Neurally Adjusted Ventilatory Assist (NAVA) in Neonates using Maquet SERVO-n - Clinical Guidelines

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INTRODUCTION

This guideline includes both Nursing & Medical management of NAVA.

Neurally Adjusted Ventilatory Assist (NAVA) is a mode of mechanical ventilation intended for use in spontaneously breathing patients. It delivers ventilation in synchrony with and in proportion to baby's efforts. The patient's own electrical diaphragmatic activity (Edi) waveform is used to trigger-on and cycle-off each assisted breath. The pressure delivered depends on the size of the Edi signal, thus providing well synchronized proportional assist ventilation. The Edi waveform is recorded with an "Edi catheter", a standard-sized naso- or orogastric feeding tube with miniaturized sensors embedded within. When correctly placed at the level of the gastroesophageal junction, the Edi signals are detected from the crural portion of the diaphragm.

1. AIM

To provide effective and appropriate non-invasive NAVA (NIV-NAVA) and invasive NAVA as respiratory support to newborns with respiratory insufficiency using SERVO-n ventilator.

2. PATIENT

- Neonates.

3. STAFF

- Medical and nursing staff.

4. EQUIPMENT

- Maquet SERVO-n 'NAVA' ventilator (refer to Maquet SERVO-n 'NAVA' ventilator setup protocol)

5. CLINICAL PRACTICE

In RHW NICU the SERVO-n ventilator (commonly known as NAVA) is used for the following purposes:

(a) Non-Invasive NAVA (NIV-NAVA)
(b) Invasive NAVA (infant is intubated)
(c) As an Edi monitoring tool

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The first step in using NAVA is the insertion of the Edi catheter
For Edi catheter insertion - refer to Maquet SERVO-n 'NAVA' ventilator setup protocol in the Nursing section.

Non-Invasive NAVA (NIV-NAVA) - using the SERVO-n:

In our NICU, we use NIV-NAVA for the following indications:

1. As a primary mode of support to avoid intubation and invasive ventilation
2. Post-extubation as a weaning mode from invasive ventilation
3. As an escalation mode from nasal CPAP (nCPAP) to avoid intubation
4. As nCPAP therapy with backup facility to treat apnoeas.

As with all ventilation it is important to manage the machine and the infant (particularly the cannula/mask interface) with skill to ensure effective ventilation is delivered.

1. Primary Mode of respiratory support
    - In theory NIV-NAVA can be used for this purpose at any gestational age.
    - In RHW NICU – since NIV-NAVA is a relatively new mode of respiratory support it is not used as the routine primary mode in neonates < 27 wks.
    - 27 wks and over –
        i. NIV-NAVA can be used as the primary mode.
        ii. Surfactant can be administered as Minimally Invasive Surfactant delivery Technique (MIST) while providing respiratory support with NIV-NAVA or High flow nasal cannula or nCPAP.
    - On arrival in the unit while transitioning from mask CPAP/IPPV and waiting for Edi catheter to be inserted/positioned the recommended settings are: PIP 16-18 cm H2O, PEEP 6-7 cm H2O, IT 0.35, backup rate 50, backup PC 10 cm H_2O above PEEP, apnoea time 2-3 seconds.
    - Once Edi catheter is positioned commence NAVA at 1.0-1.5 μV/cmH2O and titrate in 0.2 increments (see below on how to titrate to the most appropriate NAVA level). When NAVA is set at 1.5-2.0 check how much PIP is generated at that NAVA level.
    - Choosing the appropriate NAVA level: The concept of "breakpoint" (see Educational Notes) can also be used to determine the appropriate NAVA level for each baby.

2. Post-Extubation (Weaning from Invasive Ventilation)
    - Neonates of all gestational ages who have been intubated and ventilated are eligible.
    - Aim of NIV-NAVA in this scenario is to facilitate early extubation to synchronised non-invasive ventilation, prevent de-recruitment and avoid increased work of breathing and to provide back-up support for apnoeas. All these effects contribute to a reduced need for reintubation.
    - Note ventilator parameters on invasive mode prior to extubation, particularly tidal volume (Vt), peak inspiratory pressure (PIP), positive end expiratory pressure (PEEP), effort of breathing and frequency of apnoeas.
    - Place Edi catheter prior to extubation. This will allow the measurement of Edi peak and Edi min which in turn will guide and help determine the settings for NIV-NAVA.
    - Recommended RHW NICU NAVA level is 1.0-1.5, PEEP 6-7, IT 0.40, backup rate 50, backup PC 10 above PEEP, Apnoea time 2-3 seconds. Check how much PIP is generated at the set NAVA level. Local experience suggests a NAVA level that generates PIP of 16-18 cmH2O (Backup PC above PEEP of 10-12) usually provides adequate weaning support.

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3. Escalation mode from nCPAP therapy
    - Aim of NIV-NAVA in this scenario is to re-recruit the lungs, reduce the work of breathing and provide better non-invasive assistance to avoid intubation.
    - Our usual recommendation here is a higher initial NAVA level of 1.5-2.0, PEEP 6-7, IT 0.40, backup rate 50, backup PC 10 above PEEP, Apnoea time 2-3 seconds. Check how much PIP is generated at the set NAVA level. Our local experience suggests a NAVA level that generates PIP of 16-18 is usually a good level that provides adequate support.
4. nCPAP therapy but backup rate to treat apnoeas.
    - Some neonates only require nasal CPAP therapy for the respiratory support but continues to have frequent apnoeas that require further support (IPPV).
    - NIV-NAVA can be used in this scenario to deliver nCPAP but backup rate to treat apnoeas:
        1. Select NIV-NAVA mode on SERVO-n
        2. Set NAVA at zero, PEEP 6-7, IT 0.40, backup rate 50, backup PC 10 above PEEP, Apnoea time 2 seconds. With these settings, when the infant is breathing spontaneously, only nCPAP is delivered, but when the infant becomes apnoeic, backup ventilation is triggered after the apnoea time set.
    - **TIP: For nasal CPAP therapy, choose NIV-NAVA mode and set NAVA to zero. Do not choose nCPAP mode. If we choose nCPAP the SERVO-n ventilator will constantly alarm warning "leakage detected".**

Monitoring and optimisation of NIV-NAVA:

- Ensure Edi Catheter is well positioned. (Look for diminishing P and QRS waveforms on the ECG (see User Guide in Appendix 2 and Quick Check Guide) progressing from the 1st to the 4th waveform and the presence of a purple colour in the 2nd and 3rd waveforms (this may fluctuate to the 1st and 4th waveforms at times)
- Edi Catheter Malposition: (a) P waves on all lines and increasing P waves progressing from the 1st to 4th lead ⇒ push in; (b) No P and dampened QRS on all 4 ⇒ pull out; (c) Larger P and QRS on 1st and 4th waveforms —catheter curled – reinsert; (d) No signal—no resp. drive
- Nasally inserted Edi catheter is more secure and easier to look after in comparison to oral Edi catheter. A nasal Edi catheter is less likely to result in a change of position on the ECG leads. Our local experience suggests that nasal Edi catheter can be used with prongs and mask.
- Review regularly (at least every 3-6 hrs). Look at the efficiency of the seal with the baby's nose. Note the NAVA level and PIP and Edi's generated, infant's breathing effort, spontaneous respiratory rate, percentage back-up assist and any gaseous distension of abdomen. Regularly review Edi peak (normal 5-15 µV), Edi min (normal <3 µV) and percentage of backup assist. This is to avoid under or over-support. –
    1. If Edi peak is < 5 µV consistently, decrease the NAVA level.
    2. If Edi peak is > 20 µV consistently, increase the NAVA level.
    3. If desaturations & periods of apnoea are worsening do a blood gas and review the apnoea time. This may need to be decreased to < 2 sec.
- If FiO2 is increasing, work of breathing worsening and Edi peaks are increasing – All these indicate under-support. Increase the NAVA level in this scenario. Other changes can be: Increase in FiO2 and increase in PEEP may be needed if Edi min is high.

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- If Edi peak and Edi min are low, FiO2 is decreasing and work of breathing improving – decrease the NAVA level. Other changes can be reducing FiO2, reducing PEEP (if Edi min is low).
- Watch for any air trapping in the gut, particularly with size 6 Edi catheter. We often place another gastric tube into the stomach to vent the air out when size 6 Edi catheter is used.

Weaning from NIV-NAVA

- Once the NAVA is <0.5, FiO2 <0.3 and Edi peak <15 and Edi Min <3, infant can be transferred to nCPAP/High Flow therapy.
- Although some recommend daily weaning of NAVA, our experience suggests that, once the infant's respiratory distress improves, weaning of NAVA level can be quicker.

Invasive NAVA using SERVO-n Ventilator

1. SERVO-n ventilator can be used as the initial primary mode of invasive ventilatory assistance.
2. Various modes are available. (Refer to Appendix 2 for comparison of all 3 invasive modes detailed in this guide).
3. SERVO-n ventilator is a relatively new ventilator in our NICU and we recommend our staff to familiarise with only the following invasive modes:
   i. **NAVA ↔ PC mode**. Edi catheter needs to be in place to use this mode.
   ii. **PRVC (Pressure regulated volume control)** – Similar to PC-AC+VG on Draeger or SIPPV+VG. A preset tidal volume is delivered at a set rate but it is delivered at the lowest possible inspiratory pressure. PEEP and Ti are set. All breaths are synchronised with the baby's breath.
   iii. **PC (Pressure Control) -** A Controlled ventilator mode. This is similar to PC AC on Draeger. We set the inspiratory pressure above the PEEP in this mode (Total inspiratory pressure = Pressure (PC) above PEEP + PEEP). Respiratory rate set is the back-up rate.

a. NAVA ↔ PC mode

Sufficient respiratory effort is required if Invasive NAVA ventilation is to be used. The Edi catheter also needs to be in place for invasive NAVA ↔ PC ventilation. If the baby is not breathing adequately the ventilator goes into PC mode at the pressures & rate set. PC is synchronised ventilation similar to PC AC on Draeger.

(a) Setting the initial Invasive NAVA level:

Option 1. Set the NAVA level initially to 1 ($cmH_2O/\mu V$). Titrate in 0.2 increments according to the Edi peak Do this at 30 sec-1 min intervals OR if Edi peak is low titrate down below 1 to optimize the level of NAVA support as described below. A senior doctor (Consultant / Fellow) needs to be present for this titration. It would be expected to take around 10-15 min.

Option 2. Open the "neural access" menu on the ventilator and select "NAVA preview". Two pressure curves appear in the upper window: a yellow one, that represents the actual pressure delivery, and a grey one that provides an estimation of the pressure delivered (based on actual Edi and NAVA level) if the patient was switched to NAVA at this time. Adapt the NAVA level so that the estimated pressure curve (grey) resembles the actual pressure curve (yellow). If satisfactory, press "Accept". Press "NAVA" in "Select ventilation mode". The NAVA level that appears is based on the level selected in the preview window.

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(b) Setting the Backup PC rate and Pressures (Backup PC above PEEP & PEEP):

(i) Set the Backup PC rate at the rate you think appropriate (40-60/min for a premature infant starting Invasive NAVA and 40/min for a Term infant).

(ii) Set the maximum pressure that can be delivered. (we recommend starting at 10-15 cmH_2O above PEEP for Premature infants & 15 cmH_2O for Term infants) - the maximum alarm pressure that can be delivered before the ventilator terminates the breath is the (P peak) alarm.

(c) Optimizing the Invasive NAVA level:

Optimize the NAVA level according to Edi peak, which should be targeted between 5-15 µV. If Edi peak is consistently < 5 µV decrease the NAVA level. If Edi peak is consistently > 15 µV increase the NAVA level. It is best to assess the Edi levels when infants are settled.

The changes in NAVA level should be 0.1-0.2 cmH_2O/µV at a time. The changes in NAVA level are mediated in a few breaths to Edi peak. The usual NAVA level is 0.5–2.0 cmH_2O/µV.

(e) Setting and Optimizing PEEP:

Initially, we set the PEEP at 6.0. If Edi min is constantly > 3 µV (a sign of background tonic diaphragmatic activity to maintain FRC), you can increase PEEP to 7 or 8.

(f) Setting the Apnoea time:

Set the initial apnoea time at 2 seconds. If breathing is irregular and the patient unstable you may need to decrease apnoea time down to between 1-2 second. To get to < 2 sec you need to click on the safety scale + sign at the lower right of the apnoea time screen. At < 2 sec the apnoea time reduces by 0.2 sec at a time. (For calculation: 1.8 sec apnoea time = Back-up PC breaths of 33/min, 1.6 sec apnoea time = 38/min back-up PC breaths, 1.4 sec apnoea time = 43/min, 1.2 sec apnoea time = 50/min, 1 sec apnoea time = 60/min). It is important to make sure the backup ventilation does not hyperventilate the patient preventing spontaneous breathing efforts. Set Edi trigger to 0.5 µV and trigger sensitivity 1 to 2.

(g) Set Edi trigger to 0.5 µV and trigger sensitivity 1-2.

(h) Weaning patients from NAVA:

Decrease the NAVA level as the patient's pulmonary status improves. Usually, the patient is ready to be extubated when the NAVA level is < 0.5-1 cmH_2O/µV. In addition consider decreasing back up ventilation rate by increasing the apnoea time to allow increased frequency of spontaneous efforts. If this is tolerated clinically continue weaning NAVA level

Suggest leaving Edi catheter in place when extubating as Edi signal can be used as a guide as to WOB and the success of extubation at the settings tried.

ii. **PRVC mode:**

This mode is used for primary invasive assistance if the SERVO-n is used as the ventilator in acute situations (e.g. delivery suite, or admission into NICU of an intubated infant, while waiting for Edi catheter placement) – PRVC is the same (v.similar) to PC AC + VG on the Draeger.

<u>Initial PRVC settings are usually as follows</u>:

a. Baby with acute Respiratory Distress Syndrome – VG of 5ml/kg, PEEP 6, IT 0.35, rate 50-60, FiO_2 as necessary.

b. Term infant with no lung disease (e.g. intubated for surgery etc.) – VG 5ml/Kg, PEEP 6 cmH_2O, IT 0.40-0.45, rate 40, FiO_2 as necessary.

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iii. **PC (Pressure Control) mode:**

PC is similar to PC AC on the Draeger. It will synchronise with the infants efforts and deliver a set Pressure Control above PEEP. Titrate the pressure control above PEEP to achieve appropriate Vt (4-6ml/kg)

NURSING MANAGEMENT OF NIV-NAVA:

Nursing management of Invasive NAVA follows this section

1. Edi catheter management:

- Before an Edi catheter is passed use the calculation tool to assess size and length of tube and the length it should be passed to. To find this on the screen touch NAVA and then Calculation tool. Work through the steps on the screen. Correct placement means the purple Edi signal is sitting in the middle portion of the Edi positioning chart. This can be found on the screen by touching NAVA then Edi Catheter positioning (see below Appendix 2).
- If the purple signal is in the bottom portion of the screen this means the catheter is too HIGH. If it is at the top then too LOW. The arrow next to the chart will indicate the movement that needs to occur. If the Edi needs to move down then the arrow will indicate as so, vice versa for up (see below Appendix 2)
- Catheters should be changed fortnightly (Nursing rationale 6)

2. Airway management:
   PRN oral and nasal suctioning may be required. Use a short 10fr suction catheter for this. Document all suction. (rationale 1)

3. Ventilation on NIV-NAVA:
   a. Check settings at the beginning of the shift and ensure they match those documented. Assess whether infant is adequately ventilated and that you understand the method being used. If you do not then seek advice/assistance from senior nursing staff, team leader, medical team or the education team. (rationale 2)
   b. Ensure equipment is correctly sized for the infant (rationale 3). Head circumference should be measured when hat is first applied and then checked every shift. Hats may stretch and need to be replaced over time. Hats should fit comfortably over the infants head without leaving pressure marks or excessive gaping. Hat should sit over the ears, round the back of the head and just above the eyebrows. Snorkel sizes also vary. (<1kg=50mm, <2kg= 70mm, >2kg =100mm). Ensure you have the correct one and that it is secured to the hat using the blue and red Velcro grip. Ensure the correct size mask or prongs have been selected. They should provide an adequate seal over the nose/nostrils without causing pressure sores or excessive leak. Prongs must fit snugly in the nostril without going up and inside the nostril. Nose should also not blanch when prongs are in. Strap the prongs/mask low onto the face using the two side straps and Velcro applicators. As a guide aim to Velcro them over the ears. You may need more or less grey foam under the snorkel to achieve an adequate seal. All equipment sizing should be documented on bedside charts.
   c. Consider the need for blood gas analysis (rationale 4). Blood gases are performed PRN. They are more common on patients that are unstable and may be required when ventilation changes have been made.
   d. Change the disposable filter 48 hourly.
   e. Wipe down equipment with a neutral detergent daily (rationale 5).
   f. Circuit should be changed weekly.
   g. Internal expiratory block only needs to be changed at the end of treatment when it has been used on an infected patient (eg. MRSA, Serratia, RSV). At all other times it can be reused as long as the additional disposable filter has been in situ for the duration of the treatment.

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4. Nursing Observations on NIV-NAVA
   All infants on NIV-NAVA should be on continuous monitoring for saturations and ECG. These should be recorded on the observation chart hourly. Record FiO2, Pressures, Volumes, NAVA level, % leak (if high check interface), Edi peak and Edi min hourly. Four hourly blood pressures are a minimum requirement for all ICU-level 3 infants (rationale 7).

5. Troubleshooting
   For troubleshooting on NIV-NAVA (see Appendix 2: User Guide)

6. Pain and Comfort
   Ensure infant is comfortable: Non-pharmacological (non-nutritive sucking, sucrose, comfort holding and nesting) or pharmacological (Morphine, Fentanyl, Midazolam). Kangaroo care should be encouraged. Position the baby with the tubing in a position where it will not drag off the face and observe for pressure sores.

7. Cares
   Cares can be conducted in the normal way using individual assessment, 6 hrly for infants >1.2kg, 8 hrly for infants <1.2kg. Turn patient 4-6 hrly and resite skin probes 4-6 hrly regardless of care regularity. Observe for signs of skin breakdown from pressure sores.

RATIONALES for Nursing management (NIV-NAVA)

Rationale 1	To ensure clear airway at all times - using smallest bore catheter possible helps to minimise trauma to mucosal areas.
Rationale 2	As a standard safety check and for the purposes of nursing observation.
Rationale 3	To optimise seal and ventilation delivery and to maintain patient comfort.
Rationale 4	As a form of patient assessment
Rationale 5	In accordance with infection control protocols
Rationale 6	To prevent infections.
Rationale 7	To observe and record patients physiological status

NURSING MANAGEMENT OF INVASIVE NAVA:

1. Edi catheter management:
- Refer to previous page: Edi catheter management - NIV-NAVA.

2. Airway management
   a. ETT:
      i. Ensure the ETT is patent at all times. Suction using inline suction PRN using the guide in the table below. Keep spare suction catheters near to the baby also in case of inline suction failure. As a guide the suction catheter size should be twice that of the ETT size (eg. Size 3.0mm ETT= 6Fr suction catheter). Use short 10Fr suction catheters to suction the mouth and nose (rationale 1). All secretions should be documented on the observation chart including amount, viscosity, colour and smell (rationale 2)

ETT SIZE	INSERTION DEPTH
2.0mm	Green 16cm
2.5mm	Purple 17cm
3.0mm	Double Red 20cm
3.5mm	Double Yellow 22cm
4.0mm	Double Black 23cm

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ii. Ensure ETT is secure at all times. Check taping is secure and re-tape PRN with the help of another nurse and the knowledge of the medical team. Check tube placement at the beginning of your shift and with each turn/movement of the patient. Also check as part of troubleshooting.
To calculate correct ETT length use the formula below.
Oral ETT: Weight +6cm, **Nasal ETT**: Weight +7cm.
Or use the following "Neonatology Calculator" link on our NCC website:
http://www.seslhd.health.nsw.gov.au/RHW/Newborn_Care/useful_links.asp
Measure tube length in relation to the documented length on the observation chart using a tape measure (rationale 3)

b. Chest X-Ray: All patients receiving invasive ventilation via an ET Tube should have a chest x-ray taken post intubation. ETT should be positioned between T1 and T3. Chest x-ray may then be used PRN and is not done routinely in this unit (rationale 4).
c. Air entry: Chest should be auscultated a minimum of four hourly, with suctioning and/or following any movement (rationale 5).
d. The term 'DOPE' can be used to troubleshoot ETT problems.
D=Displacement, O= Obstruction, P= Pneumothorax, E= Equipment failure.

3. Ventilation
   a. Check ventilation settings at the beginning of the shift and ensure they match those documented. Assess whether patient is adequately ventilated and that you understand the method being used. If you do not, seek advice/assistance from senior nursing staff, team leader, medical team or the education team (rationale 6).
   b. Consider the need for blood gas analysis. All ventilated patients generally require one blood gas analysis per shift and more may be taken if patient is unstable or ventilation changes have been made (rationale 7). However in stable neonates on the ventilator, medical staff may decide to take blood gases less frequently.
   c. Ensure patient comfort using analgesia, nesting, comfort holding, non-nutritive sucking and/or sucrose.
   d. Change the disposable filter every 48 hours.
   e. Wipe down daily with neutral detergent.
   f. Change the circuit weekly.
   g. Internal expiratory block only needs to be changed at the end of treatment when it has been used on an infected patient (eg. MRSA, Serratia, RSV). At all other times it can be reused as long as the additional disposable filter has been in situ for the duration of the treatment (rationale 8).

4. Nursing Observations
   All ventilated patients should be on continuous monitoring for saturations and ECG. These should be recorded on the observation chart hourly. Record FiO2, Pressures, Volumes, % leak, NAVA level, EDi peak and EDi min hourly. Four hourly blood pressures are a minimum requirement for all ventilated patients (rationale 10).

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5. Troubleshooting

Problem/ Alarm	Response
Edi Catheter won't aspirate	Aspirating the Edi catheter may collapse the bore and this may be why no aspirate is obtained. They are, however, designed to be aspirated and so gentle adjustment should allow aspiration in the case of aspirate measurement. Positioning for all other feeds and gastric medication administration can be determined using the Edi catheter positioning screen.
Edi Catheter blocked	Due to the addition of an electrical wire/probe the EDi catheter has a smaller diameter lumen than the usual NG tube. This means that it can become blocked by thick viscous medications or thickened feeds. In this case it may be necessary to pass a second NG/OGT for the administration of these products.
Excessive leak	A leak of up to 60% is compensated for by the machine to 100% effectiveness. A leak up to 80% is compensated for by the machine up to 50% effectiveness. Leaks >80% cannot be guaranteed to deliver effective ventilation in invasive modes.
No patient effort	Ensure Edi is correctly positioned, if so then patient may be apnoeic in which case the backup rate will begin. Consider reducing the apnoea time if patient is not adequately supported in back up mode.
Gaseous Distension	Because of smaller lumen and difficulty in aspiration, there may often be air trapping in the gut. In this case, it may be necessary to pass a second NG/OGT for aspiration of gas and gastric contents

6. Pain and Comfort

   Ensure patient is comfortable. Non-pharmacological (non-nutritive sucking, sucrose, comfort holding and nesting) or pharmacological (morphine, fentanyl, midazolam). Kangaroo care should be encouraged for ventilated babies.

7. Cares

   Cares can be conducted in the normal way using individual assessment, 6 hourly for infants >1.2kg, 8 hourly for infants <1.2kg. Turn patient 4-6 hourly and resite skin probes 4-6 hourly regardless of care regularity. Observe for signs of skin breakdown from pressure sores.

8. Weighing and Procedures

   Patients can still be weighed whilst ventilated either on the giraffe internal scales or the outside scales. Procedures can still be conducted in the crib. Both need to take care to ensure a stable and secure airway and need to be assessed on an individual basis.

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9. **RATIONALES for Nursing Management (Invasive NAVA)**

Rationale 1	To maintain airway patency & to minimise trauma to the mucosal areas.
Rationale 2	To observe for respiratory infections
Rationale 3	To prevent accidental extubation.
Rationale 4	To ensure correct tube positioning & chest expansion whilst not exposing patient to excessive radiation.
Rationale 5	To suction PRN and observe for dislodgement of secretions or ETT
Rationale 6	As a standard safety check & for purposes of nursing observation
Rationale 7	To ensure adequate ventilatory support
Rationale 8	In accordance with infection control protocol
Rationale 9	To prevent infections.
Rationale 10	To observe and record patients physiological status

6. CONTRAINDICATIONS FOR NAVA

- **MRI scanning (remember to remove and reserve Edi catheter before entering MRI area)**
- Insufficient/absent respiratory effort (brain anomaly, medication)
- **Anomaly (oesophageal atresia, severe diaphragmatic hernia)**
- Phrenic nerve injury
- Congenital myopathy

7. DOCUMENTATION

- Integrated Clinical Notes
- Observation Chart

8. EDUCATIONAL NOTES

- Conventional ventilators use either flow or pressure changes to initiate and synchronise assisted breaths. NAVA is a new mode of respiratory support in which positive pressure is triggered by the electrical activity of the diaphragm (Edi). In other words, NAVA bypasses ventilator circuits and airways, guiding the support of each breath on the electrical activity of the diaphragm. NAVA in neonates results in less delay in delivery of the breath and has been shown to improve patient-ventilator synchrony, even with large leaks as it depends on the diaphragm activity not on any flow measurement. Small preliminary studies have shown that NAVA can be successfully used in term and preterm infants, being safe and well tolerated with no increase in intraventricular haemorrhage, pneumothorax or necrotising enterocolitis. Details of the clinical studies are given below.
- In NAVA, ventilator assists the spontaneous breath of the patient by delivering pressure directly and linearly proportional to the Edi (PIP delivered (cm H_2O) = NAVA level x Edi peak-Edi min (µV) + PEEP set). The peak inspiratory pressure (PIP) delivered is then proportional to the neural respiratory drive. Inspiration (pressure delivery) is maintained until the electrical activity decreases by 30% of the peak pressure generated and the breath is then terminated.(Stein 2014)
- In NAVA, patient determines inspiratory pressure (or volume), inspiratory and expiratory time, and respiratory rate for each breath.(Stein 2014)

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EDUCATIONAL NOTES cont'd

- NAVA Terminology
  - 'Edi' is the electrical activity of the diaphragm and can be thought of as a respiratory vital sign. The electrical nerve signal from the muscle action potentials in the crural part of the diaphragm are summated, filtered and processed to give the Edi signal. It is measured in microvolts (µV).
  - Edi peak: The highest Edi value of the waveform. It represents the maximal electrical activity of the diaphragm for a particular breath and is responsible for the size and duration of the breath (the "effort of the breath").
  - Edi min: The lowest Edi. It represents the electrical activity of the diaphragm between inspiratory efforts = baseline. It represents the spontaneous background tonic activity of the diaphragm which prevents de-recruitment of alveoli during expiration (similar to PEEP or CPAP though the machines generate that).
  - Edi trigger (in µV): It is the minimum increase in electrical activity from the previous trough that triggers the ventilator to recognize the increase in electrical activity as a breath, not just baseline noise. It is generally set at 0.5. When the ventilator is being triggered the Edi trigger is seen as a white line on the Edi trace.
  - NAVA level: NAVA level is a conversion factor that converts the Edi signal into a proportional pressure. The units of the NAVA level are cmH2O/mV. The Edi is multiplied by this NAVA level to determine airway pressure (PIP) delivered by the ventilator for each breath. The peak pressure is determined on an ongoing basis every 60 msec, and continues to increase as long as the instantaneous Edi increases, as determined by the formula:
    Peak pressure = NAVA level x Edi (peak – min) + PEEP.

- The respiratory centre in the brainstem sends a message to the diaphragm via the phrenic nerves to activate the diaphragm during spontaneous breathing. The electrodes embedded in the Edi catheter detect the electrical activity of the diaphragm and transmit the signal via the wires in the nasogastric tube to the ventilator (neural trigger). The ventilator assists the spontaneous breath of the patient by delivering pressure directly and linearly proportional to the Edi. The peak inspiratory pressure (PIP) delivered is then proportional to the neural respiratory drive. Inspiration (pressure delivery) is maintained until the electrical activity decreases by 30% of the peak pressure generated and the breath is then terminated. When using the Edi to control all aspects of the ventilator breath, the patient determines inspiratory pressure (or volume), inspiratory and expiratory time, and respiratory rate for each breath (Stein 2014).

- The Edi waveform is a measure of the baby's neural respiratory drive. Compared to adult patients, the Edi waveform in neonates has highly variable phasic Edi and a positive "tonic" Edi. The Edi waveform in adults is generally less variable with minimal tonic Edi. There are also "sighs" (i.e. recruiting breaths) in the in the neonate breathing pattern (Stein 2016).

Neurally Adjusted Ventilatory Assist (NAVA) in Neonates using Maquet SERVO-n - Clinical Guidelines cont'd

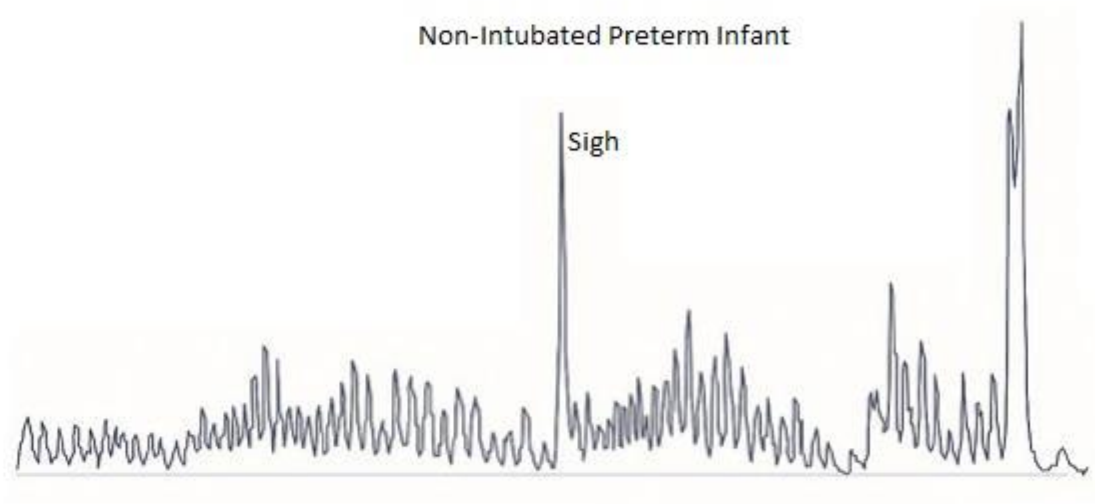
EDUCATIONAL NOTES cont'd

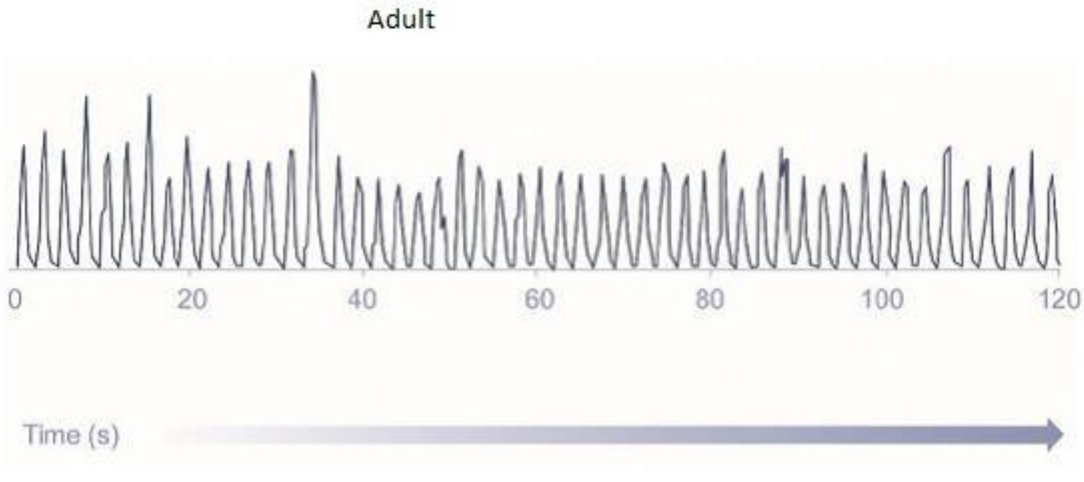
Differences between Conventional & NAVA Ventilation
(ie: Draeger PC AC/SERVO-n PRVC vs NAVA- PC/NIV-NAVA)

Conventional Ventilation	NAVA Ventilation
Infant Controls ventilator using Flow Trigger:	Infant Controls ventilator using Neural Diaphragm (Edi) Trigger:
Infant controls: • Initiation of breath • Rate (if above back-up rate set)	**Infant controls:** • Initiation of breath • Rate • Inspiratory Time √ • Peak Pressure √ • Termination of breath √
Ventilator controls: • PEEP • FiO2 • Peak Pressure or Tidal Volume • Insp Time • Minimum rate • Breath termination	**Ventilator controls:** • PEEP • FiO2 • NAVA level
Synchrony • Initiation of breath	**Synchrony** • Initiation of breath • Size of Breath √ • Termination of breath √

Neurally Adjusted Ventilatory Assist (NAVA) in Neonates using Maquet SERVO-n - Clinical Guidelines cont'd

EDUCATIONAL NOTES cont'd

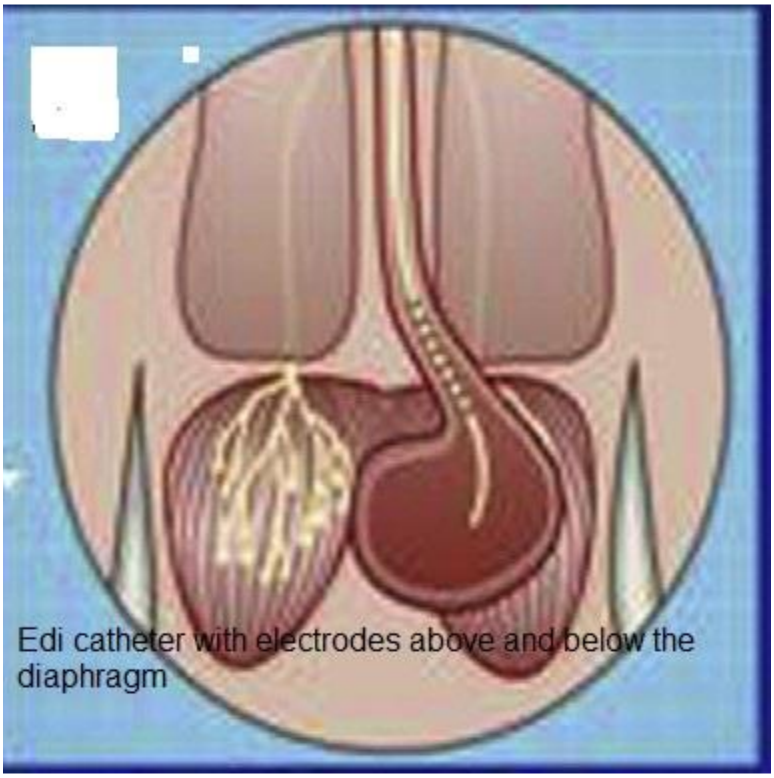




- Initial placement of the Edi catheter is determined by the standard nose-ear-xiphoid distance. The position can then be verified and adjusted using the retrocardiac electrocardiography (ECG) on the screen. Correct nasogastric catheter position is demonstrated by the largest p-waves and QRS complexes in the upper leads and subsequently progressing to minimal or absent p-waves and QRS complexes in the lower leads. The Edi signal is superimposed on the retrocardiac ECG as a purple colour on the second and third lead but may periodically fluctuate to the upper and lower leads without loss of signal integrity (Stein 2014).

Neurally Adjusted Ventilatory Assist (NAVA) in Neonates using Maquet SERVO-n - Clinical Guidelines cont'd

EDUCATIONAL NOTES cont'd



- **Normal Edi signals:**
  - The availability of normative data in both term and preterm neonates gives the clinician an Edi goal to work toward when determining the optimal ventilator support using either NAVA or conventional ventilation. If the Edi values are higher than normal, clinicians may want to consider increasing ventilatory support, and, if the Edi values are lower than normal, reducing ventilatory support.
  - Stein et al. (Stein 2012) quantified Edi peak and min values in 3 non-ventilated, spontaneously breathing term neonates. Edi peak was 11±5 and Edi min was 3±2 mV. Edi peak was higher while awake than during sleep and lower in the postprandial state than preprandial and feeding states. Edi min was higher while awake than during sleep, but was not different among feeding states. There was no decrease or deterioration in the Edi signal during feeding, suggesting that there is no electrical interference from milk coating the esophagus or catheter. Although these are the first Edi values reported in healthy neonates, the study is limited by the small sample size.
  - Stein et al. (Stein 2013) also quantified Edi peak and minimum values in non-ventilated neonates <33 weeks of gestation. Data were collected weekly using an Edi catheter placed in neonates on high flow nasal cannula (HFNC), nasal cannula (NC) or room air (RA). Seventeen neonates were enrolled at 26-33 weeks of postmenstrual age and studied from 1 to 10 weeks in duration. Overall Edi peak was 10.8±3.7 mV and Edi min was 2.8±1.1 mV. There were no differences in Edi peak and min between High Flow, nasal cannula or room air or by weight.

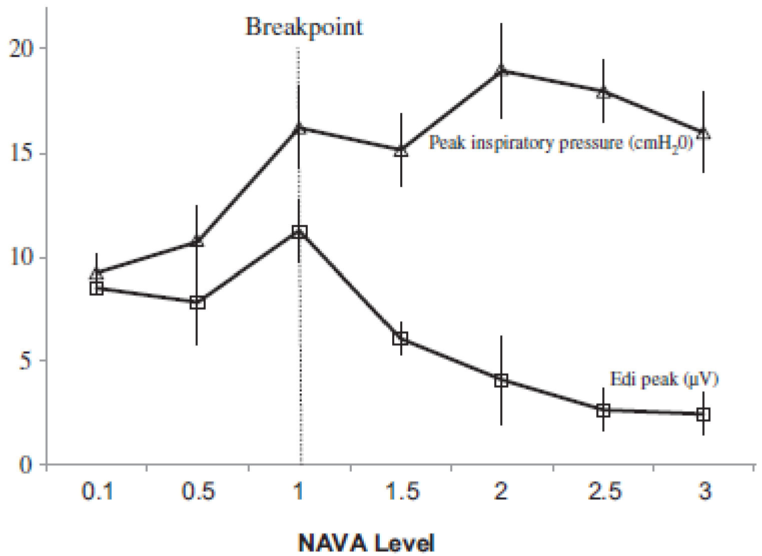
Neurally Adjusted Ventilatory Assist (NAVA) in Neonates using Maquet SERVO-n - Clinical Guidelines cont'd

EDUCATIONAL NOTES cont'd

- **Using NAVA to unload the respiratory muscles:**
  When the respiratory muscles are unable to maintain adequate ventilation and oxygenation in certain disease states, partially or totally transferring workload from the respiratory muscles to the ventilator may be advantageous. The inspiratory muscle workload is lessened and the respiratory drive is reduced as ventilatory assist increases. This is reflected by a lower Edi. If the NAVA level is increased, the workload is shifted from the patient to the ventilator. Even at the highest NAVA levels, when the ventilator assumes most of the work of breathing, the Edi continues to direct ventilation.

- **Determining the appropriate NAVA level:**
  The Edi, in conjunction with the NAVA level, controls the NAVA ventilator support. However, unlike pressure or volume-targeted modes, the delivered pressure during NAVA is continually adjusted based on the neural feedback from the respiratory centers. As the NAVA level is increased, the patient either maintains the Edi signal at the current level, resulting in increased delivered inspiratory pressure, or the patient decreases the Edi signal to maintain the same inspiratory pressure. Systematically increasing the NAVA level starts to unload the respiratory muscles and is followed by an initial increase in inspiratory pressure (PIP), (and mean airway pressure (MAP), and tidal volume (vT) in Invasive NAVA), while Edi remains constant. This is termed the first response, where respiratory muscles are insufficiently unloaded. When the NAVA level is further increased and reaches a **'breakpoint'(BrP)**, respiratory muscle unloading becomes sufficient, and the Edi signal will start to decrease (i.e. respiratory drive is decreasing), and the inspiratory pressure will reach a plateau despite a further increase of the NAVA level. The breakpoint (BrP) appears to be a unique value in each individual. In adults, this systematic approach to setting the NAVA levels offers a method to determine an appropriate assist level that results in sustained respiratory muscle unloading. Above a certain support level, the Edi signal becomes erratic, indicating over-assistance. The NAVA level can be titrated daily as the respiratory disease evolves.

- Example of a "breakpoint":
  Following figure shows the Edi and PIP data from a premature neonate on NAVA. As the NAVA level is increased from 0.1 to 3 cmH2O/mV. The first response is evident by increases in peak inspiratory pressure as the NAVA level increases from 0.1 to 1 cmH2O/mV. It appears at a level of 1 cmH2O/mV, the peak pressure no longer increases, and the Edi peak starts to decrease with further increases in NAVA level. The breakpoint (or point of optimal respiratory muscle unloading) would be determined as a NAVA level of 1 cmH2O/mV.



Neurally Adjusted Ventilatory Assist (NAVA) in Neonates using Maquet SERVO-n - Clinical Guidelines cont'd

EDUCATIONAL NOTES cont'd

Firestone et al. carried out NAVA level titrations in 21 premature neonates (mean weight at study was 795 g, range 500e1441 g). Starting at a NAVA level of 0.5 cmH2O, systematic increases in the NAVA level were performed every 3 min until they reached 4 cmH2O/mV. At first, PIP and VT increased with increasing NAVA levels, followed by a plateau phase (breakpoint) where the PIP and VT did not increase further, due to downregulation of Edi.

- **Breakpoint level for NAVA: Invasive vs Non-Invasive NAVA**
  In a recent study by Loverde et al (Loverde B, 2016), neonates demonstrated an increase in BrP, higher PIP and Edi when extubated from NAVA to NIV NAVA. This is most likely owing to the inefficiencies of NIV ventilation. This suggests that neonates require a higher NAVA level when transitioning from NAVA to NIV NAVA.

- **Clinical studies in neonates:**
  Stein et al (Stein 2016) compiled the 6 studies (n=106 babies) related to invasive NAVA (average lowest gestational age (GA) at birth 24 weeks, average birth weight 728 g, when reported) and two studies (n =17 babies) with NIV-NAVA (very similar characteristics, average lowest GA 24 weeks, birth weight 812 g).

- **Invasive NAVA studies in neonates and infants**
- Longhini et al. (Longhini 2015) performed a cross-over trial in 14 intubated preterm infants (gestational age range 27e35 weeks). Twelve h of ventilation with pressure-regulated volume control (PRVC) was compared to 12 h of NAVA. In PRVC, they found clear differences between ventilator and patient respiratory rates (the ventilator rate could be five times that of the patient), indicating auto- triggering or backup ventilation. Central apnoeas (flat Edi waveform) were significantly reduced with NAVA.
- Lee et al (Lee 2012) performed a randomised cross over trial to determine whether NAVA could lower the inspiratory pressure and respiratory muscle load in preterm infants supported with ventilators. Nineteen mechanically ventilated preterm infants were randomized to crossover ventilation with NAVA and synchronized intermittent mandatory ventilation (SIMV) with pressure support (PS) for 4 hours each in a randomized order. NAVA lowered PIP and reduced respiratory muscle load in preterm infants at equivalent FiO2 and PaCO2 in comparison with SIMV with PS.
- Firestone et al. (Firestone KS 2015), carried out NAVA level titrations in 21 premature neonates (mean weight at study was 795 g, range 500e1441 g). Starting at a NAVA level of 0.5 cmH2O, systematic increases in the NAVA level were performed every 3 min until they reached 4 cmH2O/mV. At first, PIP and VT increased with increasing NAVA levels, followed by a plateau phase (breakpoint) where the PIP and VT did not increase further, due to downregulation of Edi.
- Stein et al. (Stein H, Alosh 2013) performed a prospective cross-over comparison trial with five premature neonates. Each neonate was ventilated on NAVA for 4 h, then switched to PC for another 4 h. The cycle was repeated three times. Patients on NAVA had lower PIP, FiO2, transcutaneous pCO2, Edi peak, and respiratory rate. Compliance and tidal volume improved on NAVA.
- Beck et al. (Beck 2009) reported improved patient-ventilator interaction in seven low birth weight neonates, even in the presence of large air leaks. Neonates were ventilated with conventional ventilation (PSV or pressure support with volume guarantee) and then for 20 min on NAVA. The neonates were extubated and ventilated for another 20 min with NIV NAVA. Neonates on conventional ventilation initiated breaths comparable to NAVA but cycled-off an average of 120 ms before NAVA. Neural expiratory times and respiratory rates were lower during NAVA. There was no difference between NAVA and NIV NAVA.

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Neurally Adjusted Ventilatory Assist (NAVA) in Neonates using Maquet SERVO-n - Clinical Guidelines cont'd

EDUCATIONAL NOTES cont'd

- Breatnach et al. (Breatnach 2010) observed improved patient-ventilator synchrony during a 4 h trial of NAVA in 16 children aged 2 days to 4 years. There was a 28% reduction in peak airway pressure after 30 min on NAVA and a 32% reduction after 3 h with no change in mean airway pressure, minute ventilation, expired tidal volume, respiratory rate, heart rate, PaO2 and PaCO2.
- Bengtsson et al. (Bengtsson 2010) evaluated 30 min study periods on NAVA in 21 children undergoing surgery for congenital heart defects (four were aged <1 month and none was premature). Patients were alternated between pneumatically triggered PSV and NAVA for 30 min, receiving each modality twice. Patients ventilated on NAVA had lower peak pressures and tidal volumes and higher respiratory rates than on PSV with no change in mean airway pressure or blood gases.
- Alander et al. (Alander 2014) performed a cross-over trial in 18 neonatal and pediatric patients comparing flow-, pressure-, and NAVA triggered ventilation for 10 min each. There was no major difference between pressure- and flow-triggering during assist control. Neonates ventilated with NAVA were synchronous 91% of the time compared to 67% with pressure-triggered and 69% with flow- triggered ventilation. PIP decreased 13% on NAVA and respiratory rate increased. There was no change in mean airway pressure or blood gases. They noted that in pressure- and flow-triggered assist control there was no spontaneous respiratory effort 8-12% of the time compared to 1.3% with NAVA. No adverse events were noted during the study.
- Stein et al. (Stein J Ped 2012) retrospectively reviewed 52 neonates <1500 g ventilated initially on SIMV (PC) and then changed to NAVA and tracked up to 24 h. The average gestational age was 26 weeks (22-32 weeks), age at study 2 weeks (0e56 days) and weight at study 958 g (465e1870 g). During NAVA, these neonates decreased peak inspiratory pressures by 17-20% and FiO2 requirements by 15% compared to SIMV (PC). Despite decreased pressures in neonates that were ventilated with permissive hypercarbia, the pH improved from 7.29 on SIMV to 7.34 on NAVA and the pCO2 decreased from 54 on SIMV to 47 on NAVA. These changes were sustained over the study period. There was no change in mean airway pressure, respiratory rate, or rates of interventricular haemorrhage, pneumothorax or necrotizing enterocolitis. Long-term respiratory outcomes were not evaluated.
- Stein et al (Stein 2016) ummarized all the studies on invasive NAVA. In summary, 19 studies in 457 infant patients have compared invasive NAVA to conventional ventilation. For those who report the variables, ventilation parameters adopted by the infant are consistent with the current understanding of respiratory physiology in newborns: VT: 6.4 ± 1.7 mL/kg; respiratory rate: 45.4 ± 9.8 breaths/min; PIP: 13.9 ± 2.7 cmH2O; NAVA level: 1.4 ± 0.4 cmH2O/mV; Edi: 8.6 ± 2.3 mV.

- **Noninvasive NAVA (NIV NAVA) studies in neonates and infants**
- Beck et al. (Beck 2011) characterized the neural breathing pattern in non-intubated preterm neonates. Ten neonates with a mean gestational age of 31 weeks and birth weight of 1512 g were studied for 1 h daily for 4 days starting at a mean age of 7 days. Neonates were found to have a variable neural breathing pattern and elevated tonic Edi. Neural inspiratory times averaged 0.28 s and decreased with increasing gestational age. Whether these average inspiratory times will be the same in neonates with restrictive lung disease (e.g. respiratory distress syndrome) is not yet known.
- Zhu et al. (Zhu 2009) described 21 infants who underwent open-heart surgery for congenital heart disease (mean age: 2.9 months; mean weight: 4.2 kg) and were ventilated with PSV and NAVA for 60 min respectively in a randomized order. The PIP and Edi during NAVA were significantly lower than during PSV. Post-extubation Edi was higher in infants who needed reintubation or non-invasive mechanical ventilation than in those who were extubated successfully (30.0 % 8.4 vs 11.1 % 3.6 mV). There were no differences in the heart rate, systolic blood pressure and central venous pressure, paO2:FiO2 ratio, and pCO2.

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Neurally Adjusted Ventilatory Assist (NAVA) in Neonates using Maquet SERVO-n - Clinical Guidelines cont'd

EDUCATIONAL NOTES cont'd

- Parikka V et al (Parikka 2015) used NAVA to study the the effect of caffeine citrate on the neural control of breathing, especially central apnoea, in 17 preterm infants with a mean age of three days and mean birth weight of 900 grams. Edi was measured for 30min before and 30min after caffeine citrate loading (20mg/kg). Central apnoea was defined as any period where the Edi waveform was flat for >5s. Caffeine citrate reduced significantly the number of 5-to-10-second-long central apnoea during the 30-minute periods (12+/-11 to 7+/-7; p=0.02). Caffeine citrate increased both peak and phasic Edi leading to a significant increase in the diaphragm energy expenditure.
- Houtekie et al (Houtekie L, 2015) conducted a prospective, randomized cross-over study in 10 infants <5 kg after cardiac surgery. After extubation, subjects underwent 2 consecutive ventilatory modes after randomization into groups. In the CPAP first group, the subjects were ventilated first in nasal CPAP-1 and then in NIV-NAVA-2 for 30 min in each mode. In the NIV-NAVA first group, periods were reversed. All children were ventilated using the same interface. NIV-NAVA allows good synchronization in bi-level NIV in infant cardiac subjects weighing < 5 kg. The analysis of respiratory parameters shows that NIV NAVA decreases the work of breathing more effectively than nasal CPAP.
- Lee J, et al (Lee J, 2015) conducted a randomised phase II crossover trial to compare NIV-NAVA and NIV-PS in 15 preterm infants on patient–ventilator synchrony. NIV-NAVA and NIV-PS were applied in random order after ventilator weaning. Data were recorded for sequential 5 min periods after 10 min applications of each mode. NAVA improved patient–ventilator synchrony and diaphragmatic unloading in preterm infants during non-invasive nasal ventilation even in the presence of large air leaks.
- Baudin F, et al (Baudin F, 2015) conducted a prospective cross-over physiological study in 11 children (aged 35.2 ± 23 days) with bronchiolitis with failure of nCPAP to determine the prevalence of main inspiratory asynchrony events during non-invasive intermittent positive-pressure ventilation (NIV). Patient-ventilator inspiratory asynchronies and trigger delay were dramatically lower in NAVA mode than in PAC mode during NIV in infants with severe bronchiolitis.
- Ducharme-Crevier L, et al (Ducharme-Crevier L 2015) conducted a prospective, physiologic, crossover study in 13 children requiring NIV in the PICU to assess the feasibility and tolerance of NIV-NAVA in children and to evaluate its impact on synchrony and respiratory effort. NIV-NAVA was feasible and well tolerated in all patients. One patient asked to stop the study because of anxiety related to the leak-free facial mask. Inspiratory trigger dys-synchrony and cycling-off dys-synchrony were significantly shorter in NIV-NAVA versus initial and final conventional NIV periods (both P <0.05). Wasted efforts were also decreased in NIV-NAVA (all values expressed as median and interquartile values) (0 (0 to 0) versus 12% (4 to 20) and 6% (2 to 22), respectively; P <0.01). As a whole, total time spent in asynchrony was reduced to 8% (6 to 10) in NIV-NAVA, versus 27% (19 to 56) and 32% (21 to 38) in conventional NIV before and after NIV-NAVA, respectively (P =0.05).

9. RELATED POLICIES/PROCEDURES/CLINICAL PRACTICE LOP

- NAVA set up (Nursing Policy).

10. RISK RATING

- Medium

11. NATIONAL STANDARD

- CC – Comprehensive Care

Neurally Adjusted Ventilatory Assist (NAVA) in Neonates using Maquet SERVO-n - Clinical Guidelines cont'd

EDUCATIONAL NOTES cont'd

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Neurally Adjusted Ventilatory Assist (NAVA) in Neonates using Maquet SERVO-n - Clinical Guidelines cont'd

EDUCATIONAL NOTES cont'd

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13. ABBREVIATIONS AND DEFINITIONS OF TERMS

NCC	Newborn Care Centre	NG	Nasogastric
ETT	Endotracheal tube	OG	Orogastric
PRN	As necessary	ICU	Intensive Care Unit
PIP	Peak Inspiratory Pressure	SIPPV	Synchronised Intermittent Positive Pressure Ventilation
VG	Volume Guarantee	Ti	Inspiratory Time
MRSA	Methicillin Resistant Staphylococcus Aureus	RSV	Respiratory Syncytial Virus

AUTHORS:

Primary	Date 08/11/2016	Persons: S. Bolisetty/J. Smyth, A. Ottaway (ACNE/ CNS)
Revised	Date	Person

…../Appendices

Appendix 1:

Edi Catheter

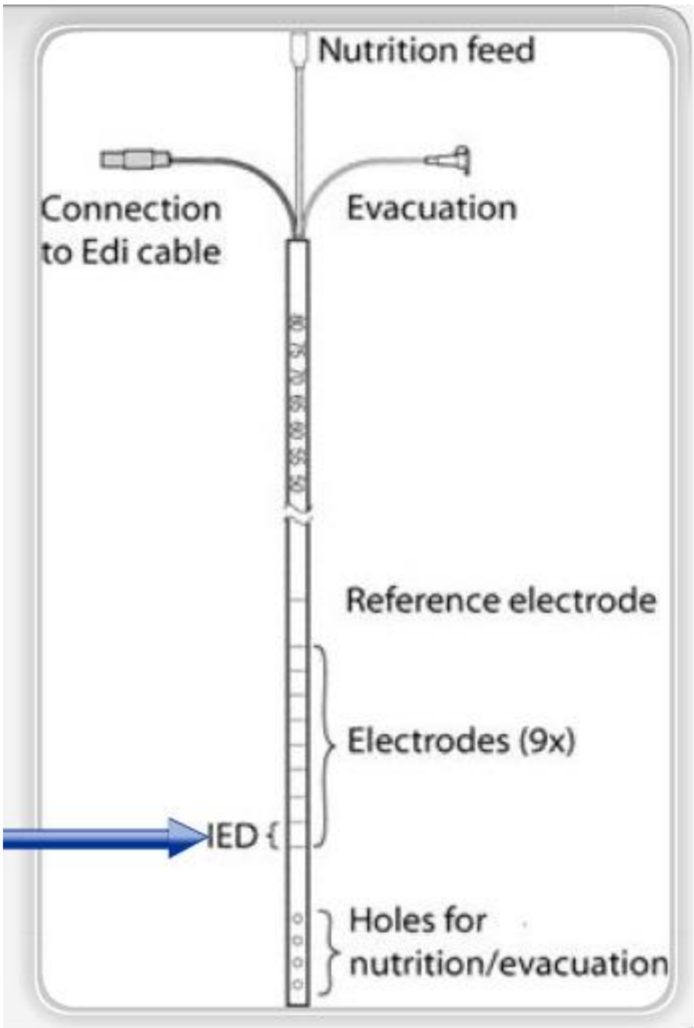
1. Sizes:
    a. <1000g - 6Fr 49cm
    (when correctly positioned tip is 2.5cm below oesophageal-gastric junction)

    b. 1000-1500g – 6 Fr 50cm
    (when correctly positioned tip is 3.5cm below oesophageal-gastric junction)

    c. 1000-2000g - 8Fr 50cm

    d. >2000g - 8 Fr 100 cm

2. Edi Catheter Components (Adult catheter shown):



Appendix 2:

QUICK USER GUIDE FOR SETTING UP & USING NIV-NAVA:

In addition to this guide follow instructions on SERVO-n ventilator & use RHW NCC NAVA Clinical Guidelines + NIV-NAVA Quick Check Guide on the last page of this Appendix.

The order of events to correctly set up and use NIV-NAVA is:

1. Confirming optimal position of the Edi catheter (see below & p1 also)
2. Initial NIV-NAVA Settings Flow Chart (see below depending on reason for use)

Once baby is stabilised on NIV-NAVA the next steps are:

- Optimisation of Ventilation using NIV-NAVA (see below)
- Weaning Ventilation on NIV-NAVA (see below)
- Troubleshooting on NIV-NAVA (see below)

1. Confirming the optimal position of the Edi catheter:

When the Edi catheter is in a good position you will see ECG landmarks as follows (shown on SCREENSHOT below)

From the top of the screen downwards below where it says LEADS mV:

- Lead 1 Tall P wave (the first peak before the QRS wave)
- Lead 2 Smaller P wave
- Lead 3 No (or v. small) P wave
- Lead 4 No P Wave & small ORS wave

- With Edi catheter in the optimal position the <u>**Purple Circles**</u> to left of ECG signals should be as seen on Leads 2 & 3 and as well as a superimposed purple colour on the ECG on Leads 2 and 3 (as shown above). The Purple colouration is only present if the Edi waveform is present.
- When Edi signal is present it may periodically fluctuate to the upper and lower leads without loss of signal integrity.

Appendix 2 (cont):

When Edi Catheter is in an <u>INCORRECT</u> position:

- If **Purple Circles** are on Lead -1 - Pull catheter back until **Purple Circles** are seen on leads 2 & 3.
- If **Purple Circles** are on Lead – 4 - Push catheter in until **Purple Circles** are seen on leads 2 & 3
- If ECG amplitudes are in reverse order (small P waves and QRS complexes in lead 1 and then tall P and QRS waves in lead 4): Push catheter in (often by 3 cm or so).
- If Tall P and QRS waves in Lead 1 and again tall P and QRS waves in lead 4 – Catheter curled back forming a loop – Reposition catheter.

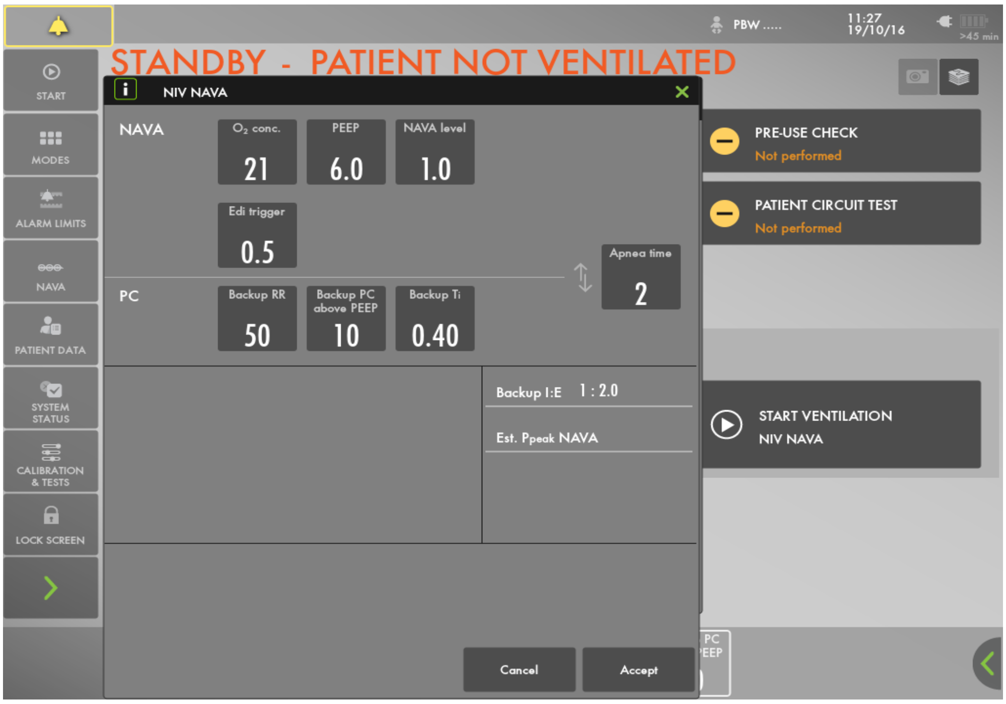
NO Edi signal on the bottom screen:

Consider the following (once you have the correct ECG landmarks as seen above)

- *Pharmacologic – Over-sedation (opioids and muscle relaxants)*
- *Over-ventilation (low pCO_2 on blood gas or low $tcCO_2$)*
- *Neuro-mechanical (immaturity, IVH, phrenic nerve injury)*

2. <u>Suggested initial settings for NIV-NAVA:</u>

(SEE SCREENSHOT BELOW + FLOW CHART ON NEXT PAGE)



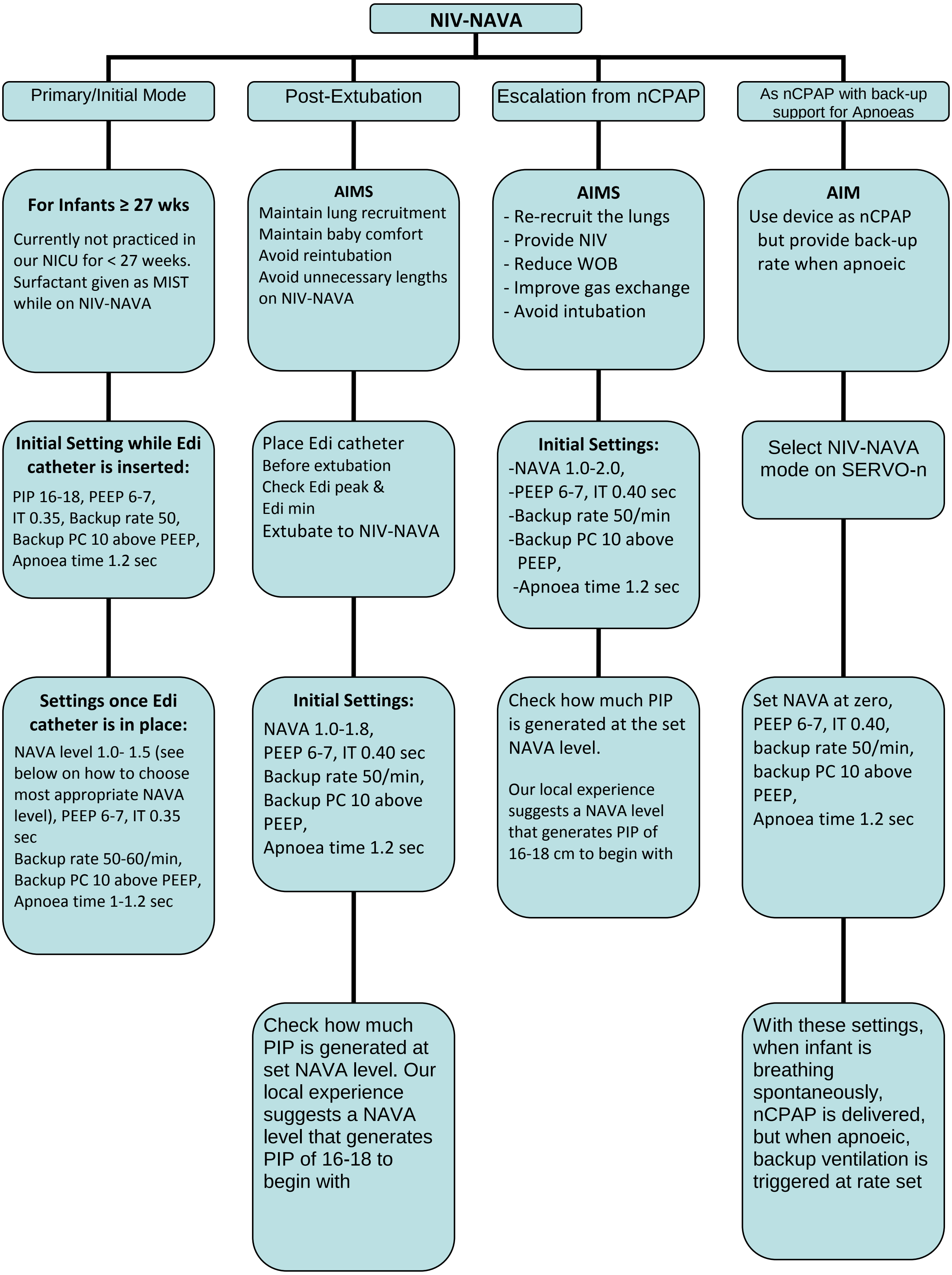
- Set FiO_2 and PEEP as per requirements and/or from previous settings of respiratory support
- Initiate NIV-NAVA with a NAVA level of 1.5 and titrate up or down as per guidance seen below for *'Optimisation of NIV-NAVA'* in consultation with medical staff.

<u>Note</u>:

- ➢ Back up PC (ventilation) will only be engaged after the Apnoea time has been reached
  (Back-up ventilation in NIV-NAVA is not synchronised)
- ➢ **Set Apnoea time to 1-2 sec depending on the back rate you want**
- ➢ Suggested settings as described in picture above: Backup PC 10cm above PEEP, Backup Ti 0 .4 sec and Resp. Rate 50. Adjust in consultation with medical staff.

Appendix 2 (cont):

2. Suggested Initial NIV-NAVA Settings Flow Chart:



Appendix 2 (cont):

Optimisation of Ventilation using NIV-NAVA:

Edi = Electrical activity of the Diaphragm

An Edi peak & Edi minimum level are measured on the SERVO-n ventilator.

- **Edi peak** level is the maximum voltage the diaphragm nerve signal reaches. It indicates the amount effort being made to breathe in and this correlates with the Work Of Breathing (WOB).
- **Edi min** level is a measure of the tone of the diaphragm at rest and if high can indicate the baby is trying to generate PEEP itself and needs more PEEP.

If Edi PEAK > 15 µV persistently:

- this may indicate increased WOB
- Ensure common causes are addressed first (eg: secretions blocking the nose or the mask or prongs wrongly positioned)
- Otherwise this will indicate the baby is asking for more support and the NAVA level will need increasing. Please increase NAVA level in 0.2 increments until Edi is persistently below 15 µV and baby is comfortable.

If Edi PEAK persistently < 5 µV:

- This usually indicates WOB is low
- Consider weaning NAVA level by 0.1 to 0.2 after discussion with medical staff

If Edi is irregular

- Consider causes: Immaturity, Hyperventilation, Sepsis, Sedation, Deterioration of condition

Edi minimum

- ➢ This is an indication of the resting activity/tone of the diaphragm
- ➢ If it is consistently > 3 µV reduction of PEEP can be considered
- ➢ Please exclude alternative reasons: splinting the diaphragm, crying, pain

Appendix 2 (cont):

Weaning Ventilation on NIV-NAVA:

- Ensure FiO_2 requirements are low (< 25-30%)
- Review frequency of backup ventilation (Backup PC %) on the Trends page and time spent in back up / min. Also review spontaneous respiratory rate *If back-up is frequent consider increasing apnoea time & reducing backup PC rate &/or Pressure Control to encourage an increase in spontaneous respiratory drive*
- Wean NAVA level by 0.1-0.2 at a time and review infants comfort, RR, Sats, pCO2, HR
- If baby does not tolerate weaning (eg: frequent O_2 desaturations) return to previous settings
- Reducing support encourages increased spontaneous efforts – Aim to optimise NAVA level to babies comfort, effort and respiratory status

Trouble Shooting on NIV-NAVA:

IF YOU EXPERIENCE A PROBLEM WHICH IS DIFFICULT TO SOLVE PLEASE TAKE A SCREENSHOT OF THE SERVO-n SCREEN (press the camera icon on the top right of the screen – this can then be reviewed later)

In non-invasive ventilation (NIV-NAVA) mode a leak is to be expected. The ventilator will compensate for this & leaks of up to ≥ 90% will still deliver ventilation as dialled up.

- Edi Catheter won't aspirate
  - Aspirating Edi catheter may collapse the bore & this may be why no aspirate is obtained. They are however designed to be aspirated so gentle adjustment should allow aspiration in the case of aspirate measurement. Positioning for all other feeds & gastric medication administration can be determined using Edi catheter positioning screen.
- Edi catheter blocked
  - Addition of an electrical wire/probe to the Edi catheter means it has a smaller diameter lumen than a usual NG tube. This means it can become blocked by thick viscous medications or thickened feeds. In this case it may be necessary to pass a second NG/OGT for administration of these products
- Excessive Leak/Low PEEP Disconnection Alarm
  - means the Leak is potentially greater than 15L/min (the flow limit of the machine)
  - Review Circuit for disconnections
  - Review interface and connections to interface.
    - **Experience indicates that it is usually the interface (prong/mask leak mouth open, secretions)**

Appendix 2 (cont):

Trouble Shooting on NIV-NAVA (cont):

- Desaturations/Bradycardia
  Consider:
  - Suitability of mode of ventilation
  - Changing NAVA level (increase)
  - Insufficient Back Up Ventilation seen in extreme prems: may see reduced Edi activity ⇒ can reduce Apnoea time down as low as 1 sec in 0.2 sec increments to give more Backup PC & Resp. Rate
  - Air in stomach (Aspirate Edi Catheter/OG tube & check positions are correct)
  - Clinical change in baby's condition- RDS, Sepsis, IVH, Pneumothorax….

- Gaseous Distension
  - Because of smaller lumen of NG tube and difficulty in aspiration, often there may be air trapping in the gut. In this case, it may be necessary to pass a second NG/OGT for aspiration of gas and gastric contents

- Sudden increase in Edi peak on Invasive NAVA
  - ? ETT blocked
  - ? Chest drain blocked
  - ? Infant in Pain

- No Pt Effort (on Edi signal)
  - Ensure Edi is correctly positioned
  - ? Over-sedation
  - ? Over-ventilation (Backup PC rate set too high) do a blood gas
  - ? Extreme Prematurity
  - ? Apnoea time too short (you may need to consider reducing the apnoea time if infant is not adequately supported in back up mode)
  - You may need to adjust the alarm setting (apnoea audio delay or turn the alarm off)

NIV-NAVA Quick Check Guide:

1. Initiation of NIV-NAVA:

1. Catheter selection
   - < 1000g use 6Fr 49cm
   - 1000-2000g use 6Fr or 8Fr 50cm
   - > 2000g use 8 Fr 100cm length
2. Follow instructions on SERVO-n & Guidelines for position & placement
3. Initiate NAVA on level 1.0 & titrate in 0.2 increments to babies comfort & to an Edi peak < 15µV
4. Target lowest FiO_2 requirements & consider PEEP titration

2. Optimising the NAVA Level and the Baby's comfort

Optimise the NAVA level to maintain Edi peak < 15µV

- If Edi peak < 5 µV consistently consider decreasing NAVA level
- If Edi peak > 15 µV consistently increase NAVA level
- Review Baby's efforts on NIV-NAVA screen and on Trends/Logs screen: Look at: Respiratory Rate spont & other, amount of Back-up PC (no. & %), Edi peak & min
- Ensure adequate Oxygen saturations
- Look at Frequency of Desaturation & Bradycardia episodes
- Check Baby is comfortable

3. Optimisation of Backup PC

- Check that Pressure above PEEP is achieving adequate chest movement
- Check Blood gases once settled on NIV-NAVA
- Set Resp. Rate (Back-up PC) according to needs (desaturations, pCO_2 and ABG)
- Set Apnoea time to reduce frequency of desaturations and bradycardic episodes

Note If Back up ventilation is too high infant will not be encouraged to breathe spontaneously consistently this may be identified by frequency of back up and % time in backup

4. Consider Weaning if

1. Low FiO2 requirement & stable
2. Hemodynamically stable
3. Baby looks comfortable
4. Resp. Rate is regular
5. Edi is regular & peak < 5 µV

Options for Weaning

- ↑ Apnoea Time up to 2-5 sec
- ↓ Back-up RR to 40/min
- ↓ Pressure above PEEP
- ↓ NAVA level 0.1-.2 at a time
- NAVA level of 0 is effectively CPAP

5. What to Review/Consider

1. Frequency of Back Up (Trends for % of time in Backup PC & no./min) Consider ↑ backup as potential hyperventilation
2. Resp Rate (spont and total)
3. Edi waveform often for regularity & for Edi peak & Edi min

Always watch for possible deterioration

The Dynamic environment means the baby can always change. How to manage this needs to be considered. Always be prepared for escalation of therapy.

Potential signs of Deterioration:

- Increased Edi variability
- Increasing FiO_2 requirements
- Bradycardias & haemodynamic variations
- Increasing Backup ventilation (PC) % & number of Backups/min