NAVA Flowchart – Adult

MAQUET
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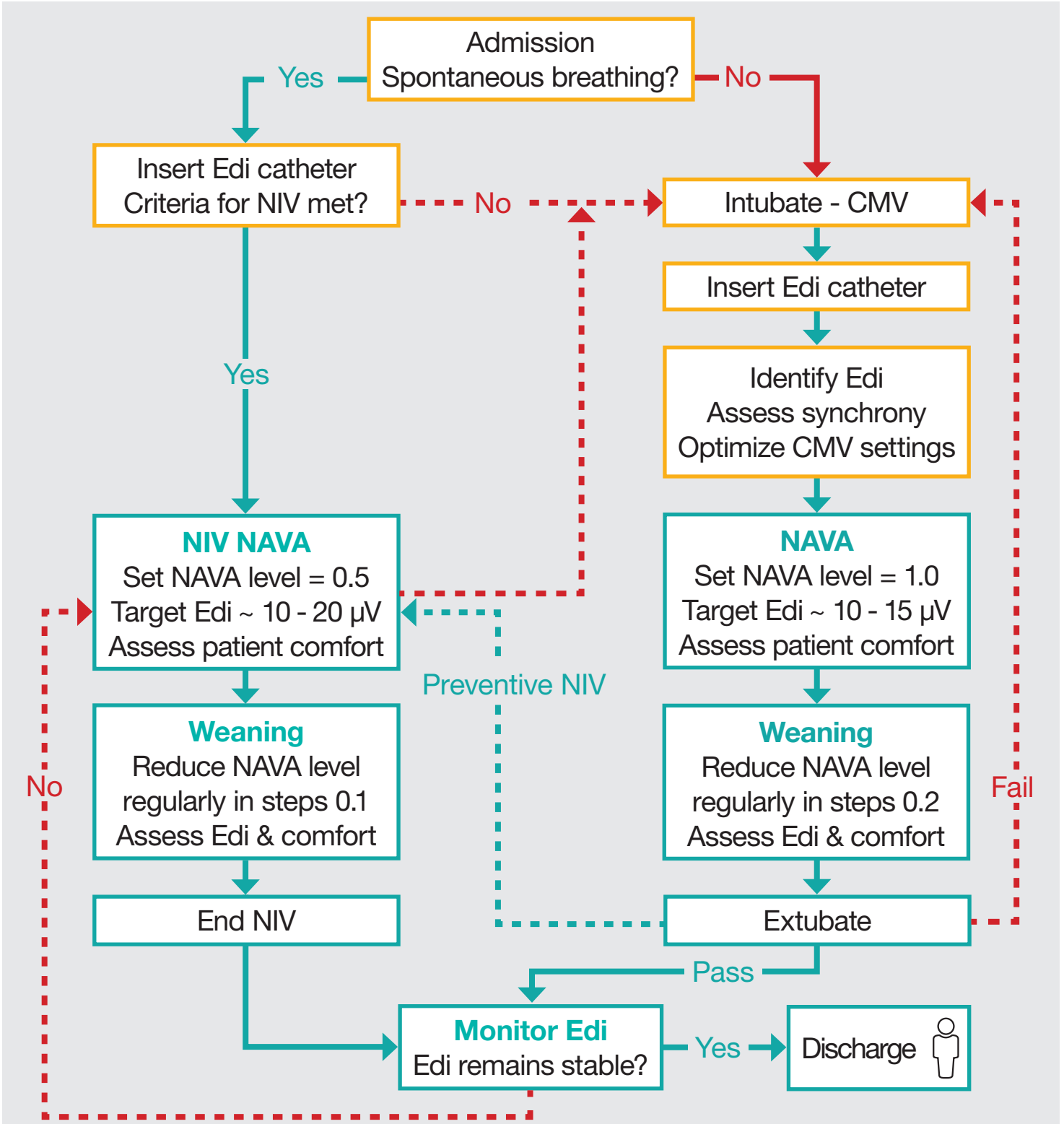


Important

Edi values for COPD patients
Clinically observed Edi peak values for patients with COPD or other chronic pulmonary diseases may be higher than 10 - 20 µV.

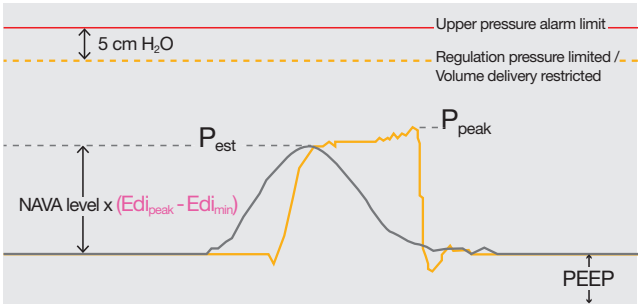
Weaning protocol
Follow local policy and weaning protocol.
Integrate NAVA level and Edi as decision criteria.

Refer to the SERVO-i/U User's Manual for operation of the ventilator

This document is intended to provide information to an international audience outside of the US.

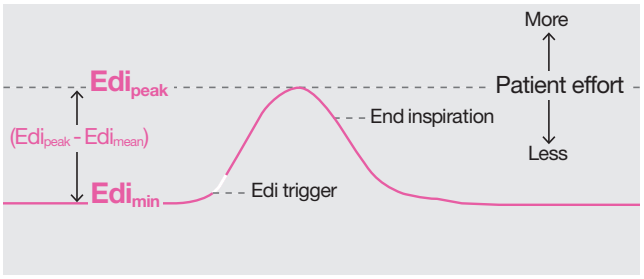
Optional method to set NAVA level

1. Open NAVA preview window
2. Adjust NAVA level so that P_{est} is slightly below P_{peak}



Note: In NAVA and NIV NAVA the available pressure is limited to 5 cm H_2O below the set upper pressure limit.

Edi = Patient´s respiratory drive



Trouble shooting

No or Low Edi signal

- High sedation level?
- Patient overassisted?
- Edi catheter out of position?
- Phrenic nerve injury?

High Edi signal

- Too low NAVA level? Patient underassisted?
- Too low PEEP?
- Airway obstruction?
- Worsened disease condition?
- High pH and/or $PaCO_2$?

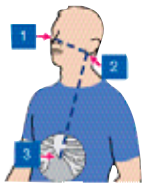
Switching to NAVA(PS)

- PS flow trigger set too sensitive?
  Consider change to pressure triggering

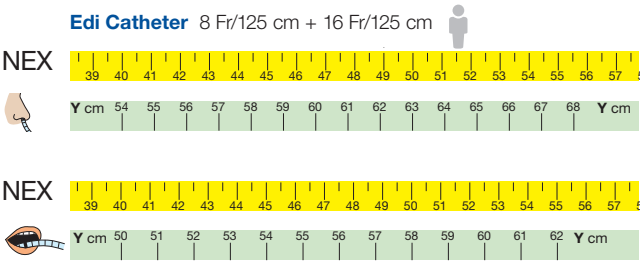
Alarm: Regulation pressure limited/ Volume delivery is restricted

- Upper pressure alarm limit set too low?

Edi cathether insertion

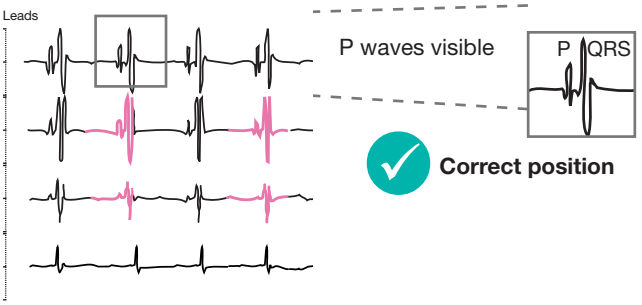


1. Connect the Edi module and cable
2. Perform the Edi module function check
3. Measure NEX the distance in cm (1-2-3):
4. Determine the insertion distance



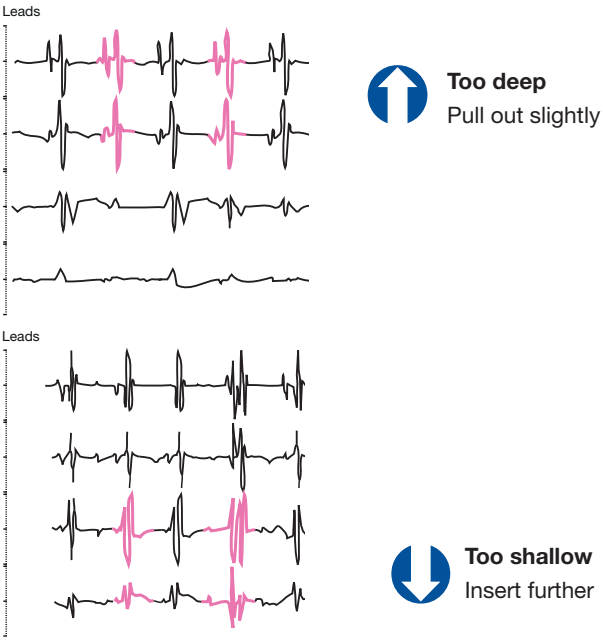
5. Dip the catheter in water and insert
6. Connect the Edi cable to catheter
7. Verify the position in the positioning window
8. Secure the Edi catheter
9. Make a note of the insertion distance
10. Verify the position regularly

Positioning window



Note: The Edi Catheter is correct positioned if the second and third leads are highlighted in pink/blue and the Edi signal is present.

Re-positioning



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NAVA – Invasive and Non Invasive

What is NAVA?

NAVA: Neurally Adjust Ventilatory Assist

Nava is a ventilator mode which:

- supports the patients spontaneous respiratory drive
- breaths are triggered when a neural message is sent from the brain to the diaphragm
- rate and tidal volume are controlled by the patients respiratory drive (ie rate & intensity of neural messages)

Cerebral Respiratory Drive

↓

Neural Impulse sent from Brain

↓

NEURAL TRIGGER: → Neural Impulse delivered to Respiratory Muscles (diaphragm)

↓

Contraction of diaphragm & respiratory muscles

↓

FLOW TRIGGER: → Air flow into lungs starting Inspiration

↓

At completion of inspiration diaphragm & respiratory muscles relax for expiration.

NAVA provides assist to a patient in synchrony with the patient's neurally driven respirations and breathing efforts, therefore enabling a smooth transition to natural respiration.

NAVA supports Neuroventilatory Coupling.

Neuro-Ventilatory Coupling

Neuro

Respiratory Drive: relates to the individuals neurological ability to determine their required respiratory needs.

- controlled by the central nervous system

Eg. Patient with elevated C02 will have increased respiratory drive ➡ brain increases the intensity of the message sent to respiratory muscles, to breathe faster and deeper ➡ increase C02 removal.

Ventilatory

Work of Breathing: relates to the individuals muscular efforts to achieve their respiratory requirements. Work of breathing is controlled by the central nervous system but dependent upon:

- Intact neural pathways to the muscles (eg. phrenic nerve)
- Strength and energy of respiratory muscles.

Eg. Patient with elevated C02 will have increased respiratory drive ➡ brain increases the intensity of the message sent to respiratory muscles, to breathe faster and deeper ➡ increase C02 removal. The patient will increase their work of breathing.

Coupling

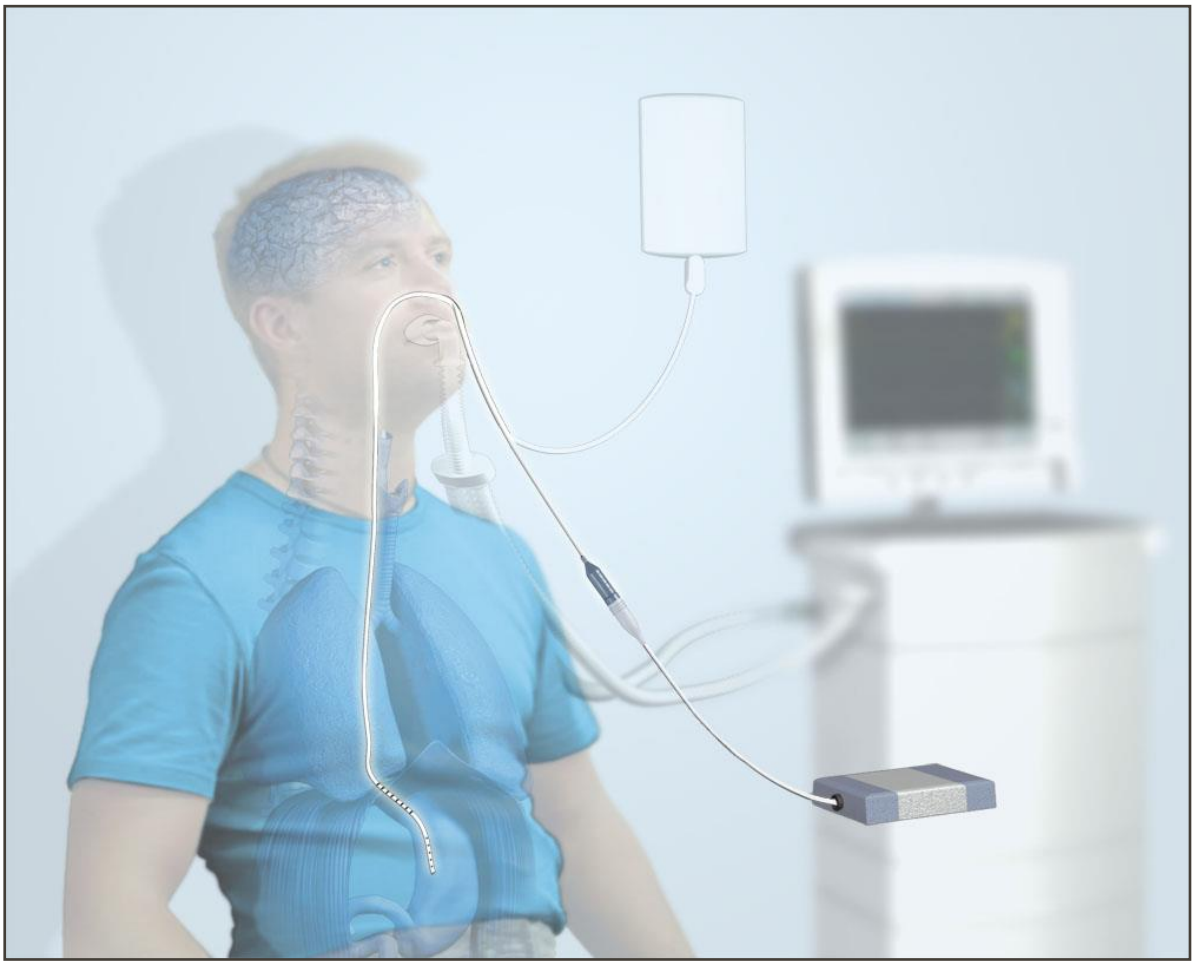
Therefore the Edi signal represents the integrated motor output to the diaphragm, and is modulated by neural feedback, reflecting the way in which the neural inspiratory breathing pattern is affected by changes in metabolic demand, respiratory muscle function, respiratory load and changes to the patient's ventilation.

NAVA Equipment

Equipment Required for NAVA

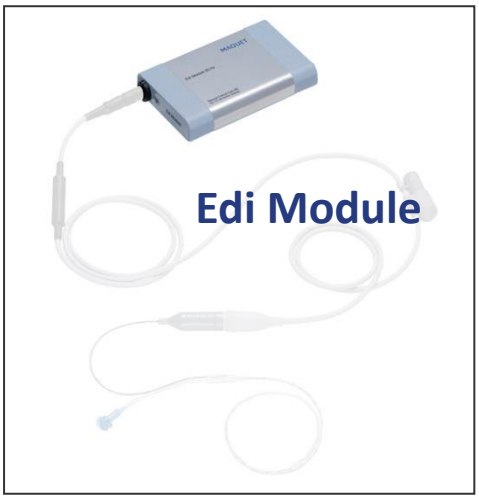
- Edi Software
- Edi Cable
- Edi Module
- Edi Catheter

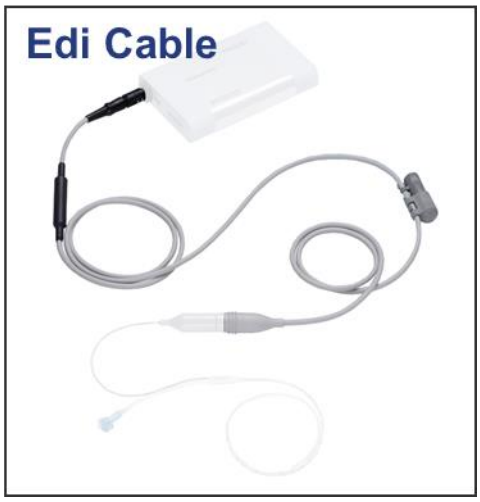
Note: the equipment preparation, insertion, testing & NAVA setup can all be performed whilst ventilating the patient in conventional modes of ventilation without any interference in the patient's support. You do NOT need to go into STANDBY.



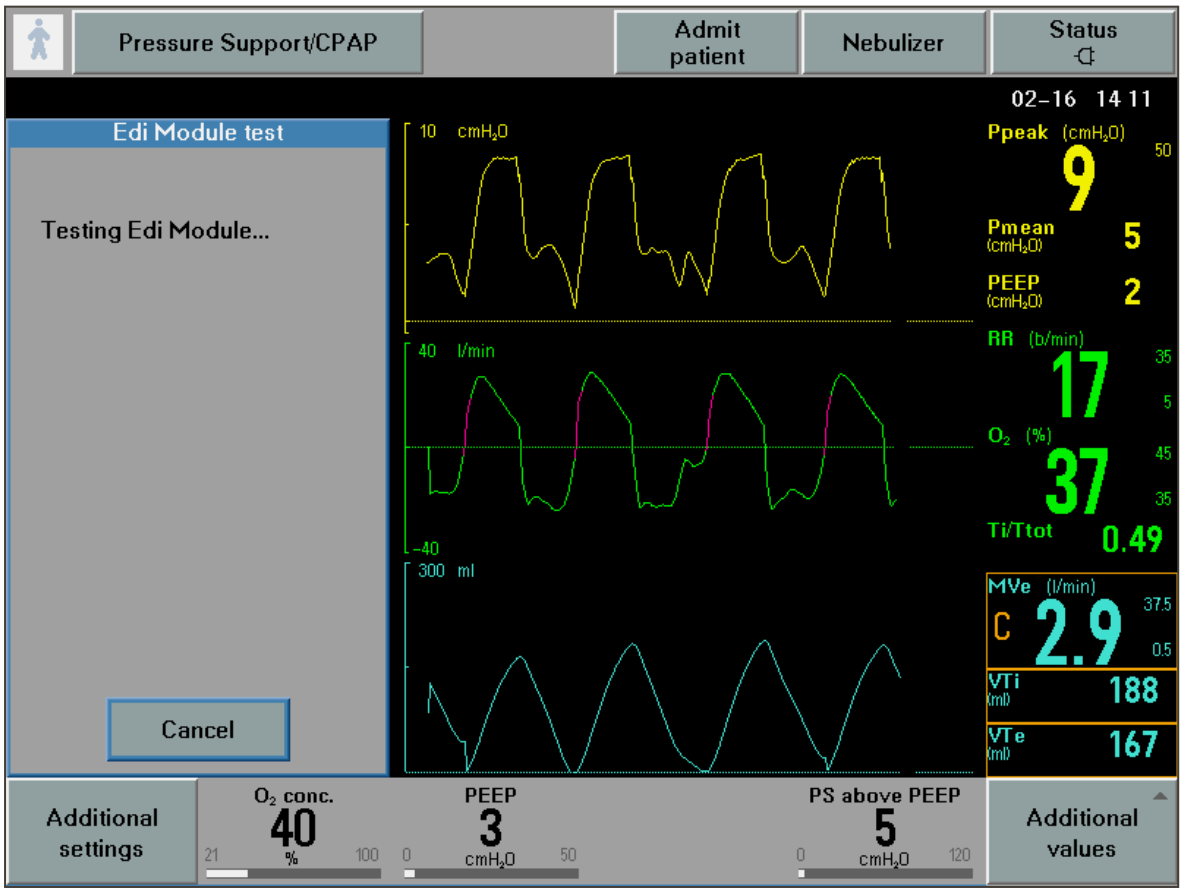
Edi Cable and Edi Module

The Edi Cable is plugged into the Edi Module, which filters and processes the Edi and ECG signals. The Edi Module is then connected into the Servo-i.





The cable & module must have a function test before use, by connecting the other end of the cable into the side port on the cable. This test will be displayed on the screen, & takes 15-20 secs.



Edi Catheter

Each catheter is individually packaged and is sterile. Instructions for insertion also come with each individually packaged catheter.

Catheters are secured on the patient's face (orally or nasally) as per unit policy.

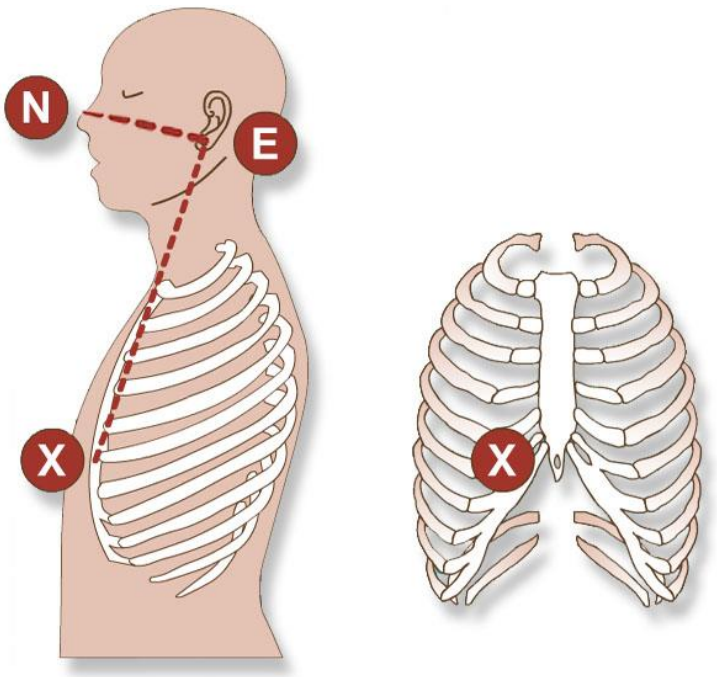
Edi Catheters

- Come in various sizes 6Fr to 16 Fr (infants to adults)
- Contain 10 electrodes at the distal end to measure Edi Signal & Oesophageal ECG.
- Disposable –NAVA functionality ensured for at least 5 days
- Contain a Barium strip for X-Ray identification
- Can be used for gastric feeding
- Have an evacuation port on sizes 12Fr and 16Fr
- Coated for easier insertion, activated by placing in water only for optimal electrical conductivity (do not use any lubricants).
- Connect to the Edi Cable and the Edi Module filters the signals measured from the catheter's electrodes.

Edi Catheter Sizing

Edi Catheter size	Inter Electrode Distance, IED	Patient weight	Patient height
16 Fr 125 cm	16 mm		> 140 cm
12 Fr 125 cm	12 mm		75 - 160 cm
8 Fr 125 cm	16 mm		> 140 cm
8 Fr 100 cm	8 mm		45 - 85 cm
6 Fr 50 cm	6 mm	1.0 - 2.0 kg	< 55 cm
6 Fr 49 cm	6 mm	0.5 - 1.5 kg	< 55 cm

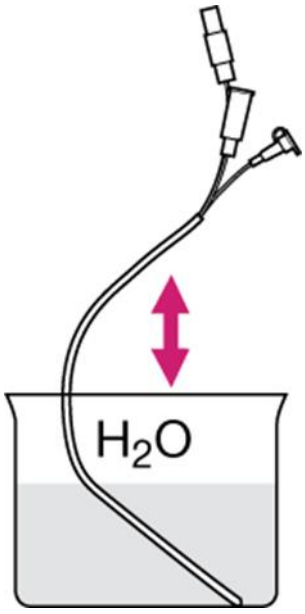
Measure the distance from the Bridge of the Nose (N) to the Earlobe (E) and then to the Xiphoid Process (X). This is the **NEX** measurement, record this.

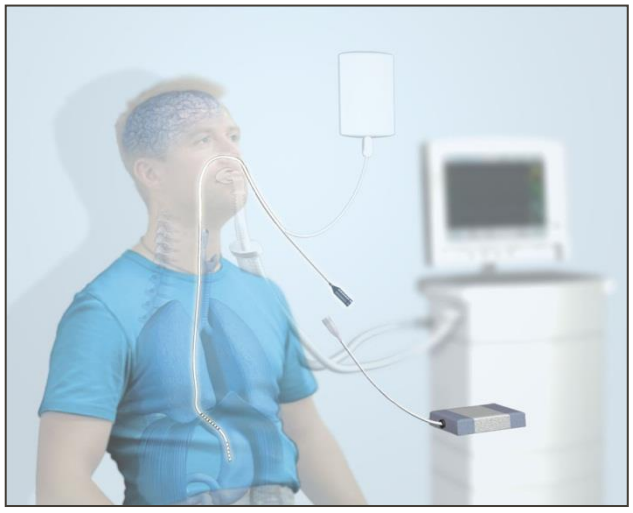


Once the position has been determined the Edi Catheter is connected to the Edi cable for insertion.

Calculate the insertion distance (Y) of the Edi catheter using the table below

Insertion distance Y for nasal insertion	
Fr/cm	**Calculation of Y**
16 Fr	NEX cm x 0.9 + 18 = Y cm
12 Fr	NEX cm x 0.9 + 15 = Y cm
8 Fr 125 cm	NEX cm x 0.9 + 18 = Y cm
8 Fr 100 cm	NEX cm x 0.9 + 8 = Y cm
6 Fr 50 cm	NEX cm x 0.9 + 3.5 = Y cm
6 Fr 49 cm	NEX cm x 0.9 + 2.5 = Y cm





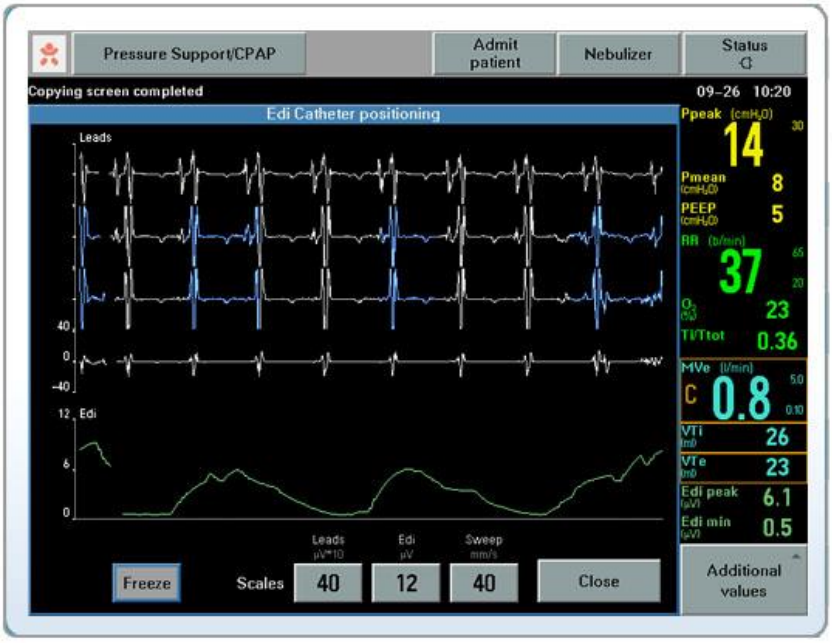
Dip the Edi catheter in water or fill the packaging at the distal end of the catheter with water and allow 1 min to activate the lubricant. Press the **“Neural Access”** key on the ventilator, then on the screen menu select “Edi Catheter Positioning”. With insertion, confirm catheter position via waveforms.

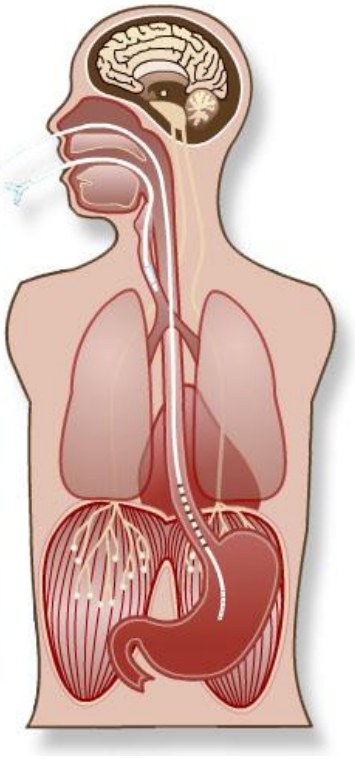
Confirmation of Edi Catheter position

Verify catheter position once catheter secured to the measured point by reading the ECG waveforms.

Aim to see:

- **P & QRS waves** are seen in the **top two waveforms**
- The **absence of P waves** in the **lower two waveforms**
- **Edi deflections are highlighted in blue**. These should be placed in the **middle two waveforms** as seen below. When these are correctly placed, secure the catheter in this position.
- Record the secured measure of the Edi catheter placement for future references.



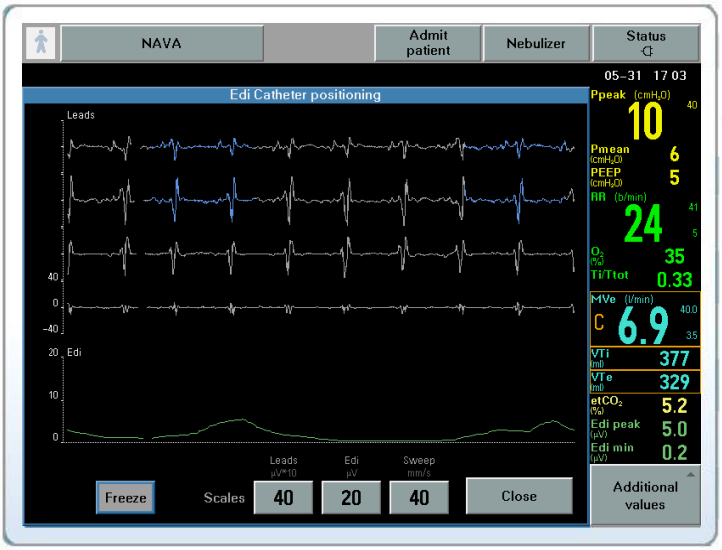


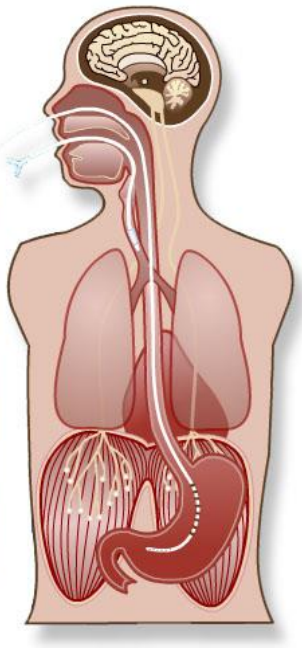
View the Edi waveform (green) at the bottom of the screen and confirm the presence of Edi Peak and Edi Min numerics.

Confirm the scale is set correctly with no clipping of the waveform peaks by increasing the upper limit of the scale via using the Quick Access fixed key on the Servo-i ventilator.

Incorrect Edi catheter Placements

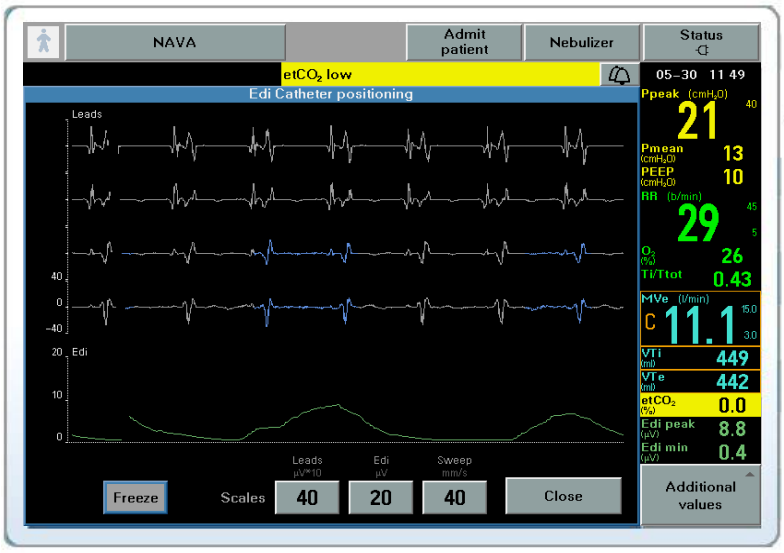
Edi Catheter positioned too far down

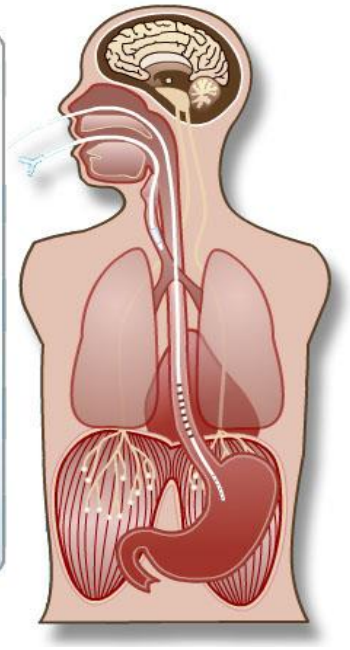




The Edi catheter requires withdrawal back till the highlighted blue waveforms are in leads 2 and 3. The Edi waveform at the bottom of the screen will be flat in appearance.

Edi Catheter is positioned too high

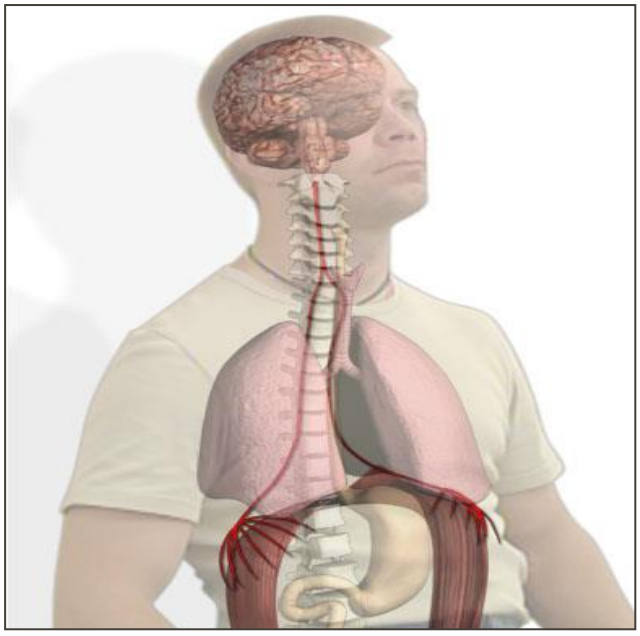




The Edi catheter requires further advancement into the patient till highlighted blue waveforms move into leads 2 and 3. Edi peaks will also increase with this.

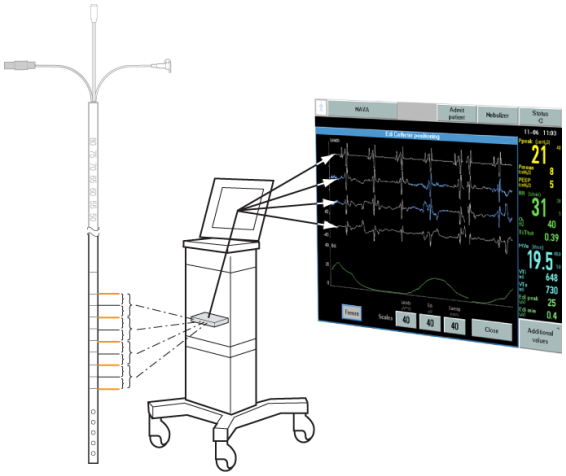
The Registered Edi Signal

The Edi Signal represents the electrical activity of the diaphragm, the body's principle breathing muscle. This signal is the measured value of the impulse transmitted to the diaphragm from the respiratory centre in the brain, via the phrenic nerves. These impulses from the phrenic nerves create an excitation of the diaphragm resulting in contraction, thus inspiration.



Edi Signal is measured 62.5 times per second, via the electrodes in the Edi Catheter, filters this via the Edi Module and then displays this on the Servo-i ventilator screen as a numeric **Edi Peak** and **Edi Min**. and also as a waveform.

The waveforms displayed are a reflection of the patient's neural drive.

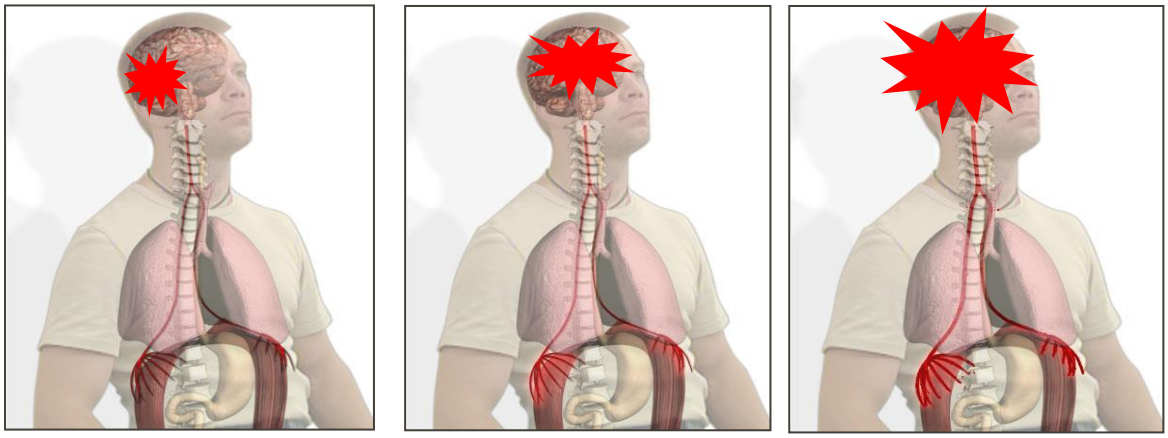


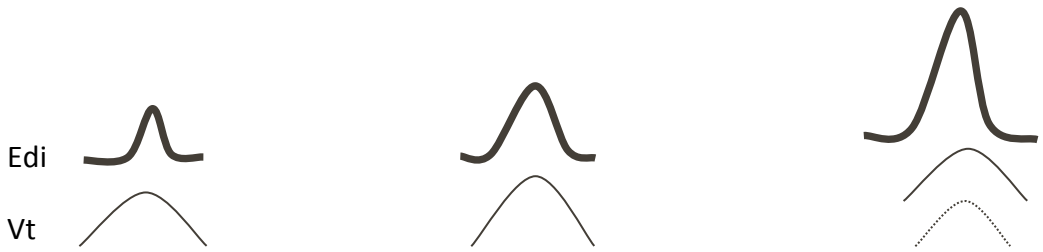
The Edi Signal serves as a respiratory vital sign in that it provides:

- Continuous monitoring of the respiratory drive
- Decision support for unloading and assist titration
- Objective criteria for intubation and extubation decisions

Edi Signal ensures the ventilator delivers support in synchrony with each breath as per the patient's neural drive, ie. Neuroventilatory Coupling.

The Edi Signal determines the pressure or level of assist required by the patient over a single breath ie. the stronger the Edi signal, then the greater the need for assistance in meeting the body's demands for inspiration.





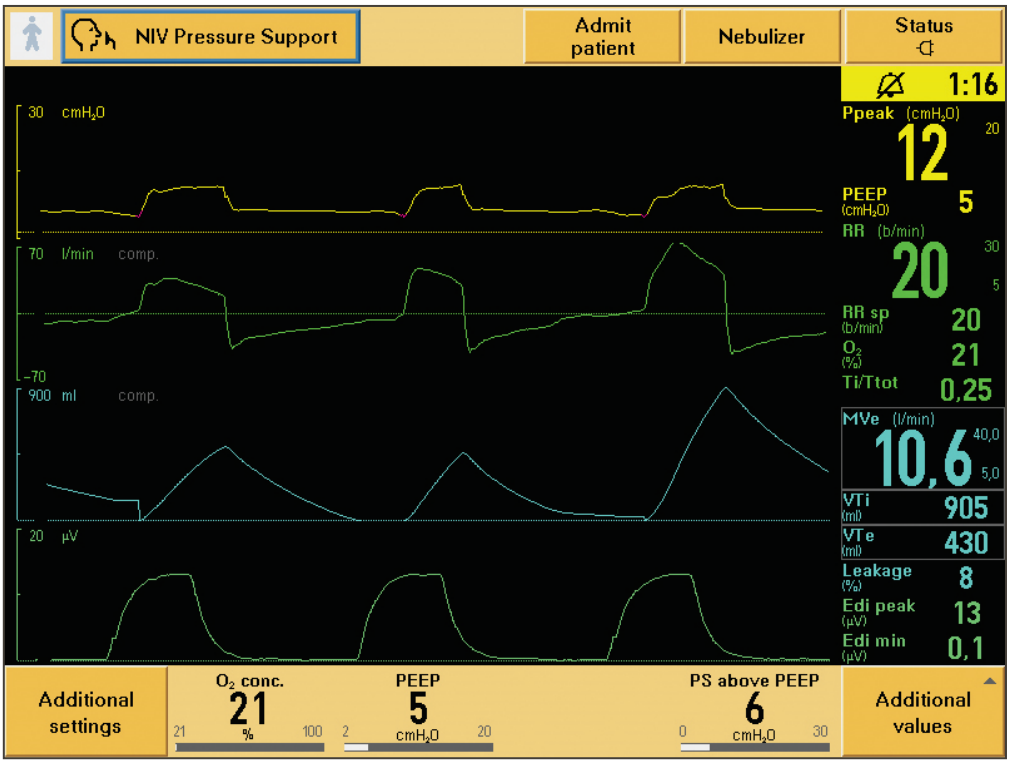
Edi Peak low **Edi Peak increased** Edi peak High

*It is important to note that sedation, muscle relaxants, hyperventilation, excessively high PEEP and neural disorders can all result in a low or absent Edi signal even if the catheter has been perfectly positioned. Consider also the patient with severe lung disease and muscle weakness, as they may be unable to increase their work of breathing to match the respiratory drive.

Edi Monitoring

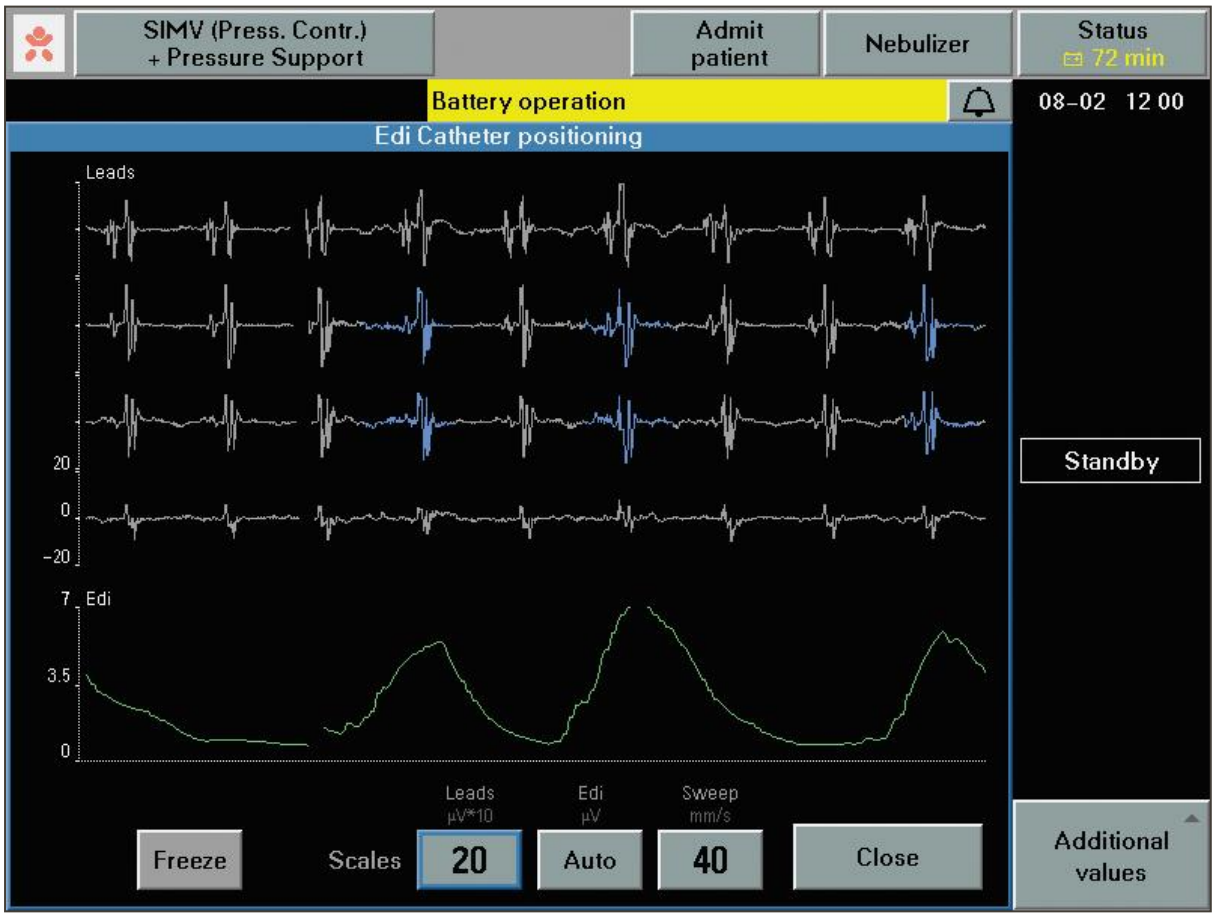
Edi signals can be monitored in invasive modes of ventilation (blue banner)

Or in Non-invasive modes (orange banner)



Edi Monitoring in Standby

With the Edi Catheter insitu, the patient's work of breathing can still be monitored using the Edi Peaks and waveform as a trend of patient improvement or deterioration.



When in Standby, pressing the Neural Access key on the ventilator will open the Neural Access menu. Select the Edi Catheter Positioning button to enable continued assessment of patient's work of breathing whilst the ventilator is not being used for ventilation of the patient.

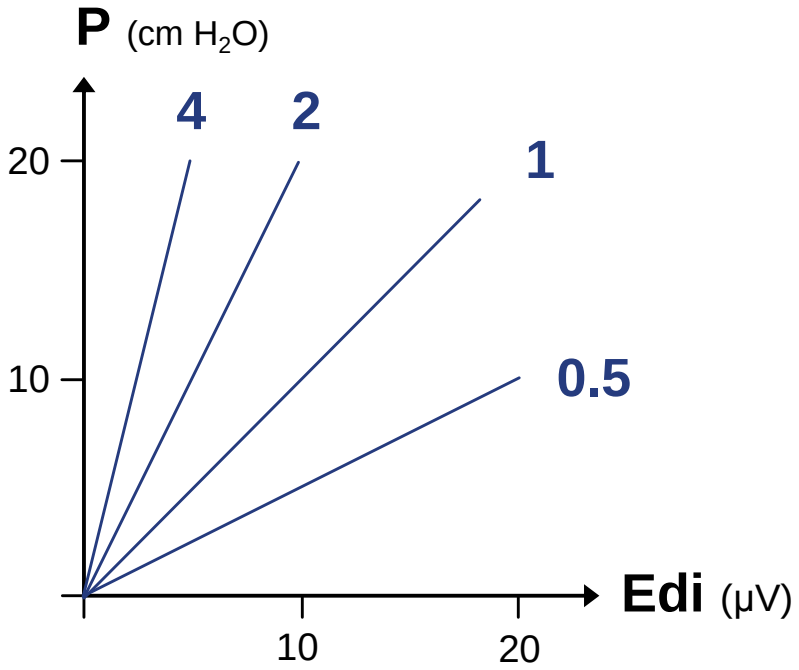
NAVA LEVEL

The NAVA level is the factor by which the Edi Signal is multiplied to adjust the amount of assist delivered to the patient. This assist is proportional to the patient's Edi. The set NAVA level reflects the amount of work of breathing the ventilator will take over from the patient, which varies for different patients.

How to choose the NAVA Level?

During NAVA, the amount of pressure delivered (in cmH20) is adjusted by multiplying the Edi (which is expressed in uV) by the NAVA level (expressed as cmH20/uV).

The NAVA level is a type of exchange rate i.e of how many cmH20 the patient will receive per uV Edi. For example, a NAVA level of 1cmH20/uV will give 5cmH20 when the Edi signal is 5uV.

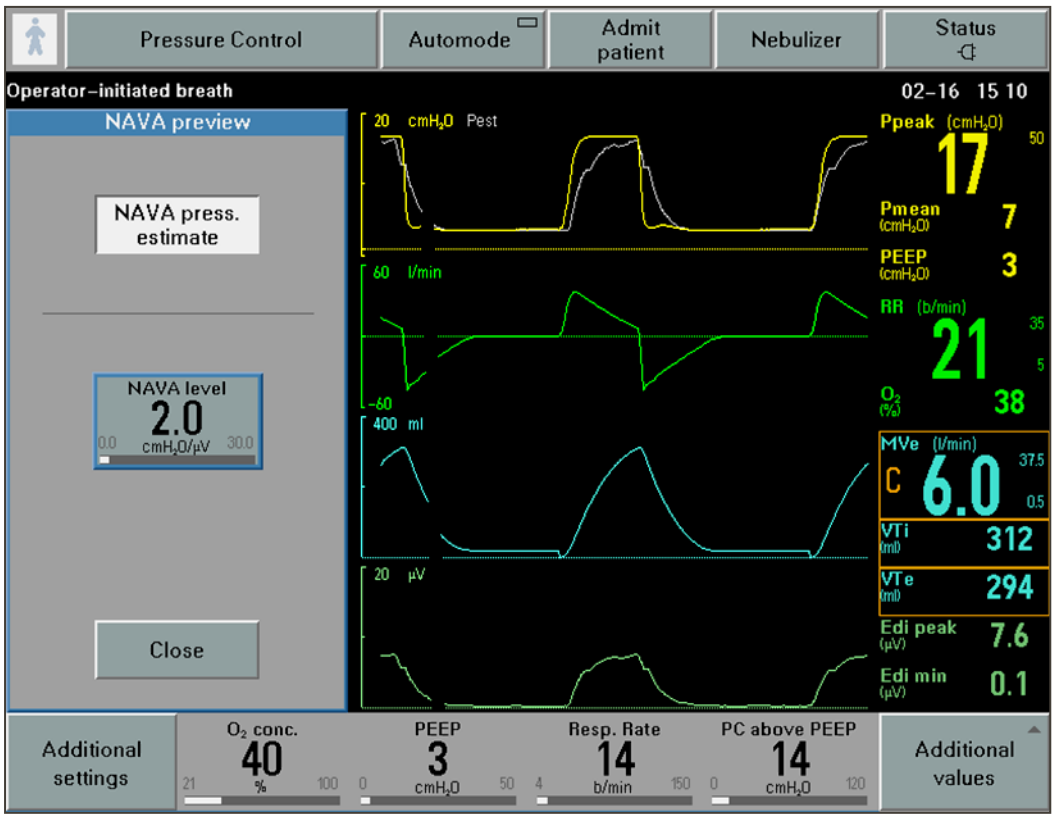


Ppeak in NAVA = NAVA Level x (Edi peak – Edi min) + PEEP

***When choosing a NAVA level, the NAVA preview window is a tool that can be accessed via the Neural Access fixed key then selecting NAVA Preview.**

NAVA Preview

This is a tool to help set NAVA level to reach an estimated NAVA Pressure. On the uppermost waveform (the pressure curve), there are two curves presented simultaneously. The grey curve shows the estimated pressure, based on the Edi signal and the set NAVA level. This preview is available in all invasive modes, NIV PC & NIV PS. It cannot be used in NIV if NIV NAVA is the first ventilation choice.



When using this window, it is advisable to start with a low NAVA Level, recommended 1.0 cmH20/uV and trend this number using the NAVA direct access knob to increase the Press NAVA Level and by using the main rotary dial, aim to produce the same pressure as that used in the current ventilation mode. Pressing “Close” will save this selected NAVA Level for when the time is decided to commence NAVA.

Breath Triggering in NAVA

BREATH TRIGGERING IN NAVA

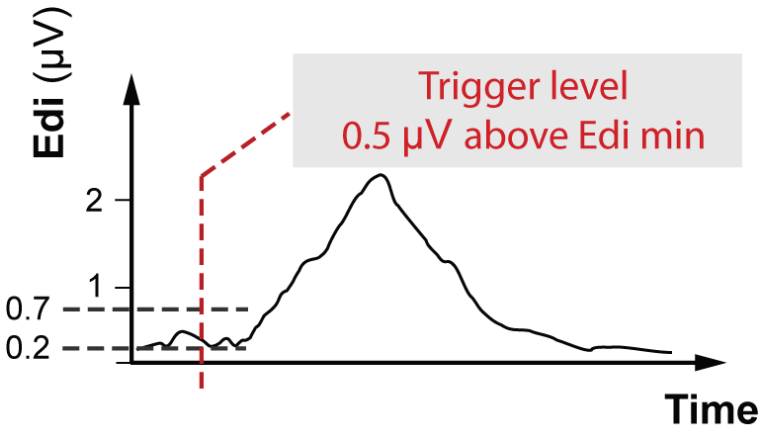
When ventilating with NAVA, inspiration is triggered in one of three ways:

- By the Edi signal (shown in picture).
- Pneumatically by flow.
- Pneumatically by pressure.

Inspiration triggering occurs on a first-come-first-served basis.

Expiration is normally triggered by a decrease in Edi.

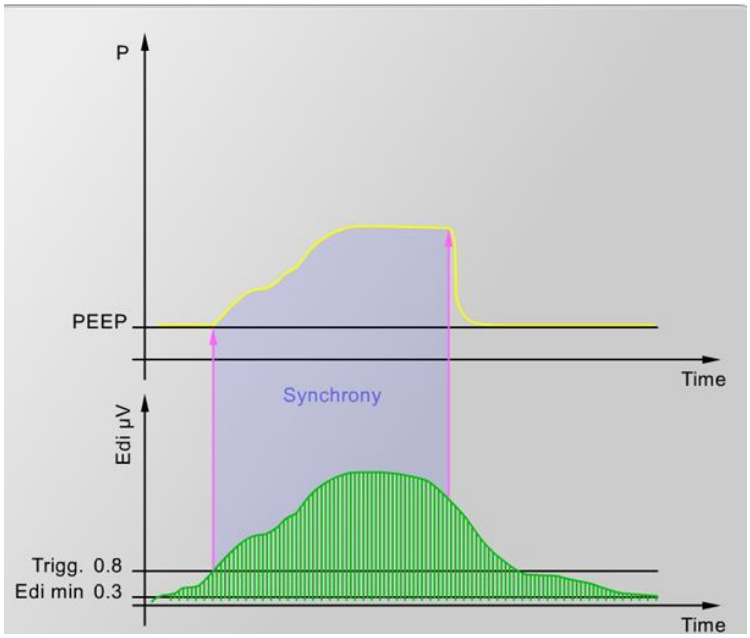
Trigger Edi is the set value that will trigger the ventilator to assist the patient in breathing. This value has a default setting on 0.5uV and has a range of 0-2uV.



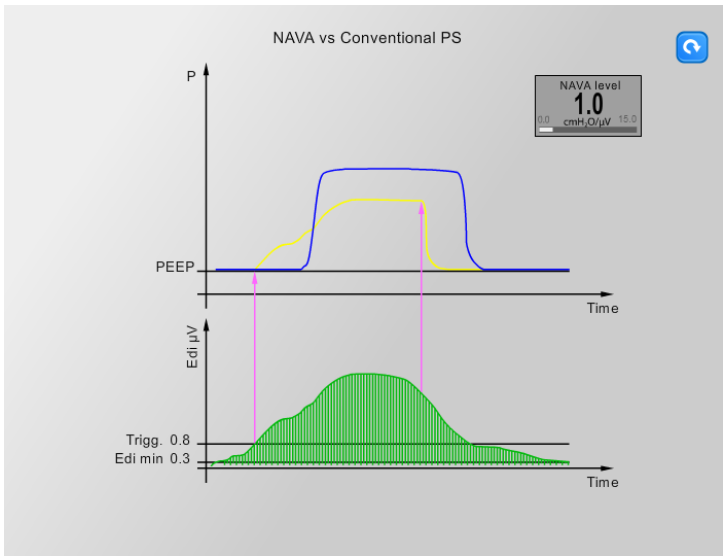
NAVA Ventilation

Ventilation in NAVA is triggered by an increase in the Edi Signal from the Edi Min, not at an absolute level of Edi.

Inspiration Phase of Triggered Edi -> breath will be triggered at a level = to Edi Min + Set Triggered Edi (above example: 0.3 + set trigger Edi of 0.5uV means a breath will be triggered with assist when the level is 0.8).

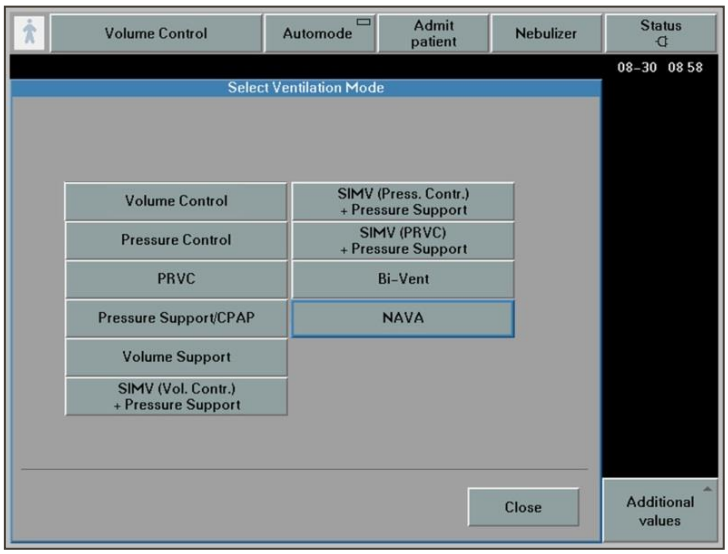


Expiration Phase: start when the Edi Signal has fallen to 70% of its Edi peak value. Assist from the ventilator will cease. In PS Mode, pressure delivery continues causing asynchrony and respiratory distress in the patient.

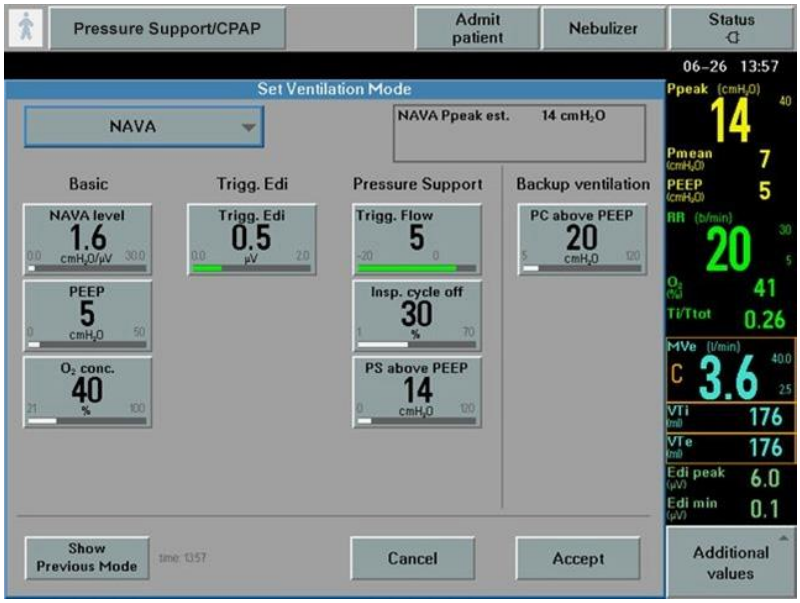


Changing to Invasive NAVA:

- Ensure the patient Edi peak is > 5 & regular.
- Observe the Edi Peak and the Edi Min before commencing NAVA
- Open **NAVA Preview**, observe grey wave & select the chosen NAVA Level.
- Open the Ventilation Modes window, select NAVA and the saved NAVA Level chosen in **NAVA Preview** will commence at that level of assist to support the patient's ventilation.

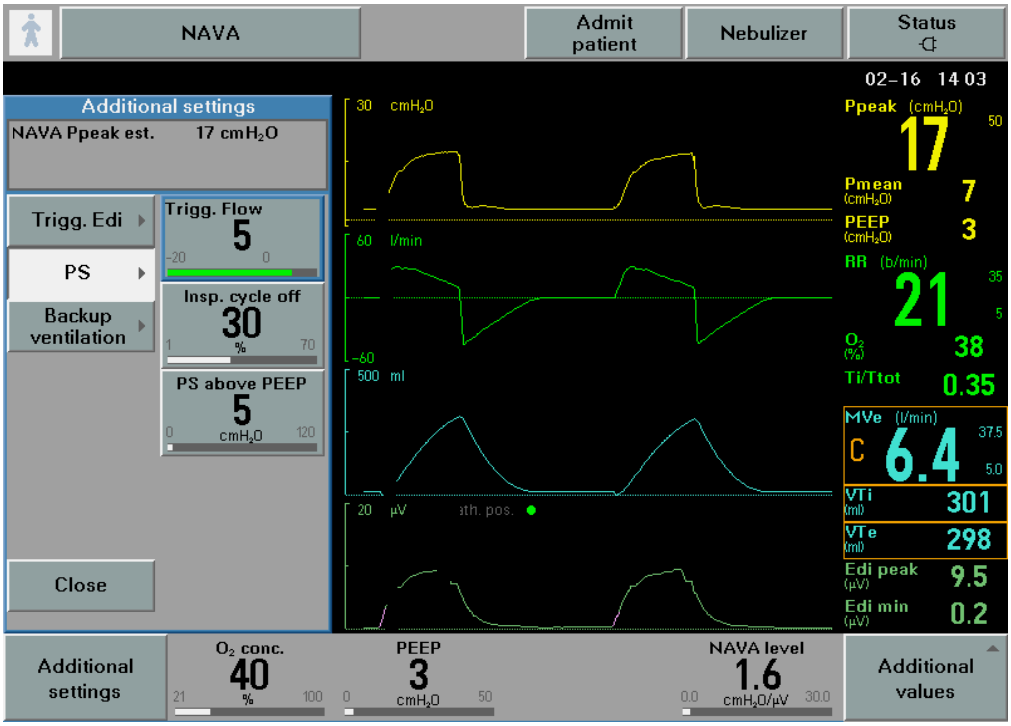


- PEEP & Fi02 remain at previous settings.
- Trigg Edi has a default setting of 0.5uV, but can be set between 0.10-2.0 uV

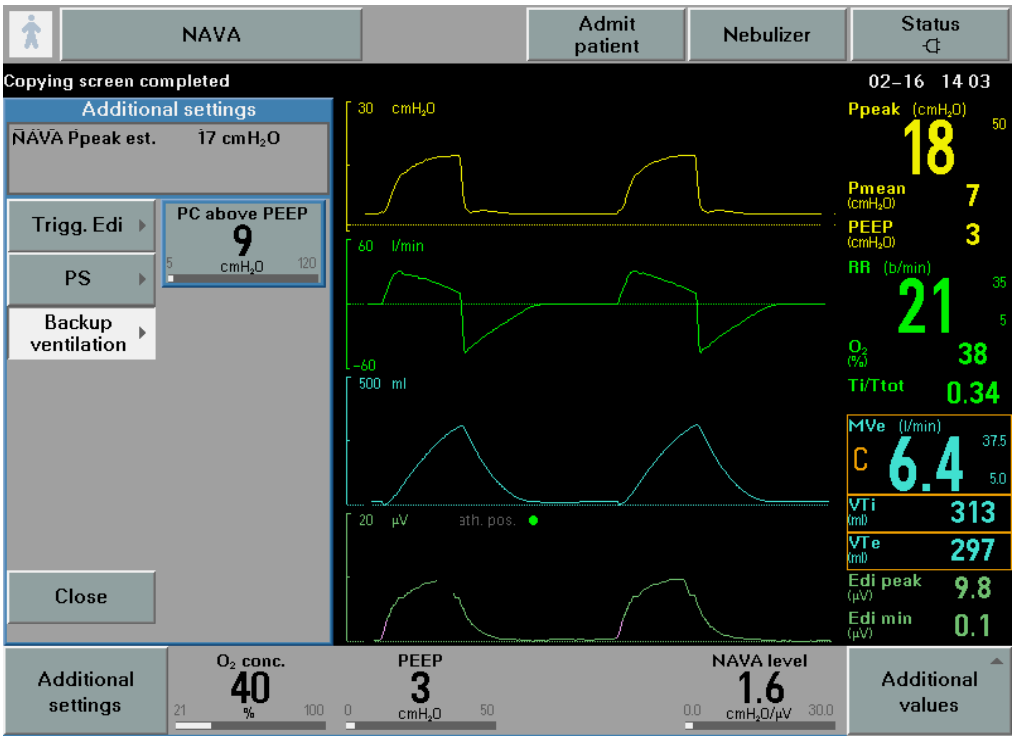


Ensure Pressure Support & Backup Ventilation parameters are appropriately set as the ventilator will use these if the NAVA trigger is inadequate. (Cycle off criteria: 70% of the peak Edi Signal for normal & high Edi signals)

NAVA (PS)

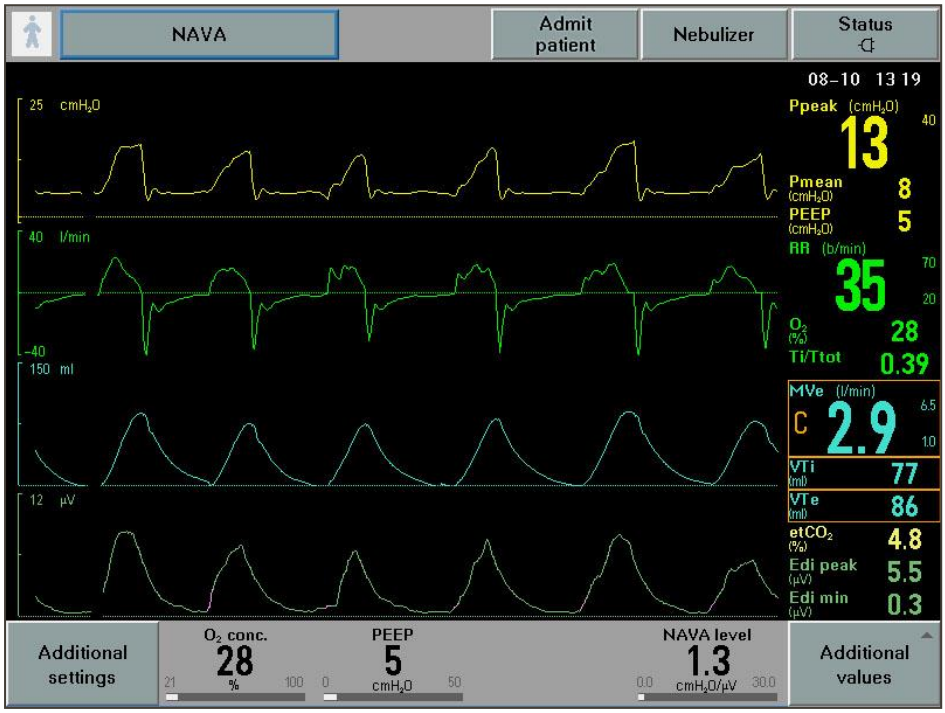


Backup NAVA (PC)



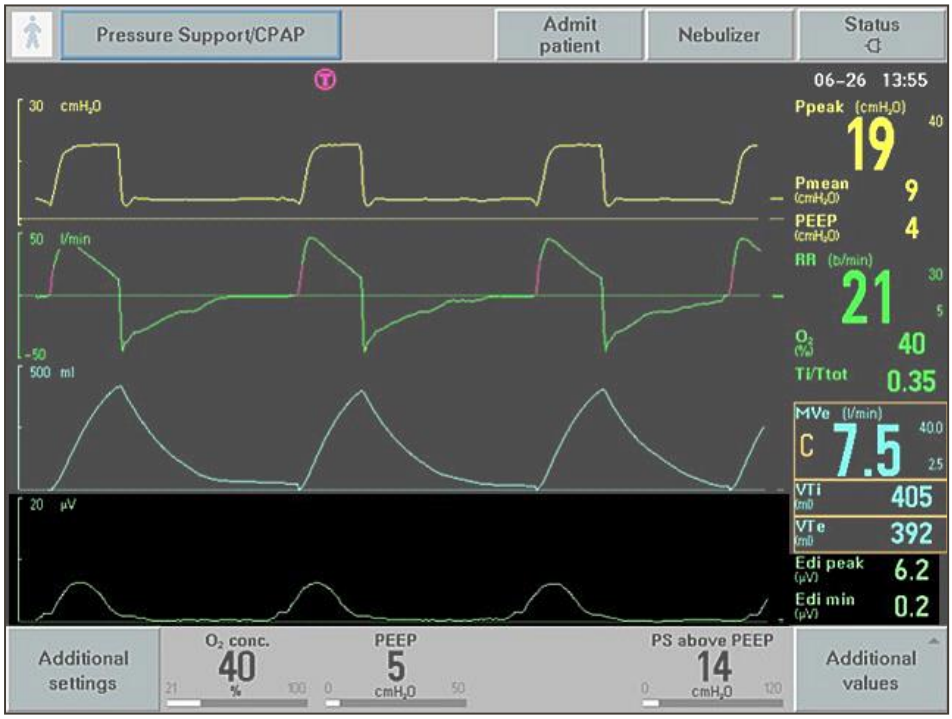
Running in NAVA Mode

Inspiratory support is delivered in proportion to Edi (insp. trigger & cycle off



Different inspiratory trigger colours will appear on the screen for Edi, Flow & Pressure. NAVA trigger is Light Pink T

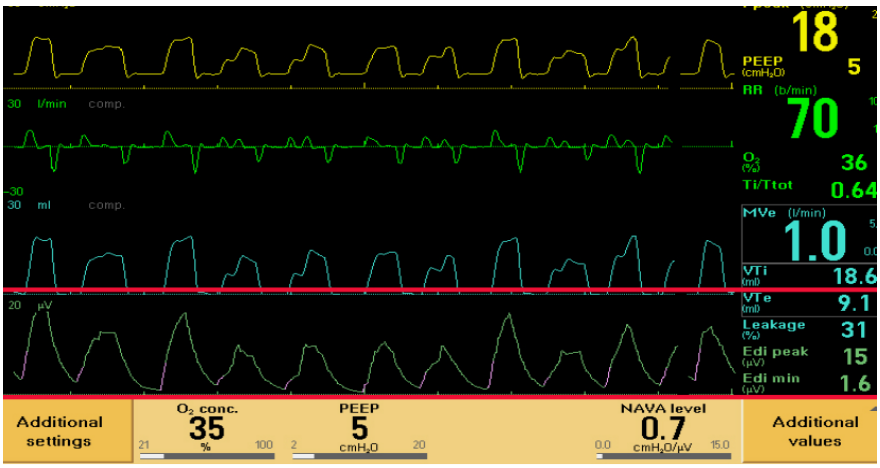
Flow and Pressure Triggering is **Dark Pink T**



Changing to NIV NAVA:

To commence NIV NAVA, Servo-i must be in Standby Mode.
Chose a patient category (adult or infant) and non-invasive ventilation.
*Banner displayed on the ventilator screen will be Orange.

NAVA Level is **recommended to start low (0.5uV)** & trend up or down, in increments of 0.1uV, whilst observing the displayed Edi Peak measures and the patient's response to the level of assist from NAVA. With the increase, or sometimes possibly decrease in NAVA level, Edi Peaks and patient work of breathing should reduce. Tidal volumes will also measure lower.



Finding a level that achieves a reduced effort in breathing by the patient, with improved synchrony with the ventilator, improved oxygen saturations and **Edi Peaks approximately 15-20** can take several minutes, but for some patients, it can be an immediate effect.

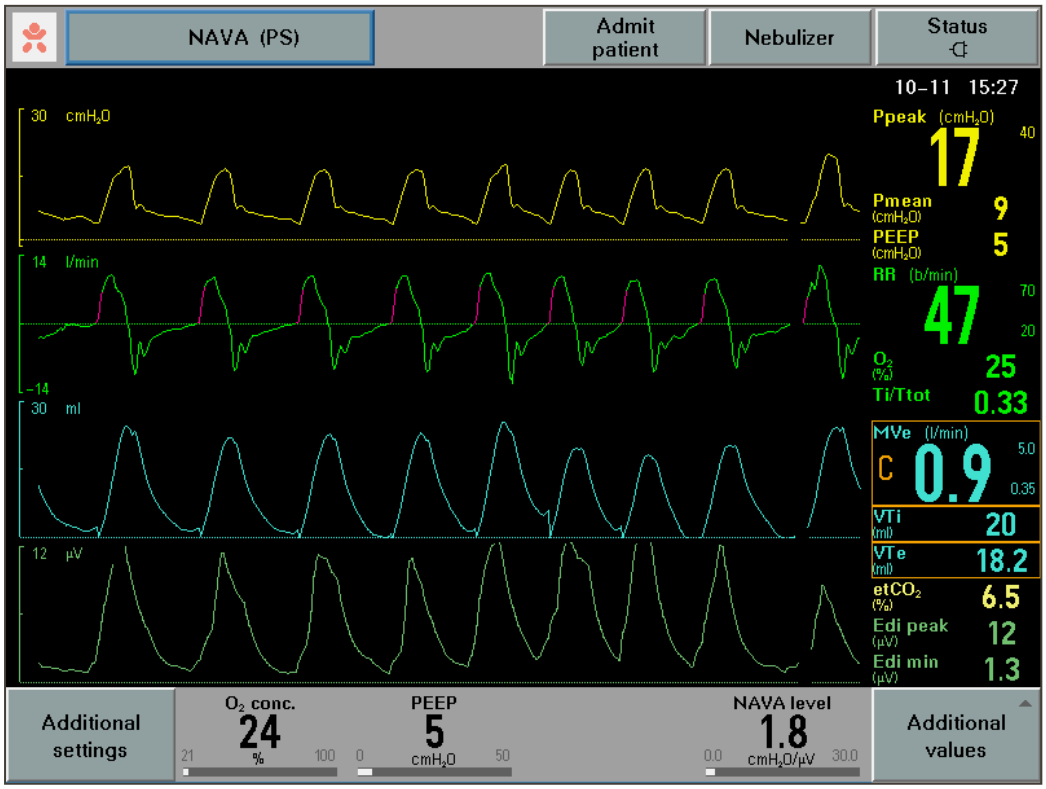
Basic Settings: Fi02 as required, PEEP as per Edi Min & Trigg Edi at 0.5uV

NAVA to NAVA (PS)

Switching to NAVA (PS)

The ventilator switches from NAVA to NAVA (PS) if one or more of the following conditions are fulfilled:

- The Edi respiratory rate differs from the pneumatic respiratory rate with more than 25% for at least 5 s.
- The calculated respiratory rates are based on the last 20 s.



Switching back from NAVA (PS) to NAVA

The ventilator switches back automatically from NAVA (PS) to NAVA if all of the following conditions are fulfilled.

- The Edi respiratory rate differs from the pneumatic respiratory rate with less than 20%.
- At least 7 of the last 10 breaths are classified as synchronous with the Edi signal.

Therefore it is necessary to have the NAVA (PS) values (Trigg Flow, Cycle off & PS above PEEP) pre-selected to enable the ventilator to switch back to NAVA mode when signalled.

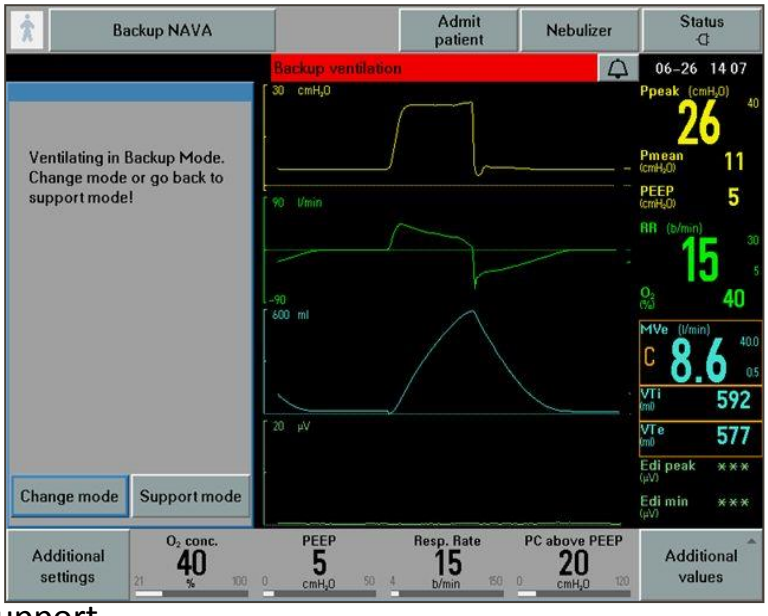
If the Pneumatic trigger can no longer be detected in NAVA (PS) then the ventilator will switch to Back up Ventilation (PC Mode).

Back Up Ventilation

If the Edi Signal is permanently low or absent, due to Edi Catheter incorrectly placed, Edi Catheter accidently removed or the patient is apnoeic with no pneumatic trigger, then the ventilator will switch to Back Up ventilation. This mode is Pressure Control Mode, thus a PC Level above PEEP, Resp Rate & Ti time must be pre-selected to support the patient if the Edi Signal cannot be detected.

NAVA

Backup NAVA



If the ventilator has switched back & forth from NAVA and Back Up ventilation more than 3 times in 2 mins, or the patient only triggers one breath with the Edi signal to interrupt 2 back up periods, then the ventilator will lock and prompt for a change in mode or return to support.

Alarm for Asynchrony

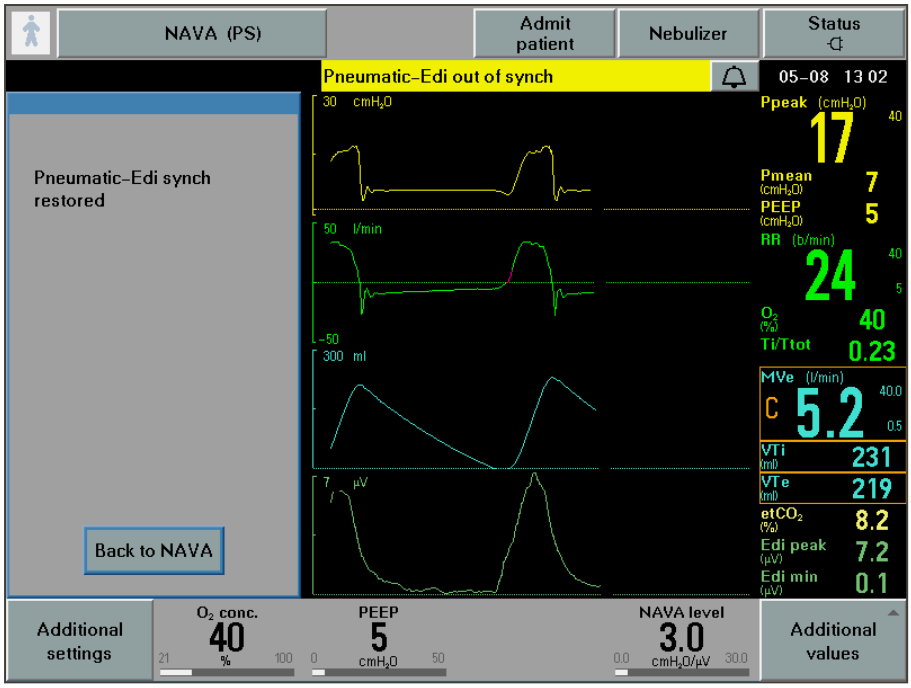
High Priority Alarm

The ventilator will switch back and forth without alarming until one of the following conditions is fulfilled:

- The ventilator has been in NAVA (PS) > 120 s.
- There are 6 switches from NAVA to NAVA (PS) in the last 5 minutes.

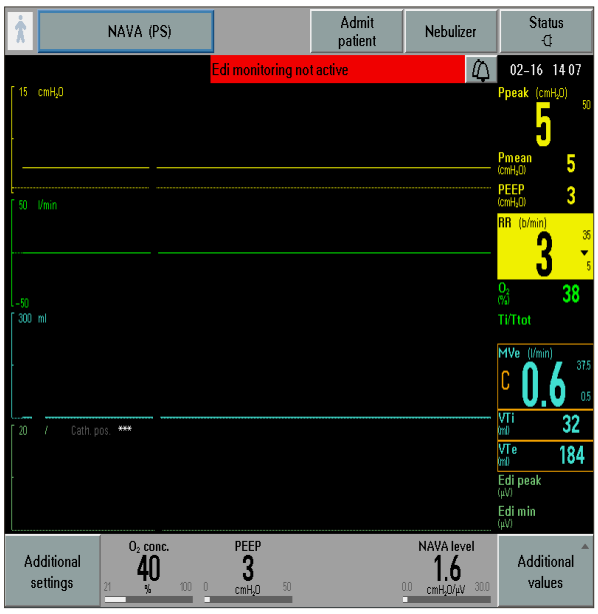
The asynchrony alarm “Pneumatic-Edi out of synch” will appear since the measured Edi signal is out of phase with pressure & flow signals generated by the patient.

On recovery of Edi signal & synchrony is re-established, a message “Pneumatic-Edi synch restored” appears. Press “Back to NAVA” or wait 10 seconds & the ventilator will return to NAVA itself.



Additional Priority Alarms:

- Message and dialog when Edi Module and/or Edi catheter is disconnected
- High priority alarm when Edi Module and/or Edi catheter is disconnected

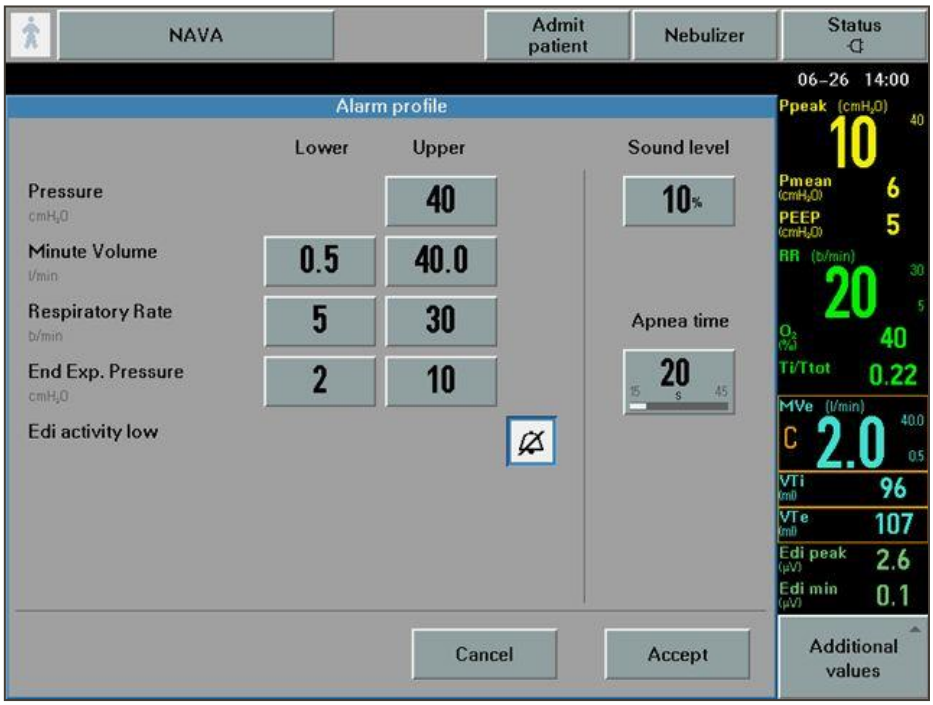


Alarms continued:

- Patient related alarm: Edi activity low – can be permanently silenced

"Unreliable Edi Signal" is another alarm for checking the Edi Catheter position.

- Pressure regulation limited alarm – activated 5 cm H_2O below Upper Pressure limit



That is, if NAVA level is increased and patient's Ppeak increases > 35, the ventilator will alarm and the words "Regulation Pressure Limited" will appear on the screen, prompting you to review NAVA Level, and/or the alarm limits.

Example: Quick Management Tips for NAVA

Guidelines for Using Invasive NAVA

Setting Guide:

- Starting NAVA level 1
- Edi Trigger 0.5 mV
- Target Edi peak = 5-15 mV (approx)

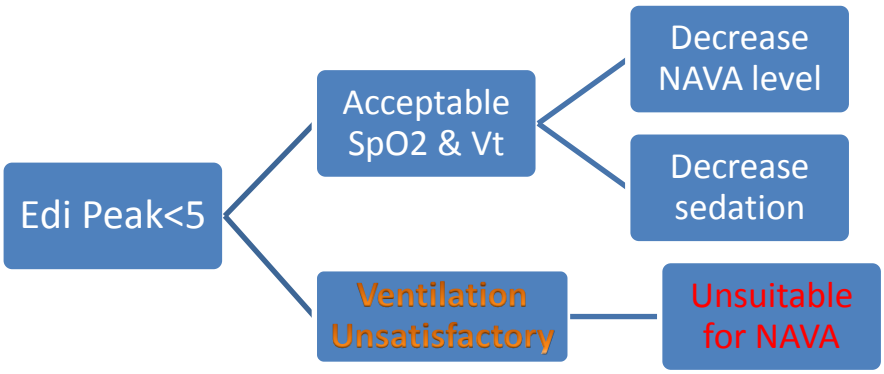
– If Edi peak > 15 mV → increase the NAVA

– If Edi peak < 5 mV → review sedation

- Target Edi min = 0.2 – 2 mV (approx)

– If Edi min > 2 mV → increase PEEP

Edi Peak <5 = Reduced Neural Message



Low Edi Peak reflects a reduced respiratory drive. Two main reasons for this:
1. Too much ventilatory support (over ventilating)
2. Respiratory depression secondary to sedation/drugs

By decreasing the respiratory support (↓NAVA level or ↓ minute volume on conventional modes) you will be able to assess if this is the cause of ↓ Edi Peak). If the patient is unsuitable for NAVA, the Edi signal can be monitored during conventional ventilation to observe for changes in Edi signal.

Edi Min > 2 = Continuous Neural Message

An elevated Edi Min indicates that there is a failure of the diaphragm to relax during expiration. This is generally associated with lung disease such decreased lung compliance. The patient is trying to maintain an adequate FRC [functional residual capacity]. The addition of PEEP maintains the FRC and allows the patient to rest their diaphragm during expiration

Edi Peak > 15 = increased neural message

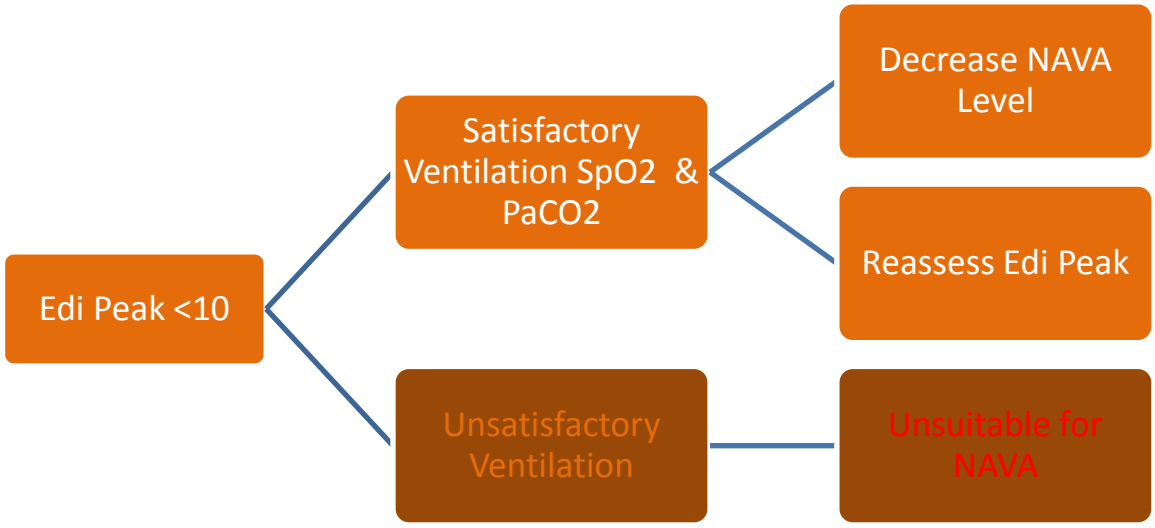
Increased Edi Peak is associated with increased respiratory drive. This may occur in lung disease where work of breathing is increased due to increased airways resistance or decreased lung compliance. By increasing the NAVA level the patient is provided with greater ventilator support, decreasing their work of breathing.

Guidelines for Using NIV NAVA

Setting Guide:

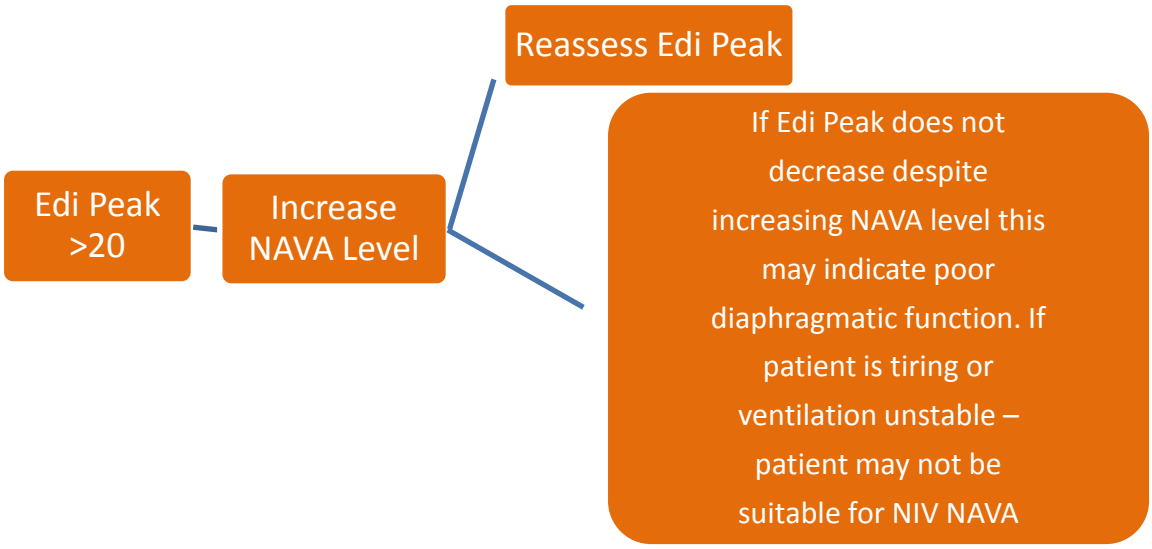
- Starting NAVA level 0 - titrate up by 0.1
- Edi Trigger 0.5 mV
- Target Edi peak = 10-20 mV (approx)
  - If Edi peak > 15 mV → increase the NAVA
  - If Edi peak < 5 mV → review sedation
- Target Edi min = 0.2 – 2 mV (approx)
  - If Edi min > 2 mV → increase PEEP

Edi Peak < 10mV = decreased neural message



Low Edi Peak reflects a reduced respiratory drive most likely due to too much ventilator support (over ventilating). By decreasing the respiratory support (eg ↓NAVA level or ↓pressure support) you will be able to assess if this is the cause of ↓ Edi Peak). If the patient is unsuitable for NAVA, the Edi signal can be monitored during conventional ventilation to observe for changes in Edi signal.

Edi Peak > 20mV = increased neural message



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Edi Min > 2 = continuous neural message

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