MAQUET
GETINGE GROUP

CRITICAL CARE

SERVO Education
NAVA TUTORIAL

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1 INTRODUCTION

The objective of this tutorial is to help the user understand how to use the new mode of ventilation for the SERVO-i ventilator - NAVA, or Neurally Adjusted Ventilatory Assist.

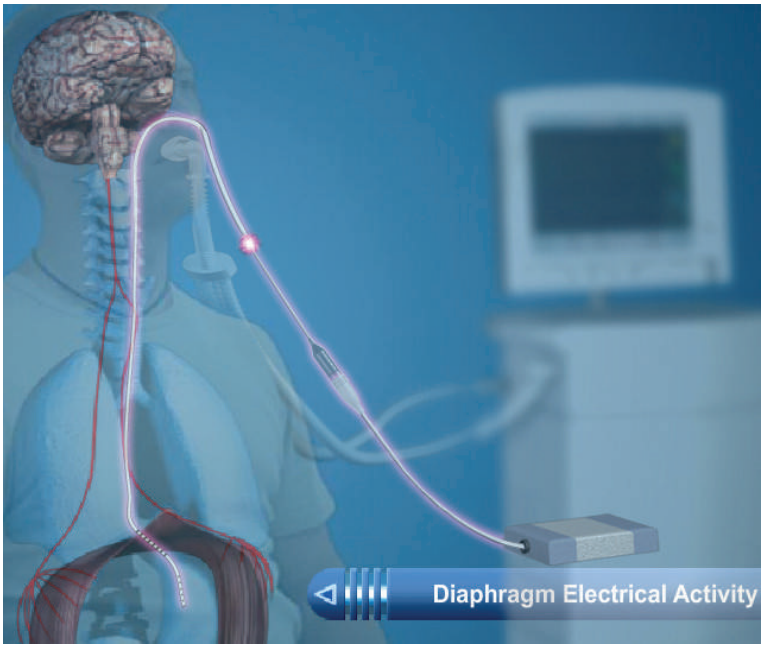
This tutorial includes the following:

- information about the NAVA concept
- a detailed description of how to use it
- exercises
- patient cases to illustrate NAVA use
- a key to the exercises.

Note: This Tutorial only covers selected topics and cannot replace the NAVA Study Guide or the User's Manuals relevant to NAVA.

2 THE NAVA CONCEPT

NAVA delivers ventilatory assist in proportion to and in synchrony with the patient's Edi signal.



To facilitate a more in-depth understanding of the use of NAVA, some of the NAVA parameters are covered in more detail below.

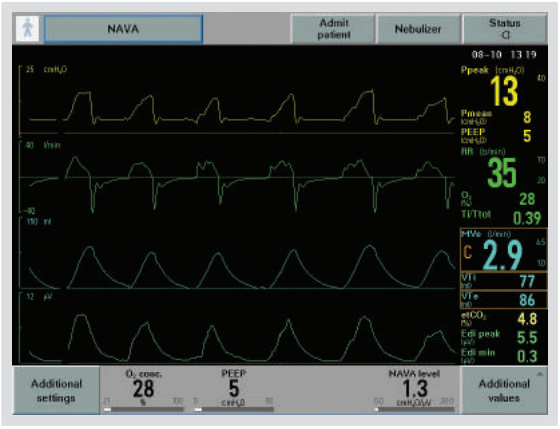
2.1 NAVA RESPIRATION CYCLE

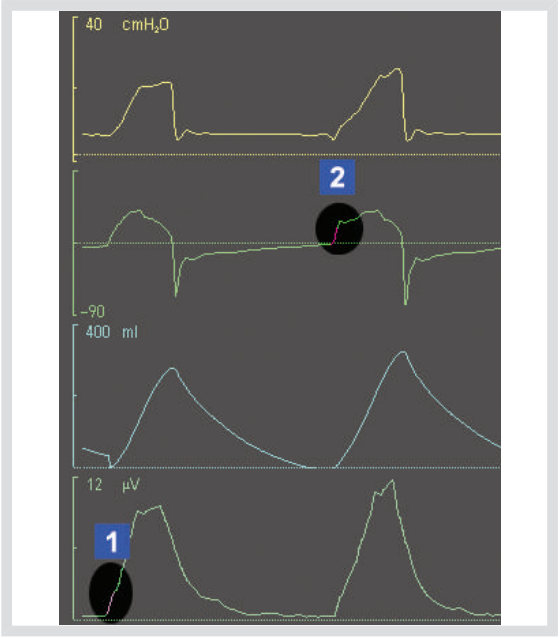
The Edi signal varies from breath to breath, which means that the supporting pressure will also vary.

Inspiration starts

When the patient triggers a breath, gas flows into the lungs at a varying pressure proportional to the patient's Edi.

Triggering of a breath is either Edi, flow or pressure trigger. Even if the breath is triggered on flow or pressure, the breath delivered to the patient remains proportional to the patient's Edi signal.

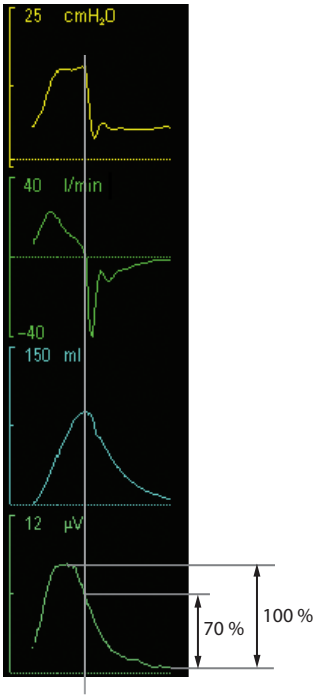




1. Edi triggered breath
2. Flow triggered breath

Expiratory phase starts

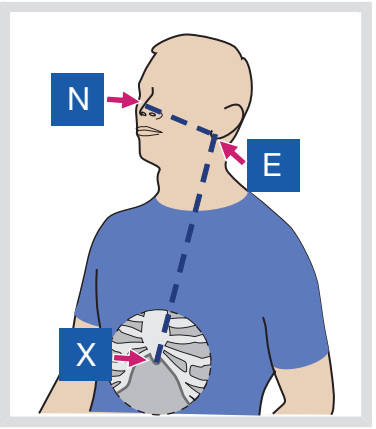
- if the pressure increases 3 cmH2O above the inspiratory target pressure;
- when the Edi signal decreases below 70% of the peak value during the ongoing inspiration (40% for low Edi signals);
- if the upper pressure limit is exceeded: when the maximum time limit for inspiration is exceeded:
  - For adults, 2.5 seconds;
  - For infants, 1.5 seconds.



2.2 POSITIONING OF THE EDI CATHETER

Correct calculation of the insertion distance for the Edi Catheter is crucial for the performance of NAVA. The process can be summarized as follows:

- Select the right Edi Catheter size for the patient;
- Measure the NEX distance on the patient;
- Calculate the insertion distance by means of the tables for nasal or oral insertion respectively.



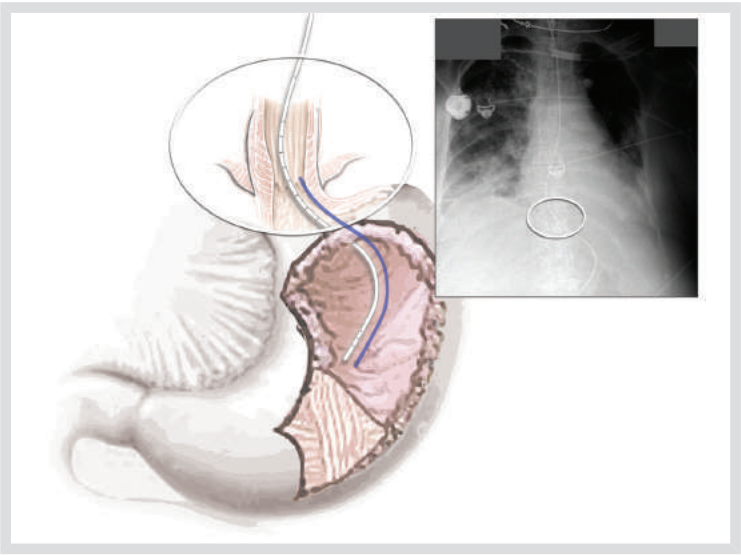
Insertion distance Y for nasal insertion	
Fr/cm	**Calculation of Y**
16 Fr	NEX cm x 0.9 + 18 = Y cm
12 Fr	NEX cm x 0.9 + 15 = Y cm
8 Fr 125 cm	NEX cm x 0.9 + 18 = Y cm
8 Fr 100 cm	NEX cm x 0.9 + 8 = Y cm
6 Fr 50 cm	NEX cm x 0.9 + 3.5 = Y cm
6 Fr 49 cm	NEX cm x 0.9 + 2.5 = Y cm

Insertion distance Y for oral insertion	
Fr/cm	**Calculation of Y**
16 Fr	NEX cm x 0.8 + 18 = Y cm
12 Fr	NEX cm x 0.8 + 15 = Y cm
8 Fr 125 cm	NEX cm x 0.8 + 18 = Y cm
8 Fr 100 cm	NEX cm x 0.8 + 8 = Y cm
6 Fr 50 cm	NEX cm x 0.8 + 3.5 = Y cm
6 Fr 49 cm	NEX cm x 0.8 + 2.5 = Y cm

When inserting the Edi Catheter, it is very important that the electrodes should be positioned where the Edi signal is strongest, i.e. centered in the esophagus at the level of the diaphragm. This is the purpose of the calculations in the two tables above.

In the tables, a fixed numerical value has been added to each formula. For instance, in the formula for 16 Fr, the value 18 is added in the final position of the formula.

The additional fixed value in the tables is the distance between the middle electrode in the array of measuring electrodes and the lower tip of the Edi Catheter. The drawn blue line beside the Edi Catheter in the picture indicates this distance.



EXERCISES

1. What do the letters in the acronym NEX stand for?

"N" stands for:

"E" stands for:

"X" stands for:

2. Calculate the Edi Catheter insertion distance when:

- Edi Catheter size = 16 Fr
- NEX measurement = 50 cm
- Nasal insertion

Insertion distance = _____ x _____ + _____ = _____ ≈ _____ cm

3. Calculate the Edi Catheter insertion distance when:

- Edi Catheter size = 16 Fr
- NEX measurement = 56 cm
- Oral insertion

Insertion distance = _____ x _____ + _____ = _____ ≈ _____ cm

4. Calculate the Edi Catheter insertion distance when:

- Edi Catheter size = 8 Fr 100 cm
- NEX measurement = 20.5 cm
- Nasal insertion

Insertion distance = _____ x _____ + _____ = _____ ≈ _____ cm

2.3 TRIGGER LEVEL

In NAVA mode, the trigger detects increases in Edi and should be set to a level where random variability in the background noise does not exceed the trigger level.

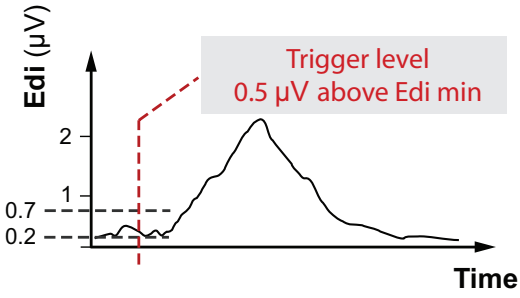
It is important to emphasize that NAVA is triggered by an increase in Edi from the Edi minimum and not at any absolute level of Edi.

As a secondary source, NAVA also employs the pneumatic trigger, flow or pressure, which operates in combination with the neural trigger on a first-come-first-served basis. The examples and exercise below deal with Edi triggered breaths only.

EXAMPLE 1

The variability of the background noise is typically less than 0.5 µV, which is the default trigger level value. In this example, the SERVO-i will provide support when the Edi signal exceeds 0.7 µV.

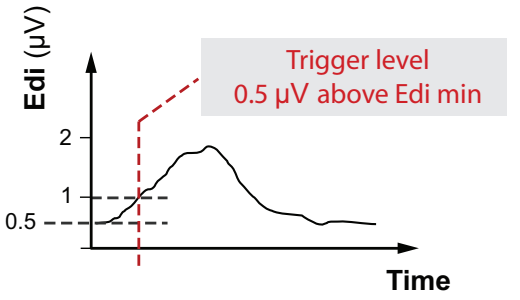
- Edi min = 0.2 µV
- Edi trigger level = 0.5 µV
- Inspiration will be triggered at 0.2 µV + 0.5 µV = 0.7 µV.



EXAMPLE 2

In this example, the Edi min value is 0.5 µV and trigger level is kept as the default value (i.e. 0.5 µV). The ventilator is activated when the Edi signal exceeds 1 µV.

- Inspiration will be triggered at 0.5 µV + 0.5 µV = 1 µV.



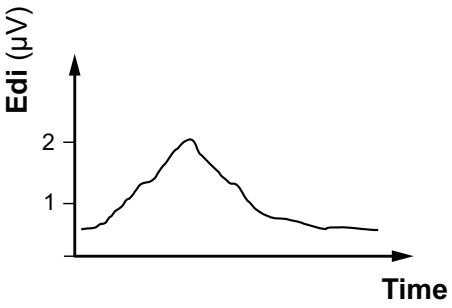
EXERCISES

- The Edi trigger level is set to 0.7 µV
- Edi min for this breath is 0.5 µV

5. At what Edi signal level will NAVA be triggered?

µV

Make a mark on the Edi curve at the Edi signal level where NAVA is triggered.



2.4 NAVA LEVEL

During NAVA, the amount of pressure delivered (in cmH_2O) is adjusted by multiplying the Edi signal (which is expressed in µV) by a proportionality factor, known as the NAVA level (expressed in $cmH_2O/\mu V$). The NAVA level expresses how many cmH_2O the patient will receive per µV Edi – the relationship is linear.

FORMULA FOR ESTIMATING PEAK PRESSURES DURING NAVA

Formula for calculating the pressure:

P_{peak} est. = NAVA level x (Edi peak – Edi min) + PEEP

In the examples and exercises below, we perform the calculations that are automatically performed by the ventilator. It is important to understand how the NAVA level concept works and how the patient is interacting with the SERVO-i by means of the Edi Signal.

EXAMPLE 1

The following values were set:

- PEEP = 6 cmH_2O
- NAVA level = 1 $cmH_2O/\mu V$

For one breath, the following Edi signals was registered by NAVA:

- Edi peak = 5.8 µV
- Edi min = 0.8 µV

As can be seen in the calculation, the resulting Edi signal for this breath is 5 µV. The delivered pressure is:

P_{peak} est. = NAVA level x (Edi peak – Edi min) + PEEP
= 1 x (5.8 – 0.8) + 6 = 1 x 5 + 6 = 11 cmH_2O

EXAMPLE 2

The following values were set:

- PEEP = 6 cmH_2O
- NAVA level = 2 $cmH_2O/\mu V$

For one breath, the following Edi signals was registered by NAVA:

- Edi peak = 5.6 µV
- Edi min = 0.6 µV

The delivered pressure for this breath is:

P_{peak} est. = NAVA level x (Edi peak – Edi min) + PEEP
= 2 x (5.6 – 0.6) + 6 = 2 x 5 + 6 = 16 cmH_2O

EXERCISES

The following values were set:

- PEEP = 4 cmH_2O
- NAVA level = 1.5 $cmH_2O/\mu V$

For one breath, the following Edi signals were registered by NAVA:

- Edi peak = 9.5 µV
- Edi min = 0.5 µV

6. What will be the delivered pressure for this breath?

P_{peak} est. = _____ x _____ + _____ = _____ ≈ _____ cmH_2O

USING THE FORMULA AND THE GRAPH

The relationship expressed by the formula can also be illustrated with a graph.

EXAMPLE

- PEEP = 8 cmH_2O
- NAVA level = 1.2 $cmH_2O/\mu V$

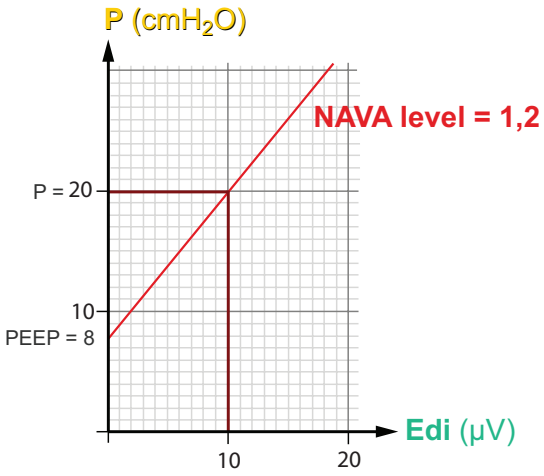
For one breath, the following Edi signals were measured:

- Edi peak = 10.7 µV
- Edi min = 0.7 µV

P_{peak} est. = NAVA level x (Edi peak – Edi min) + PEEP = 1.2 x 10 + 8 = 20 cmH_2O

When displaying the linear relationship in a graph, one can find the assist pressure resulting from the Edi signal for that breath at the set NAVA level.

In this example, the pressure can be read on the y-axis (P = 20), which is the same value as given by the formula.



EXERCISES

This exercise is based on the example above. What would the peak pressure be if (Edi peak – Edi min) = 14 µV ?

7. Use the graph to find the value.

_____ cmH_2O

8. Calculate the value with the formula:

P_{peak} est. =

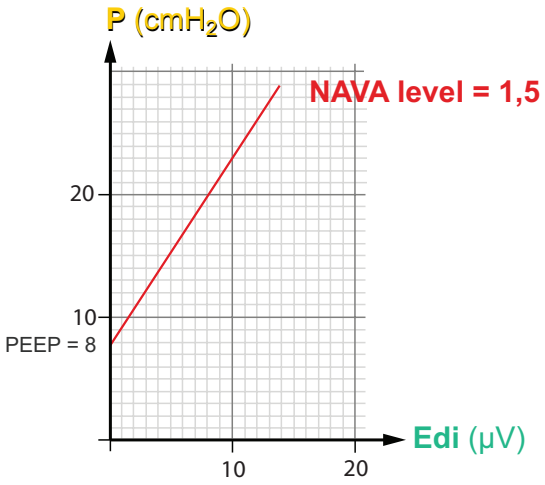
_____ x _____ + _____ = _____ ≈ _____ cmH_2O

EXERCISES

Compared with the last example, the patient now needs more assist from the SERVO-i. The NAVA level is therefore set to 1.5 $cmH_2O/µV$. PEEP is set to 8 cmH_2O.

- PEEP = 8 cmH_2O
- NAVA level = 1.5 $cmH_2O/µV$
- Edi (Edi peak - Edi min) = 10 µV

The line for NAVA level = 1.5 $cmH_2O/µV$ is drawn in the picture starting at 8 cmH_2O (i.e. the PEEP setting).



9. Find the peak pressure value using the graph above.

cmH_2O

10. Calculate the value with the formula:

P_{peak} est. =

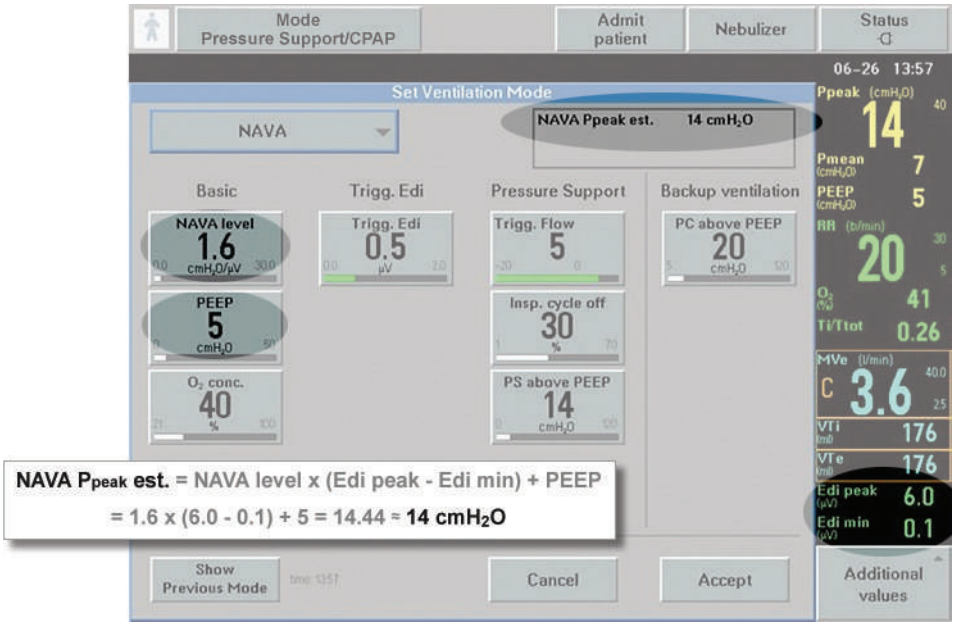
_____ x _____ + _____ = _____ ≈ _____ cmH_2O

CALCULATIONS PERFORMED BY THE SERVO-i

The calculations in the example and exercises above are performed by the ventilator.

EXAMPLE

- PEEP = 5 cmH_2O
- NAVA level = 1.6 $cmH_2O/\mu V$
- Edi (Edi peak - Edi min) = (6.0 - 0.1) = 5.9 µV



During conventional modes, the NAVA peak pressures can be estimated by the ventilator (even if the patient is not breathing with NAVA), based on the Edi signal of the patient. The resulting NAVA P_{peak} est. is displayed in the upper right corner of the *Set Ventilation Mode* window.

2.5 SETTINGS FOR NAVA PRESSURE SUPPORT

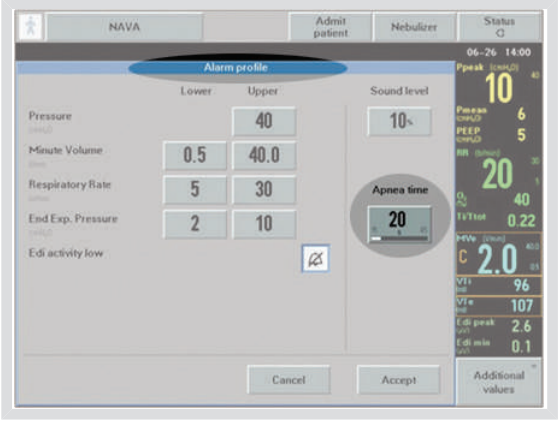
It is very important to set adequate values for NAVA Pressure support:

- Trigg. Flow/Pressure (Pneumatic trigger level)
- Insp. cycle off
- PS above PEEP

If the pressure support level is not properly set, it may affect the patient's Edi signal and the SERVO-i will not be able to switch back to NAVA.

To set an adequate Pressure Support level, it is possible to use the Edi signal superimposed on the pressure curve.

In case of apnea, the SERVO-i will switch to NAVA backup (i.e. Pressure Control) after the set Apnea time (the apnea time is set in the Alarm profile).



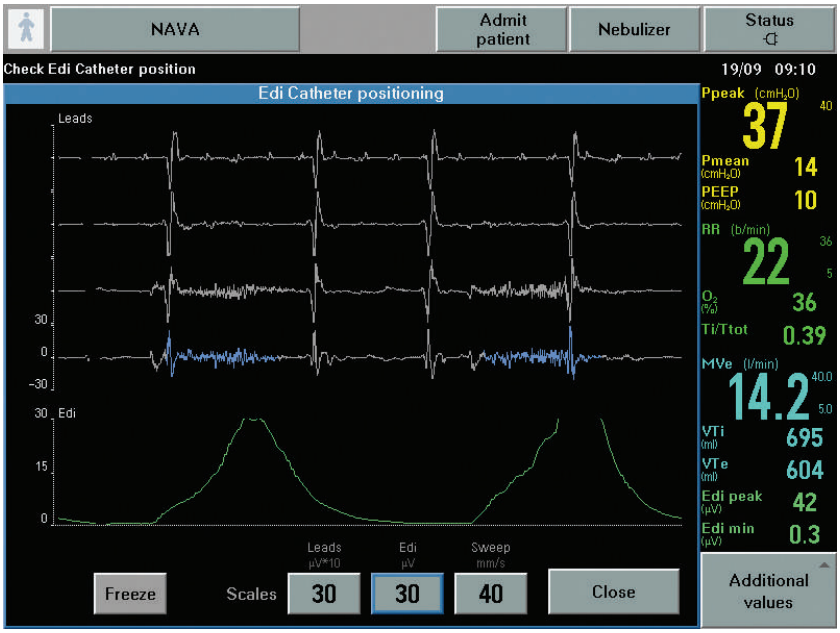
2.6 EXAMPLES OF ESOPHAGUS ECG MONITORING

ATRIAL FLUTTER

Monitoring by means of the Edi signal can be utilized for diagnostic purposes.

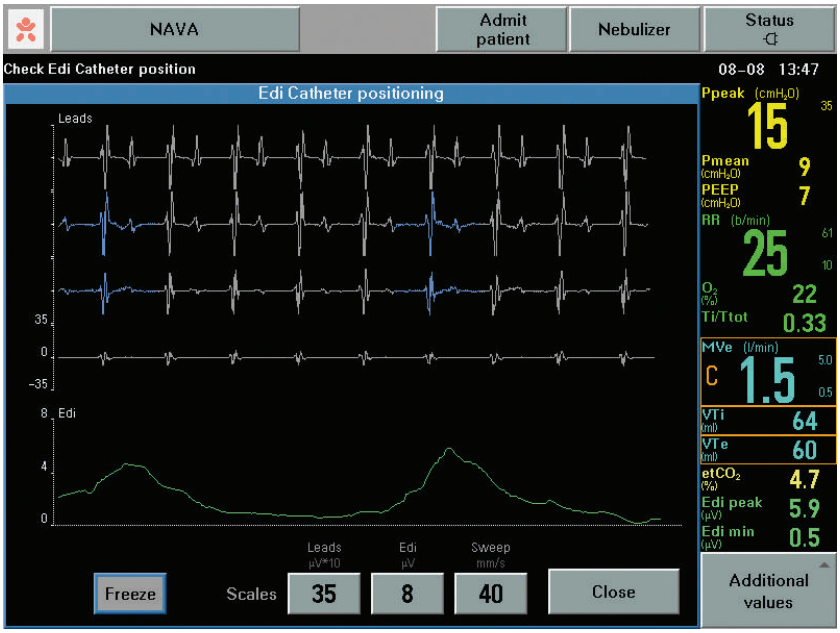
Atrial flutter is an abnormality of the heart rhythm resulting in a rapid and sometimes irregular heartbeat.

This screen shot exemplifies an atrial flutter that is detectable in the positioning window. This atrial flutter was not detected during “standard” ECG.



AV BLOCK 1

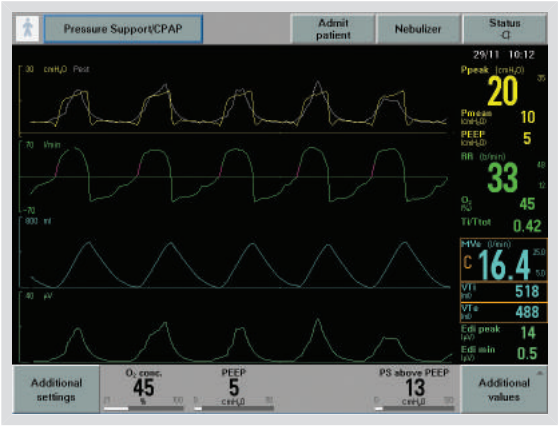
AV Block 1 (first-degree atrio-ventricular block) is characterized by a delay in the conduction time between the atrium and the ventricle (seen in the ECG as a lengthened PR interval > 210 ms). All P waves are followed by QRS complexes.



2.7 MONITORING THE EDI SIGNAL

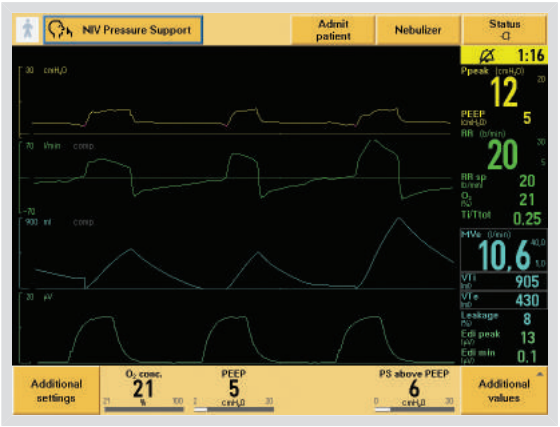
The Edi signal can be monitored in all modes of ventilation when the Edi Catheter is inserted. The Edi signal can even be monitored in Standby position using the *Edi Catheter positioning* window.

Pressure Support/CPAP with the Edi signal superimposed on the pressure curve.

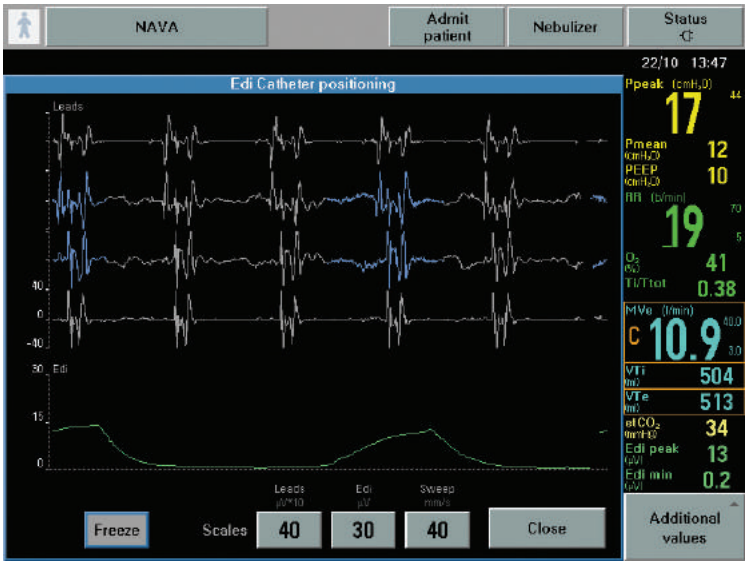


Standby with monitoring of Edi signal

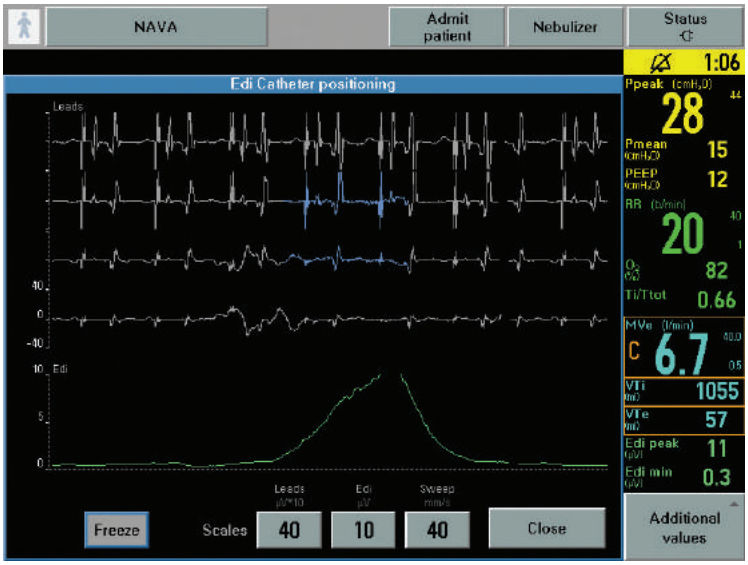
NIV Pressure Support with monitoring of Edi signal



2.8 PATIENTS WITH PACEMAKERS

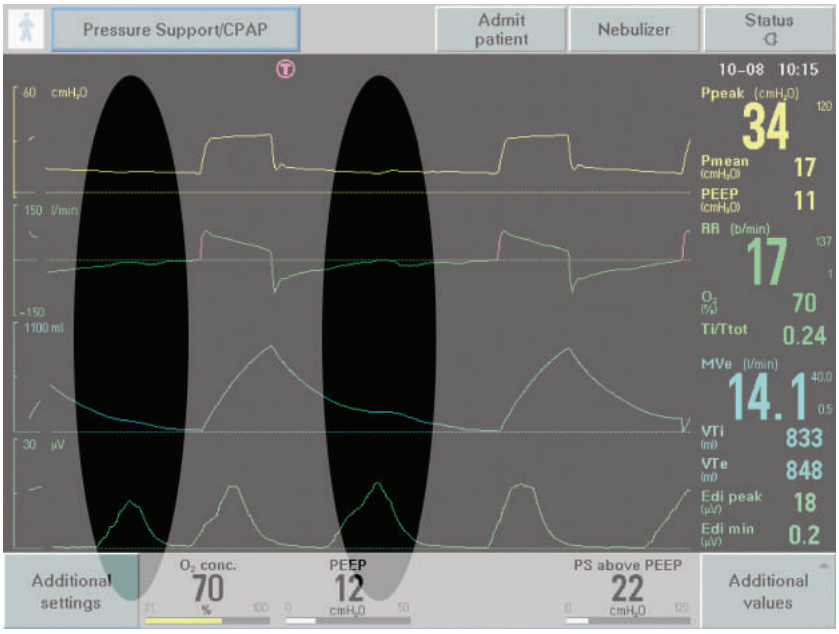


Example of a patient with an ICD (Implantable Cardioverter Defibrillator).



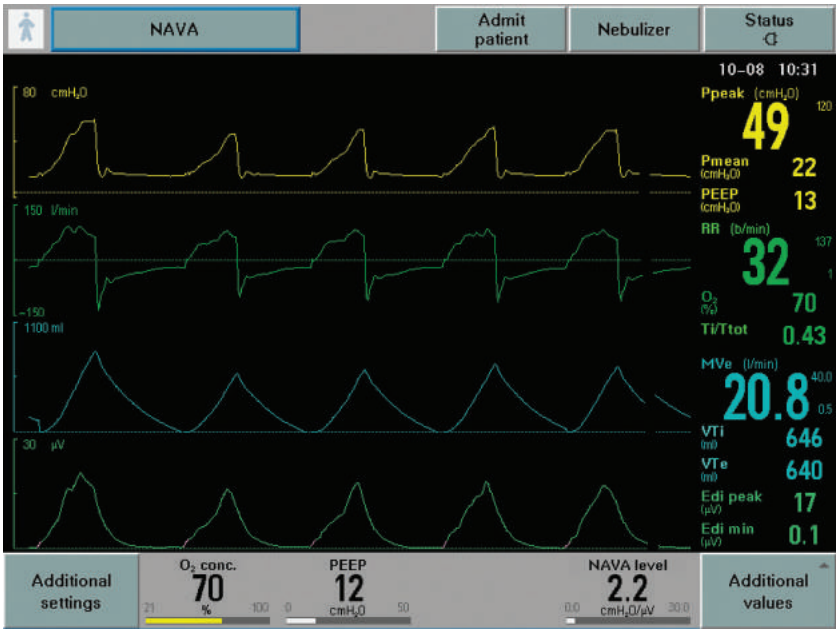
Example of a patient with a temporary external pacemaker.

2.9 WASTED INSPIRATORY EFFORT



Tracings of the airway pressure, flow, volume, and electrical activity of the diaphragm (Edi) of a patient ventilated in Pressure Support with 22 cmH_2O over a positive end expiratory pressure (PEEP) of 12 cmH_2O while using conventional, flow based trigger/cycling systems.

Two of the patient's inspiratory efforts of the patient are not assisted by the ventilator (so called "wasted inspiratory efforts"), reflecting maximal asynchrony between ventilator and patient. A substantial level of intrinsic PEEP was suspected of causing triggering failure in this patient.

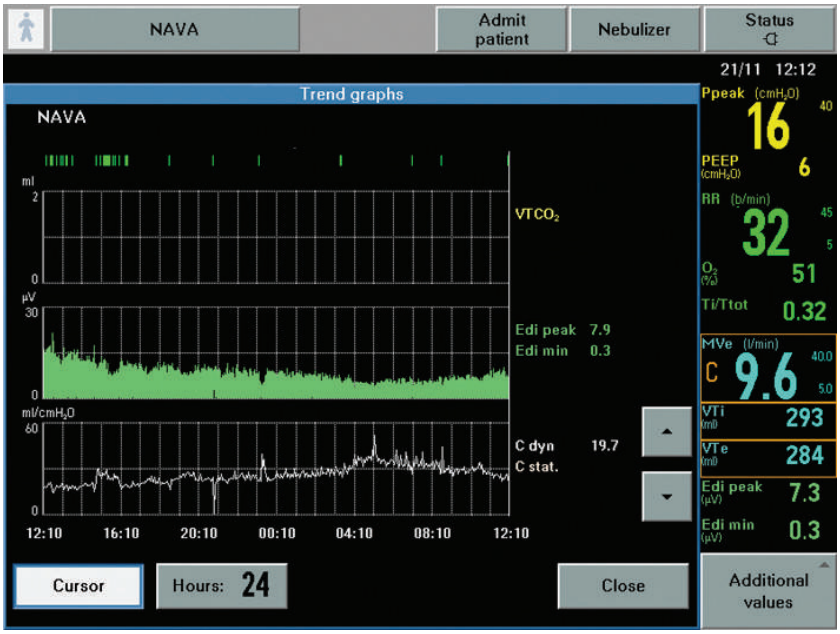


The same tracings are shown above after switching to NAVA.

Each inspiratory effort by the patient is assisted in synchrony with and in proportion to the Edi. There are neither wasted inspiratory efforts nor delays in initiating (trigger-on) and terminating (Insp. cycle-off) the ventilator assist.

2.10 TRENDS

In NAVA it is very useful to look at the trends to follow the patient's progress.



Trends for 24 hours are displayed:

- $VTCO_2$ (CO_2 module inserted and the CAPNOSTAT® III sensor is connected)
- Edi peak
- Edi minimum
- Dynamic and static compliance

Trends for 24 hours are displayed:

- Peak airway pressure
- Mean airway pressure
- Pause airway pressure (values are not available in NAVA)
- PEEP
- Respiratory Rate
- Insp. and Exp. minute volume

2.11 PRACTICAL TIPS

Note Edi Catheter insertion length

It is a good idea to mark the Edi Catheter at its final position and to make a note of the final distance in cm in the charting system of the hospital.

Ventilation Record Card

The Ventilation Record Card allows patient data to be transferred from the SERVO-i to a PC where it can be accessed at a later date. It is useful from a teaching point of view as well as for diagnostic purposes. For more information, see the Servo-i Study Guide

Suctioning and disconnection

During suctioning (not with a closed suction system) and disconnection of the patient, it is important to use the Suction Support function, otherwise the asynchrony alarm may be activated.

If Edi Catheter is pulled out

If the Edi Catheter is pulled out by mistake, the Servo-i will switch to NAVA (PS).

Disconnection of Edi Module

If the Edi Module is disconnected, the Servo-i will switch to NAVA (PS).

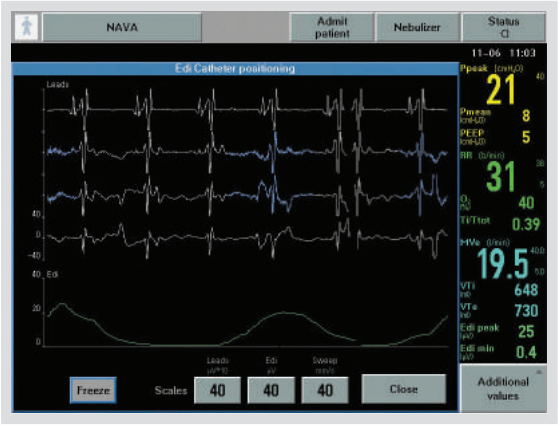
Scale settings

Verify that the Edi scale is fixed and set appropriately (greater than or equal to 5µV). Avoid clipping the Edi Signal, i.e. avoid too low an upper limit on the scale.

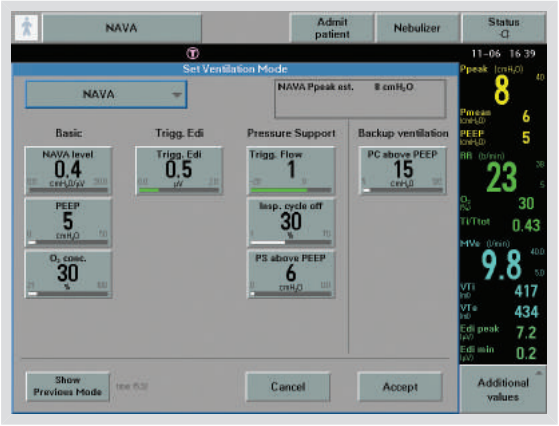
P0.1

P0.1 measures the patient's inspiratory effort during spontaneous breathing. In NAVA, the P0.1 values can vary as some breaths are pneumatically triggered, while most of the breaths are neurally triggered. The P0.1 can only be measured if the breaths are pneumatically triggered.

EXERCISES



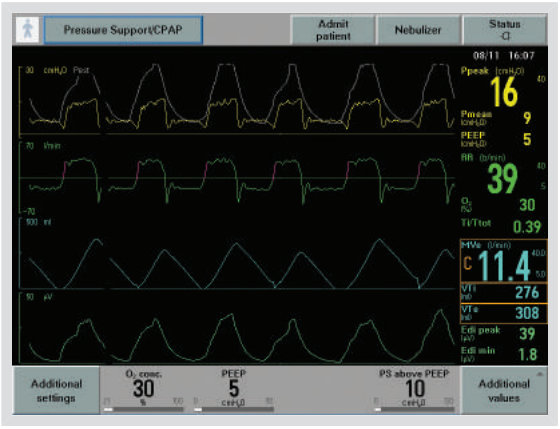
11. How can you verify that the Edi Catheter is in the right position?



12. How much is the estimated Ppeak pressure with these settings?

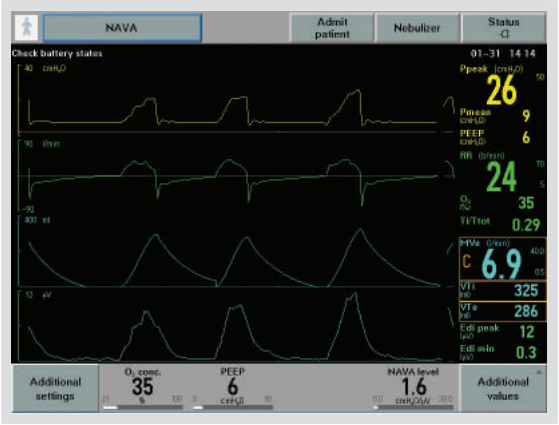
The patient is in Pressure Support ventilation.

Comment: In this example, the NAVA level is probably set too high compared to the pressure support level (estimated pressure is above the prescribed PS level).



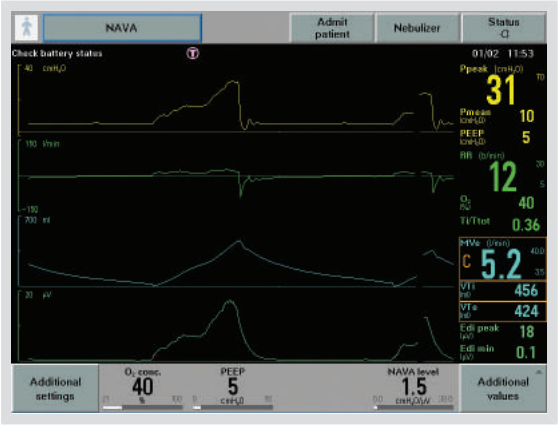
13. How is the synchrony between the Edi signal and the delivered Pressure Support breaths?

14. How much is the estimated Ppeak pressure with these settings?



15. What is the Edi peak in the last breath in this sequence?

16. What is the Edi min in the last breath in this sequence?



17. How is the patient triggering this breath?

3 A FEW PATIENT CASES

In this chapter, a few cases from clinical practice will be presented.

- **Case 1:** A postoperative patient (heart surgery) in which there were no Edi signal detected when the Edi Catheter was inserted.
- **Case 2:** A COPD patient with severe bilateral pneumonia. The patient has been ventilated over a month. Weaning attempts have failed during that time.
- **Case 3:** A pneumonia patient who has been ventilated for more than a month. The patient is difficult to wean from the ventilator (2 attempts failed).
- **Case 4:** This case shows the benefit of Edi monitoring, also when the patient is not breathing in NAVA.

CASE 1

This case is a postoperative patient (heart surgery) in which there were no Edi signal detected when the Edi Catheter was inserted.

- Male, postoperative ventilation
- No specific lung disease
- Sedation with propofol 2%, 5 ml/h (1 ml solution = 20 mg propofol)
- External atrial pacemaker
- Starting mode: Pressure Control ventilation

Pressure Control ventilation

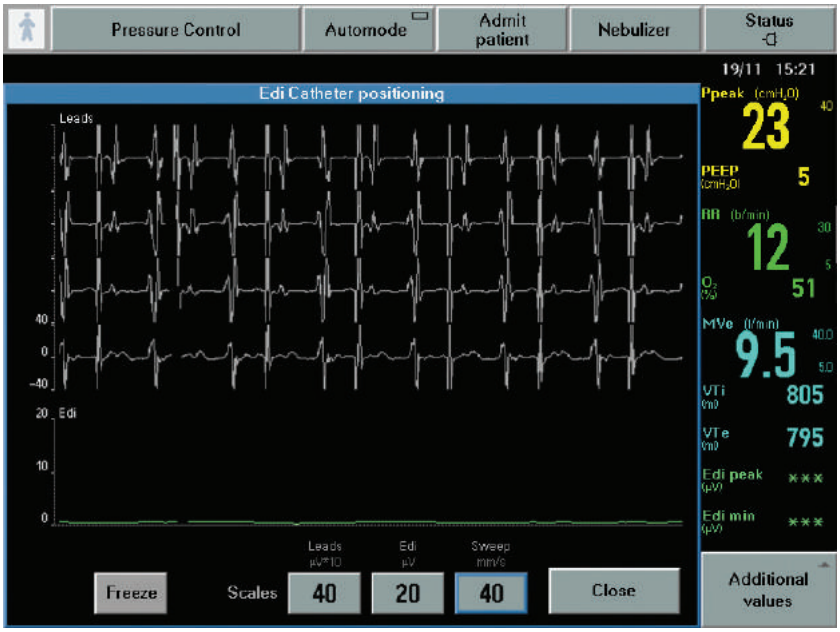
- PC above PEEP: 18 cmH_2O
- PEEP: 5 cmH_2O
- FiO_2: 0.5
- I:E 1:2
- Trigg. Flow 3

Insertion of the Edi Catheter

- NEX measurement: 56 cm
- Edi Catheter: 16 Fr
- Insertion length (nasal insertion): 56 x 0.9 + 18 = 68.4 approx. 68 cm

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

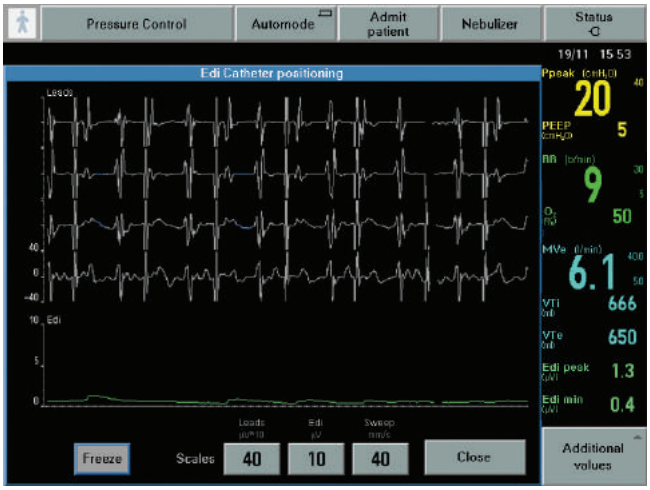
Edi Catheter positioning window



There is no Edi signal due to treatment with propofol (propofol has been observed to decrease the Edi signal). The dosage of propofol was somewhat decreased.

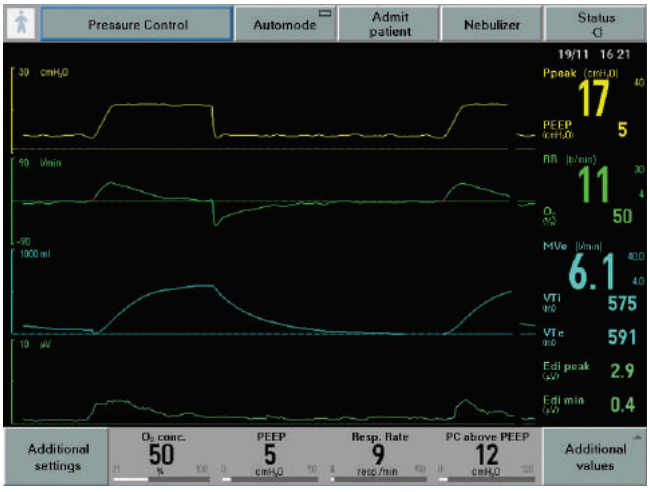
After 30 minutes

To optimize the insertion distance, NEX was re-measured and the insertion distance was re-calculated to 70 cm (instead of 68 cm).



The Edi signal is starting to be visible, but is still low. The dosage of propofol was decreased further.

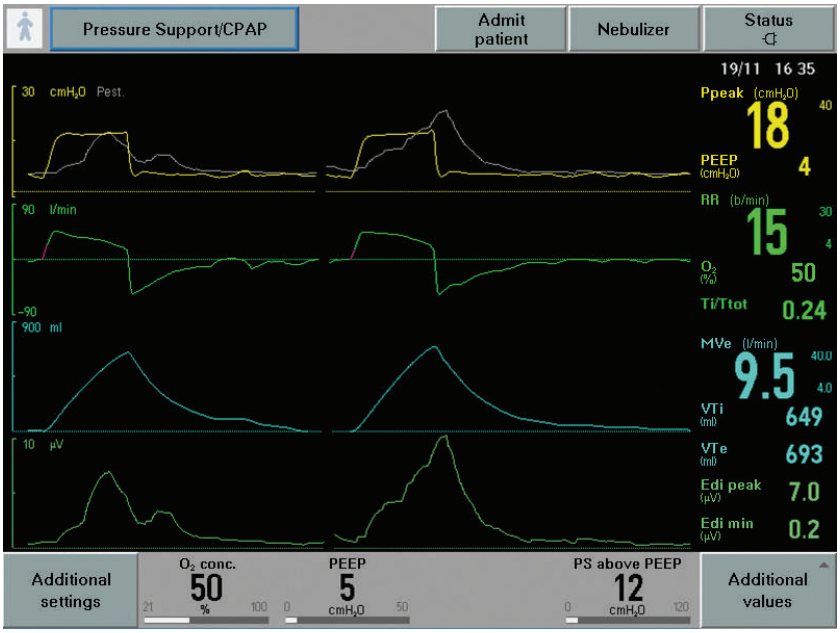
After 2 hours



The Edi signal is more visible.

After 2 hours, 15 minutes

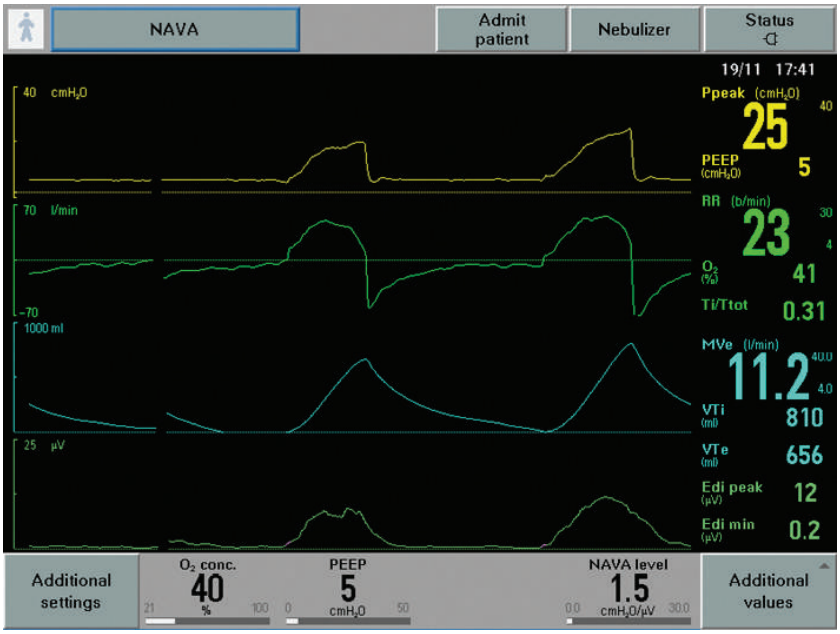
The patient is ventilated with Pressure Support.



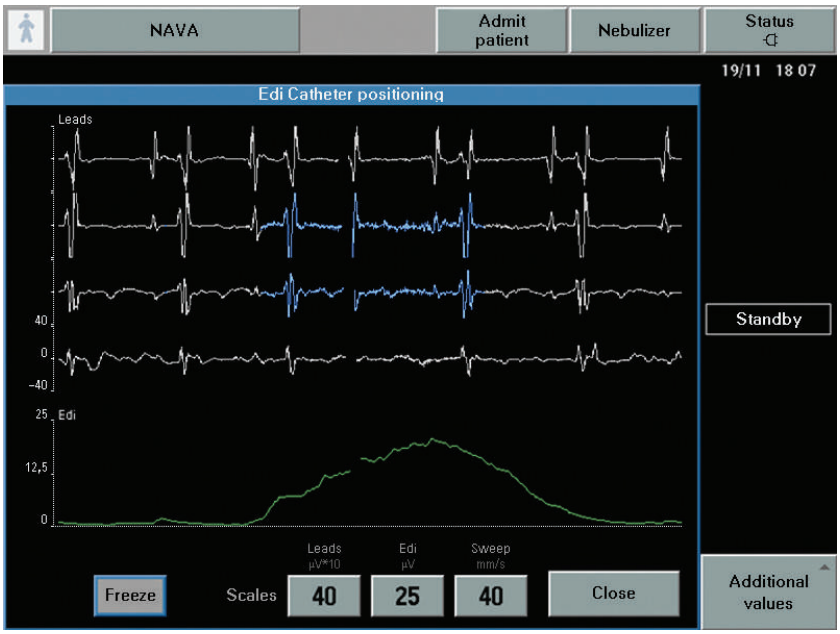
The Edi signal is increasing in the Pressure Support mode. The patient's Edi signal is suitable for NAVA.

Patient ventilated with NAVA

- NAVA level: 1.5 $cmH_2O/\mu V$
- PEEP: 5 cmH_2O
- O_2 conc: 40%



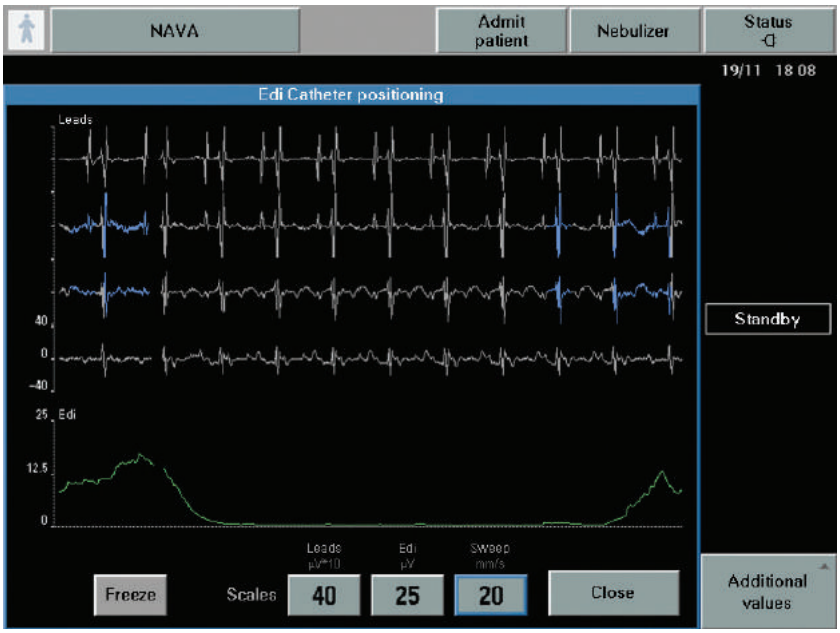
Monitoring of the Edi signal in Standby mode



The patient was disconnected from the SERVO-i. The monitoring of the Edi signal continued.

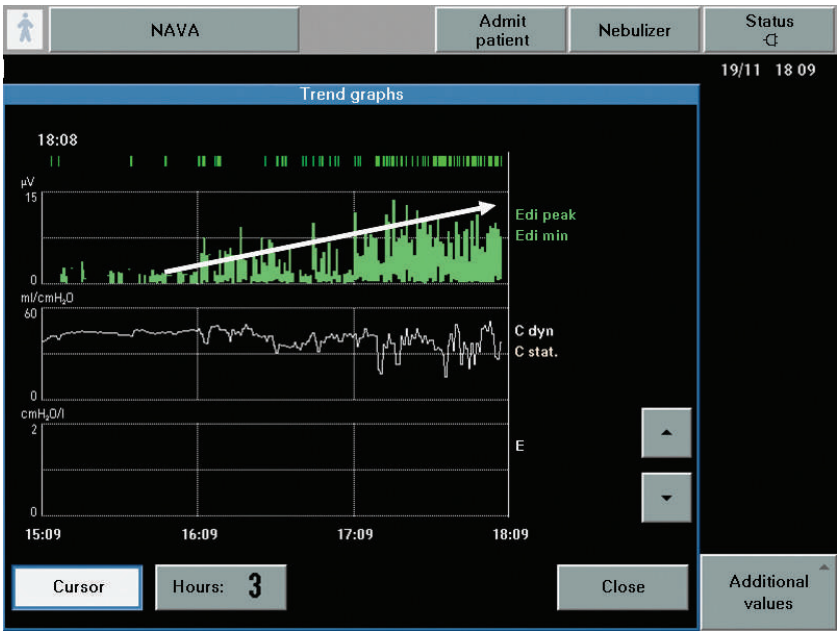
Patient is extubated

After extubation, the patient is breathing spontaneously. The Edi Catheter is still in place and the patient's Edi signal can be monitored.



Comment: The sweep speed in the two screen shots above is set to different values (20 and 40 respectively).

Edi signal trend



There is a clear trend showing an increasing Edi signal.

This case shows how important it is to measure the NEX distance carefully. Calculate the insertion distance and verify with the help of the Edi Catheter positioning window. This patient had no Edi signal at the outset, probably due to the effects of propofol. When the propofol dose was decreased, the Edi signal increased.

CASE 2

This case involves a COPD patient with severe bilateral pneumonia. The patient has been ventilated over a month. Weaning attempts have failed during that time.

- Male
- COPD / severe bilateral pneumonia
- Starting mode: Pressure Support

Pressure support ventilation

- PS above PEEP: 26 cmH_2O
- PEEP: 10 cmH_2O
- O2 concentration: 60%
- Tinsp rise: 0.15 sec
- Trigg flow: 2
- Insp. Cycle off: 30%

Back up ventilation

- PC above PEEP: 26 cmH_2O

Blood gases

- pH 7.45
- pCO_2 57
- HCO_3 39.6
- BE 13.9
- pO_2 86
- O_2 sat 98.2

Insertion of the Edi Catheter

- NEX measurement: 54 cm
- Edi Catheter: 16 Fr
- Insertion length (nasal insertion): 54 x 0.9 + 18 = 66.6 approx. 67 cm

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

- P waves and QRS waves are present in the top leads and the P waves disappear in the lower leads.
- The Edi signal is present, and leads 2 and 3 are highlighted in blue.
- No adjustment needed from calculated insertion length.

Settings in NAVA

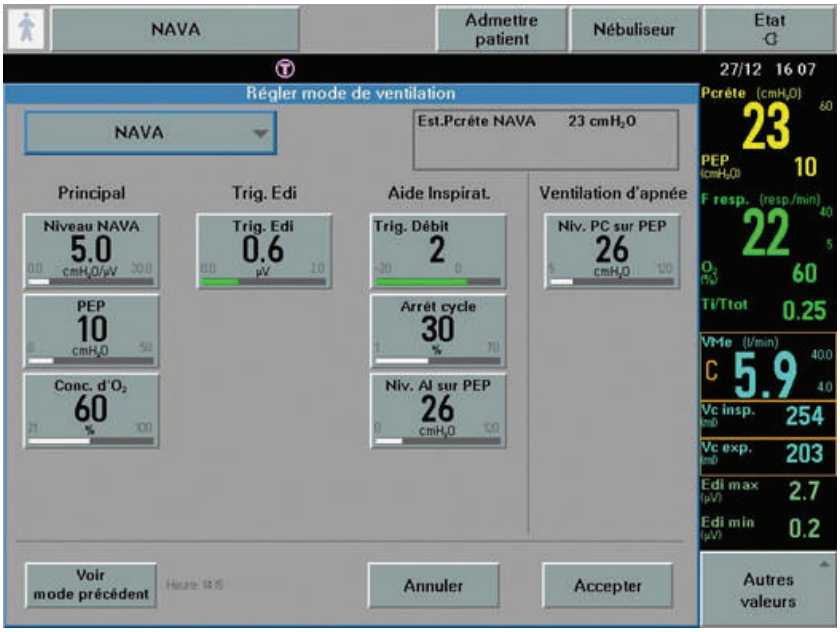
- NAVA level: 5 $cmH_2O/\mu V$
- PEEP: 10 cmH_2O
- O2 conc: 60%
- Trigg. Edi: 0.6 µV

NAVA Pressure Support

- Trigg. Flow 2
- Inspiration cycle off: 30%
- PS above PEEP: 26 cmH_2O

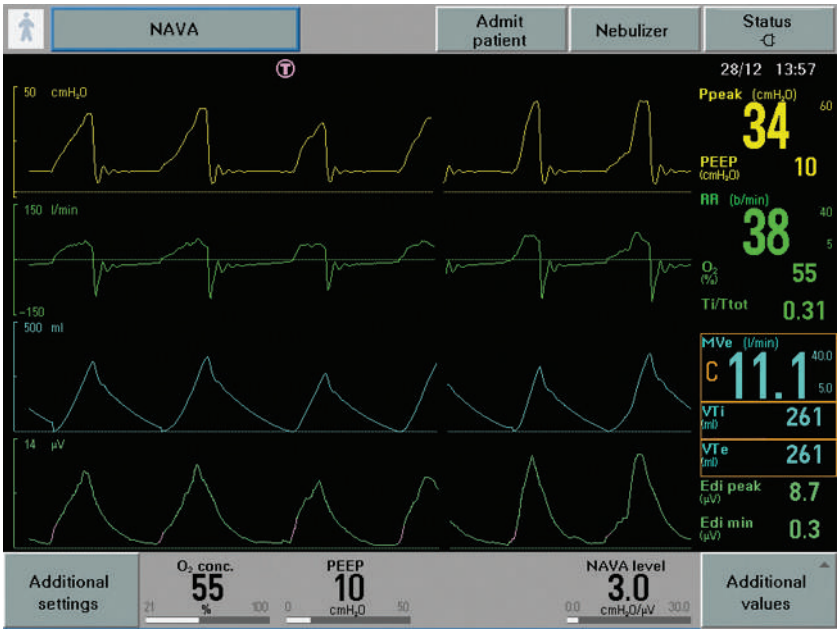
Backup ventilation

- PC above PEEP: 26 cmH_2O



Blood gases after 1 hour with NAVA

- pH 7.48
- pCO_2 48
- HCO_3 35.7
- BE 11.1
- pO_2 92
- O_2 sat 98.7

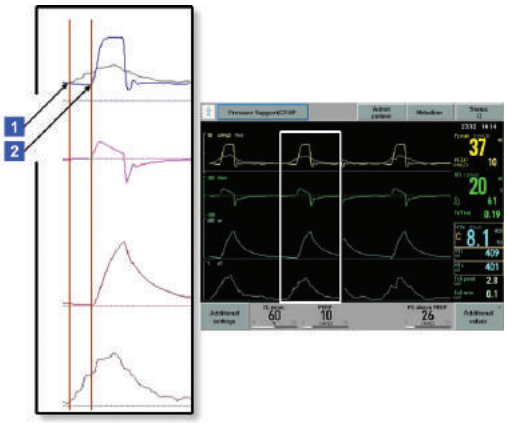


The NAVA level was decreased to 3.0 cmH_2O/ µV.

Discussion

1. Trigger for neurally initiated inspiration
2. Pneumatic mechanical inspiration

There is an inspiration delay as seen in the uppermost waveform where the Edi signal is superimposed on the pressure curve.

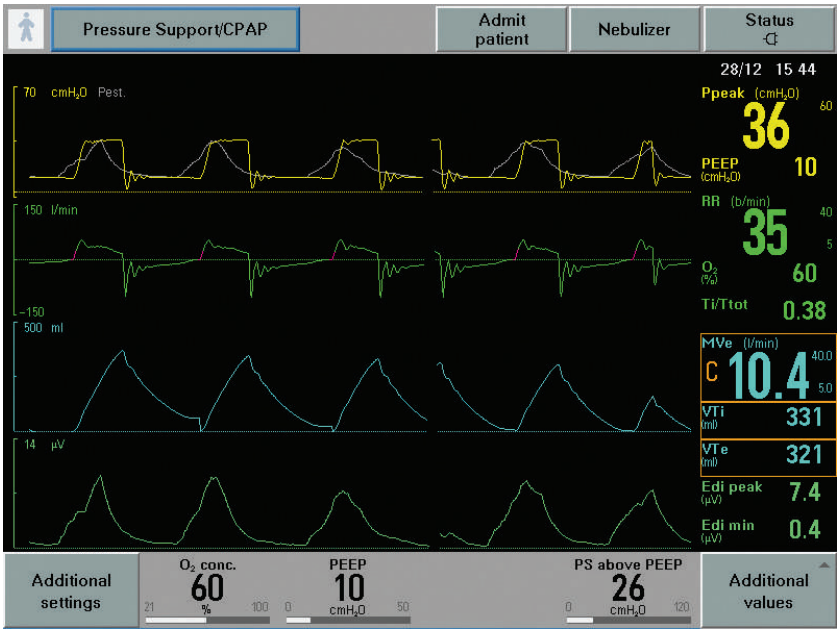


In this case and with these settings in Pressure Support ventilation (PS), the ventilator is triggered when the neural drive is high. Moreover, the pressure support level is high whereas the neural drive is low, and therefore maybe causing asynchrony between breath delivery and Edi signal.

Some of the possible reasons for increased asynchrony during PS with increasing levels of assist could be:

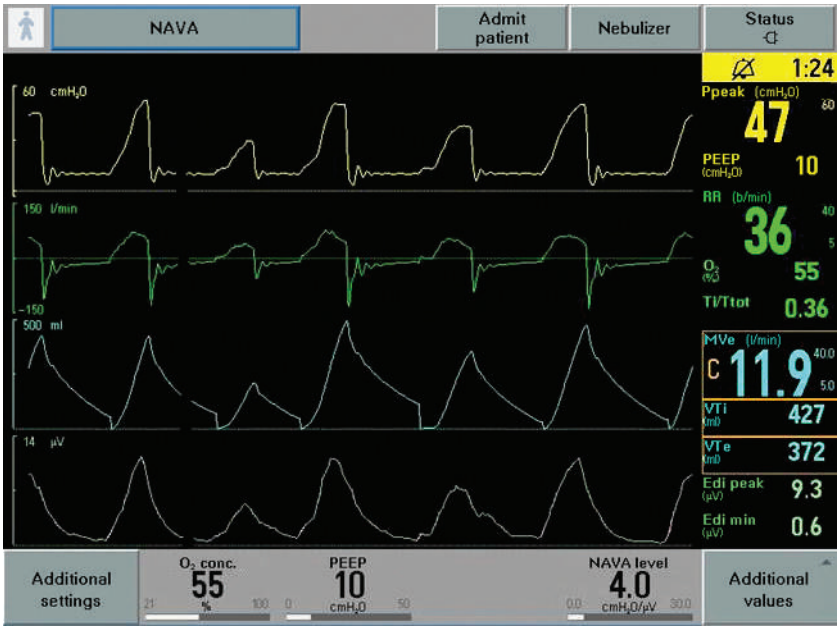
- reduced respiratory drive
- dynamic hyperinflation
- too high levels of assist.

The last option, too high a level of assist, could be verified by decreasing the PS level and observing whether the Edi signal increases and synchrony improves.



A frequent reason for over-assist during PS is the belief that a reduction in breathing frequency is a sign of clinical improvement. As part of the off-cycling algorithm for PS, an increase in PS level will ensure continued delivery of assist even during neural exhalation, thereby eliciting the Hering-Breuer reflex that prolongs exhalation and reduces the respiratory rate (Kondili E, Prinianakis G, Anastasaki M, et al. Acute effects of ventilator settings on respiratory motor output in patients with acute lung injury. Intensive Care Med 2001; 27: 1147-57).

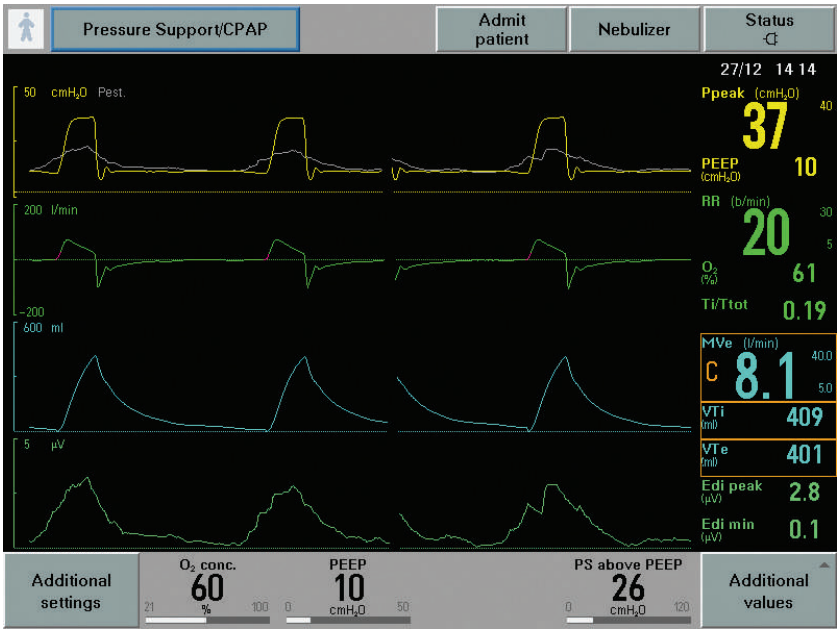
A reduction in breathing frequency with increasing PS level will thus give a false impression that the assist is actually helping the patient, whereas it may in fact only reflect the fact that the asynchronous assist elicits the Hering-Breuer reflex. The consequence is that the patient will probably be over-assisted, as may be the case in the patient discussed here.

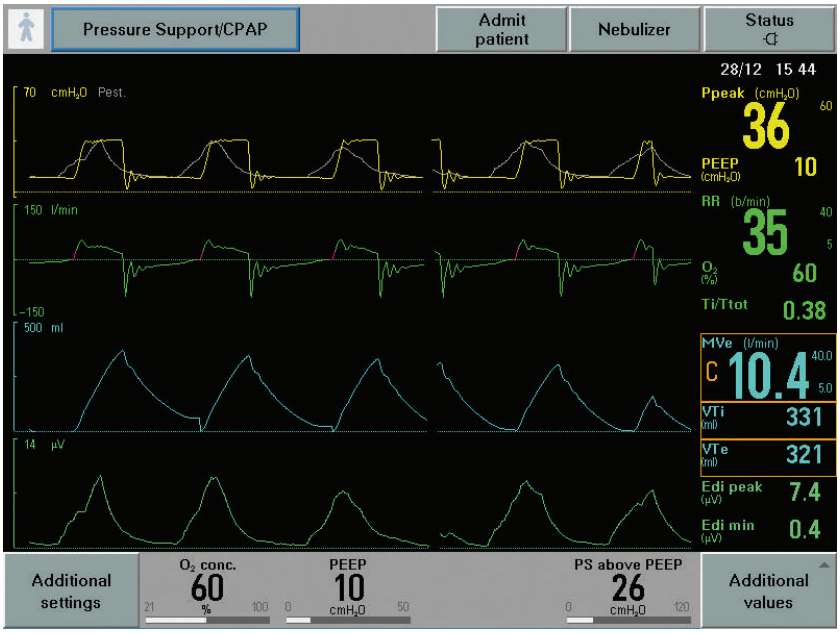


With regard to NAVA in this patient, breathing frequency is higher, since NAVA does not continue to deliver assist during neural exhalation. With regard to the high NAVA level (4-5 $cmH_2O/\mu V$) and relatively normal Edi level (5-10 µV), this suggest that the chosen NAVA level chosen might be too high. To facilitate weaning, one could try to reduce the NAVA level to see if the patient tolerates the lower assist delivered.

A typical response to a reduced NAVA level would be an increase, in Edi reflecting an increase in the patient's neural output to the diaphragm, which also determines the pressure generated by the diaphragm (Beck J, Sinderby C, Lindstrom L, and Grassino A. 1998. Effects of lung volume on diaphragm EMG signal strength during voluntary contractions. J Appl Physiol. 85:1123-1134).

This increase in Edi would also increase the pressure delivered by the ventilator, and partially compensate for the reduced NAVA level associated with all neural efforts. If ventilation and blood gases are still satisfactory, and the Edi signal trend does not indicate progressively increasing effort, and there is no progression of rapid and shallow breathing, this would suggest that the patient has tolerated the reduced NAVA level well.





A study of patient-ventilator synchrony reports that about 25 % of patients have a high incidence of asynchrony during mechanical ventilation. Such high incidence of asynchrony is associated with prolonged duration of mechanical ventilation, and patients whose inspiratory efforts are frequently unable to trigger the ventilator may receive excessive levels of ventilatory support (Thille AW, Rodriguez P, Cabello B, Lellouche F, and Brochard L. 2006. Patient-ventilator asynchrony during assisted mechanical ventilation. Intensive Care Med. 32:1515-1522).

CASE 3

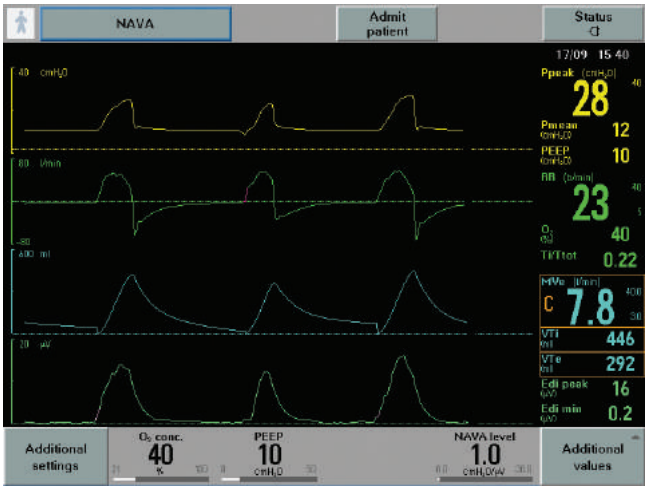
This case is a pneumonia patient who has been ventilated for more than a month. The patient is difficult to wean from the ventilator (2 attempts failed before NAVA use).

- Female
- Pneumonia
- NEX measurement: 42 cm
- Edi Catheter: 16 Fr
- Insertion length (nasal insertion): 42 x 0.9 + 18 = 55.8 approx. 56 cm

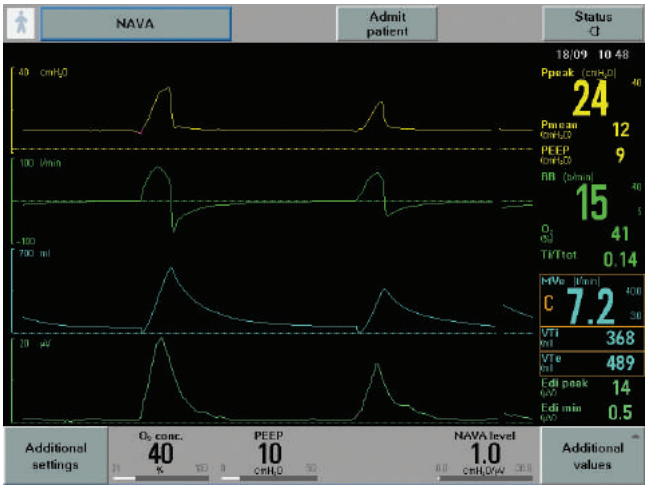
Insertion distance Y for nasal insertion	
Fr/cm	**Calculation of Y**
16 Fr	NEX cm x 0.9 + 18 = Y cm
12 Fr	NEX cm x 0.9 + 15 = Y cm
8 Fr 125 cm	NEX cm x 0.9 + 18 = Y cm
8 Fr 100 cm	NEX cm x 0.9 + 8 = Y cm
6 Fr 50 cm	NEX cm x 0.9 + 3.5 = Y cm
6 Fr 49 cm	NEX cm x 0.9 + 2.5 = Y cm

- NAVA level: 1.0 $cmH_2O/\mu V$
- PEEP: 10 cmH_2O
- O_2 conc: 40%

17th September



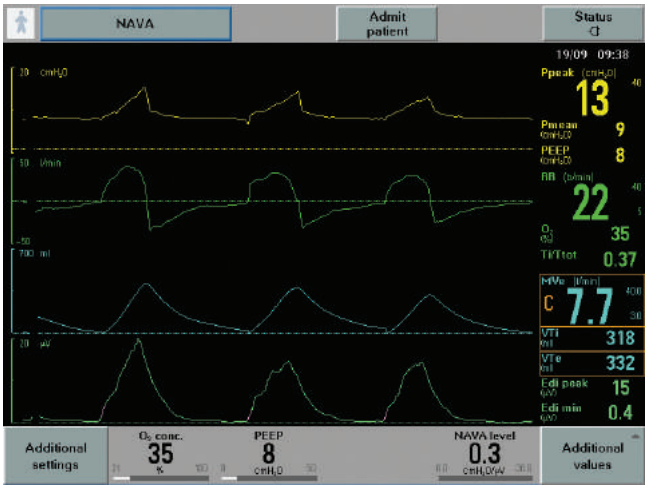
18th September



After 2 days in NAVA with a NAVA level of 1.0 $cmH_2O/\mu V$, the weaning started by slowly decreasing the NAVA level in steps of 0.1 $cmH_2O/\mu V$. PEEP and O_2 conc. was also decreased.

19th September

- NAVA level: 0.3 $cmH_2O/\mu V$
- PEEP: 8 cmH_2O



20th September

The patient was extubated. The Edi Catheter was kept in place so as to be able to monitor the Edi signal.

This patient was successfully weaned after three days with NAVA.

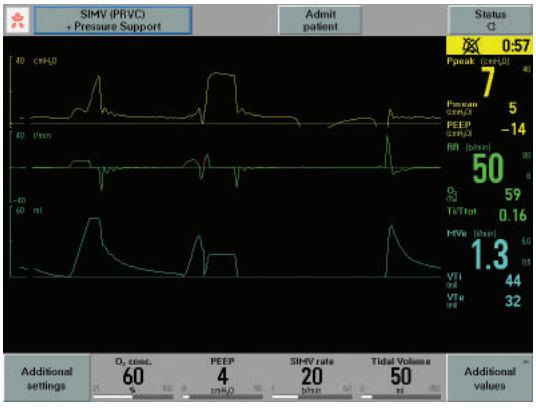
CASE 4

This case shows the benefit of Edi monitoring, also when the patient is not breathing in NAVA.

- Baby (male), 2.8 kg
- Transposition of the great arteries
- Edi Catheter: 8 Fr
- NEX measured: 16 cm
- Insertion length (nasal insertion): 16 x 0.9 + 8 = 22.4 approx. 22 cm

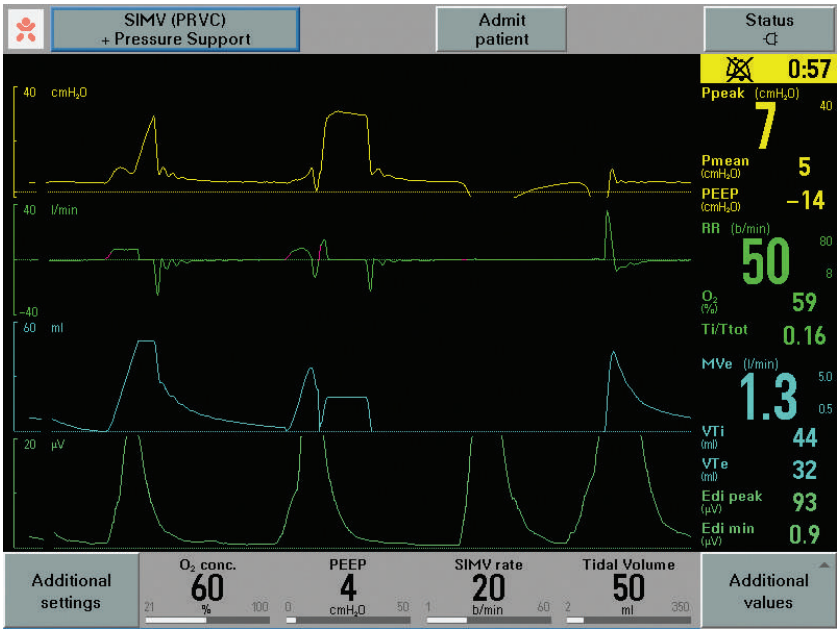
Insertion distance Y for nasal insertion	
Fr/cm	**Calculation of Y**
16 Fr	NEX cm x 0.9 + 18 = Y cm
12 Fr	NEX cm x 0.9 + 15 = Y cm
8 Fr 125 cm	NEX cm x 0.9 + 18 = Y cm
8 Fr 100 cm	NEX cm x 0.9 + 8 = Y cm
6 Fr 50 cm	NEX cm x 0.9 + 3.5 = Y cm
6 Fr 49 cm	NEX cm x 0.9 + 2.5 = Y cm

- NAVA level: 1.0 $cmH_2O/\mu V$
- PEEP: 10 cmH_2O



- Patient ventilated in SIMV (PRVC) + Pressure Support
- Blood gases are normal
- 3rd breath is an occlusion (Exp. Hold is pressed)

The picture indicates that there seems to be nothing remarkable about this patient.



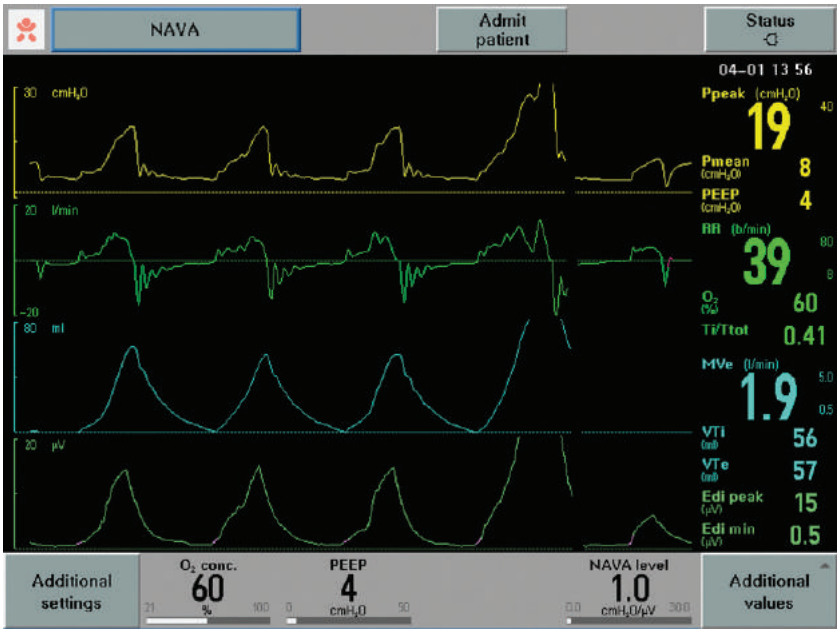
This picture is the same screen shot as on the previous page, but without the masking of the Edi signal. The high Edi signal indicates that the unloading provided by the ventilator is insufficient.

The patient is switched to NAVA.

Settings in NAVA

- Target pressure was chosen to correspond to the approximate settings in the previous mode.
- NAVA level: 1.0 $cmH_2O/\mu V$

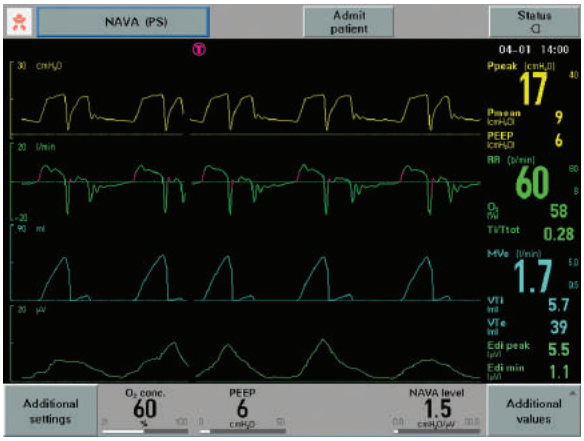
An immediate response can be seen in the Edi signal, which was considerably decreased.



Due to the presence of water in the patient circuit, which the SERVO-i interprets as asynchrony, the ventilator switched to NAVA (PS).

Autocycling?

In NAVA (PS), an initial interpretation of autocycling was incorrect. The pattern was actually due to premature cycle-off, i.e. the patient is still pulling when the SERVO-i cycles to expiration.



Intervention

Prolongation of the inspiratory time was achieved by decreasing the Insp. cycle off from 30% to 10%.

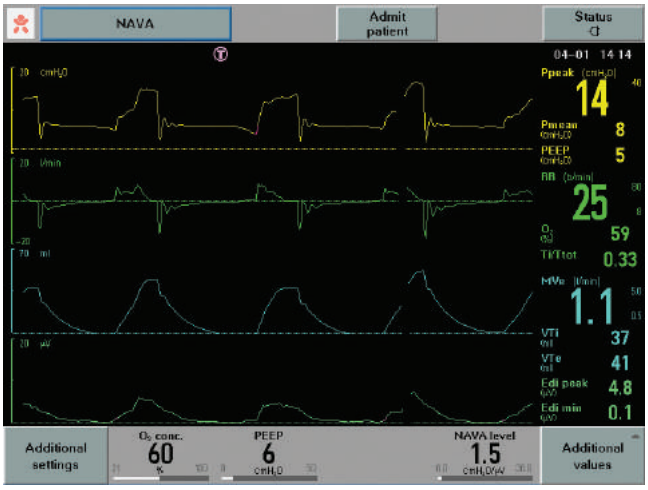
Note: Trigger is set to *Trigg. Pressure* -1 because of leakage.

Result of intervention

The patient circuit is emptied from water. Synchrony with NAVA (PS) is restored. Efficacy of breath delivery is much improved, which rendered the patient apneic.

NAVA synchrony restored

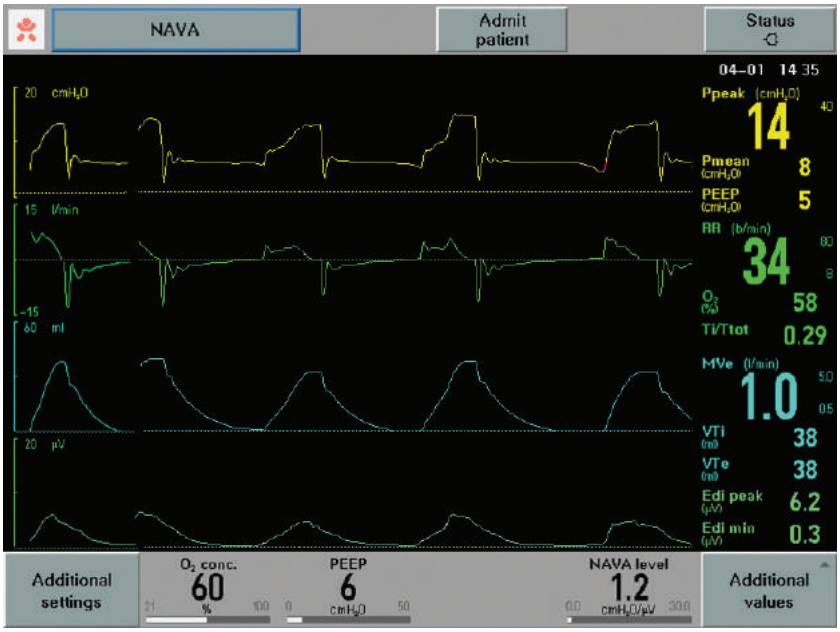
The SERVO-i switches back to NAVA. NAVA level is set to 1.5 $cmH_2O/\mu V$.



Synchrony is restored.

NAVA, 20 minutes later

NAVA level is decreased to 1.2 $cmH_2O/\mu V$.



The patient is ventilated for 2 days with NAVA and then extubated.

This case shows the benefits of monitoring the Edi signal even in other modes of ventilation, since it is then possible to finetune the ventilator settings.

4 EXERCISE KEY

4.1 ANSWERS TO NUMBERED QUESTIONS IN CHAPTER 1

1. **N**ose, **E**arlobe, **X**iphoid process
2. 50 x 0.9 + 18 = 63 cm
3. 56 x 0.8 + 18 = 62.8 ; Approx. = 63 cm
4. 20.5 x 0.9 + 8 = 26.45 ; Approx. = 26 cm
5. 1.2 µV
6. 1.5 x 9 + 4 = 17.5 ; Approx. = 18 cm
7. Between 24 and 25 cmH_2O
8. 24.8 cmH_2O
9. 23 cmH_2O
10. 23 cmH_2O
11. P waves are present in the top leads and disappear in the lower leads. The leads highlighted in blue are in the center (the second and third leads) where the Edi curve reaches its highest value.
12. 8 cmH_2O
13. In the picture, there is an inspiration delay in Pressure Support, which can be seen in the uppermost waveform where the Edi signal is superimposed on the pressure curve.
14. 18 cmH_2O
15. 12 µV
16. 0.3 µV
17. Neural triggering

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