation mode.

OTHER MESSAGES

Regulation Pressure Limited:

- Activated during NAVA at a level 5 cmH_2O below the set upper pressure limit.
- An attempt to increase the NAVA level results in an audible tone to alert the user to the message.
- The maximum available pressure level is thus 5 cmH_2O below the set upper pressure limit.