Brighton and Sussex University Hospitals NHS Trust

BSUH Paediatric Guidelines

Guidelines for the use of the BiPAP machine

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BiPAP is a variation of pressure controlled ventilation.

It differs from conventional pressure-controlled ventilation in that spontaneous breathing is always possible. BiPAP permits spontaneous breathing not only during expiration, but also during mandatory breaths.

Useful Definitions

Respiratory failure

- A state of reduced oxygenation in the absence of intra-cardiac shunting.
- Divided into type I respiratory failure in which the primary problem is one of oxygenation and the $PaCO_2$ is low or normal, and type 2 in which the patient is also failing to adequately clear CO_2, causing a raised $PaCO_2$.

Conventional ventilation

- Mechanical ventilation via a tracheal tube (either oral or tracheostomy).

Non-invasive ventilation (NIV)

- A method of providing ventilatory support without the need for tracheal intubation.
- Different types of NIV include continuous positive airway pressure (CPAP), volume controlled ventilation and pressure controlled ventilation. The term NIPPV (non-invasive positive pressure ventilation) is also widely used.

Bi level positive airway pressure (BiPAP©)

- This is the trade name for the machines most commonly used in the UK to provide two levels of airway pressure.
- Positive pressure is maintained throughout the respiratory cycle, with a higher pressure during inspiration.
- BiPAP results in reduced work of breathing and an improvement in tidal volume and CO_2 removal.
- It is therefore useful in the treatment of type 2 respiratory failure.

Note that **bi-phasic positive airways pressure (BIPAP)** is different to BiPAP and less commonly encountered. The patient breathes at a preset level of CPAP and at timed intervals (not synchronised to the patient's inspiratory efforts) the level of CPAP is reduced to a lower level. The intermittent reduction in CPAP leads to a large expiration and therefore increases CO_2 elimination.

Equipment and initial set up:

NIV requires a machine capable of delivering pressurised, oxygenated gas through a mask to the patient.

VIVO (our BiPAP machine) require oxygen to be added to the distal breathing circuit through a side port. The inspired oxygen concentration is variable with this, depending on flow within the circuit, and it is not possible to provide more than 60% inspired oxygen.

The machine is attached to the patient via a breathing circuit. This tube delivers the inspiratory gas and also allows the sensors to detect the patient's respiratory effort. A vital component of the circuit is the **mandatory expiratory valve**, which allows exhaled gases to escape. Blockage of this valve for any reason may have disastrous consequences as high flow gas is driven towards the patient with no means of escape (critically important if the patient is being ventilated via a tracheostomy).

Humidification of inhaled gases is important if the integrity and function of the respiratory tract is to be maintained and various options exist to humidify gases in non-invasive circuits.

The least efficient method involves the placement of a `wet sponge' within the circuit. More efficient methods include bubbling the gas through a cold, or preferably hot, water bath (this is used with VIVO). This water should be sterile; in order to reduce the risk of bacterial contamination and the temperature needs to be carefully controlled.

Care also needs to be taken in order to prevent water collecting within the circuit as this can be delivered to the patient inadvertently.

Naso-gastric tubes should be considered with NIV in order to drain air introduced into the stomach.

The circuit is usually attached to the patient via a mask.

Indications :

- NIV is indicated in acute or acute-on-chronic hypercapnic respiratory failure due to chest wall deformity or neuromuscular problems
- Many patients with acute pneumonia and hypoxaemia resistant to high flow oxygen will require intubation.
- CPAP improves oxygenation in patients with diffuse pneumonia who remain hypoxic despite maximum medical treatment.
- NIV can be used as an alternative to tracheal intubation if the patient becomes hypercapnic.

Advantages of NIV compared to conventional ventilation

Compared with conventional ventilation, NIV is a relatively inexpensive and simple technique which prevents the need for conventional ventilation in some patients and improves survival.

Major advantages include:

- Avoiding many of the complications associated with conventional ventilation.
- Needs less intensive medical/ nursing care

Contraindications to the use of NIV

These may be **absolute**:

- Non-compliant patient
- Unconscious patient / unable to protect airway.
- Haemodynamic instability

Or **relative**:

- Facial fractures
- Excessive secretions
- After recent facial or upper airway surgery
- In the presence of facial abnormalities such as burns or trauma
- If there is fixed obstruction of the upper airway
- If the patient is vomiting
- Recent upper gastrointestinal surgery,
- Confusion/agitation
- Bowel obstruction

NIV can be used in the presence of these contraindications provided contingency plans for tracheal intubation have been made, or if a decision has been made not to proceed to invasive ventilation.

• Although NIV has been used successfully in the presence of a pneumothorax, in most patients with a pneumothorax an inter-costal drain should be inserted before commencing NIV.

Complications:

In patients with acute inflammatory pulmonary processes and the inability to clear secretions, pneumothorax is a potential complication.

Further studies need to be done.

SETTING UP

Refer to power point presentation for setting up the machine

How to apply the mask?

The mask is held on the face by a harness which passes around the back of the head. When tightening the straps, it is important to find a balance between leaving the mask so loose that there is an uncontrollable leak and making it uncomfortably tight. Pressure relieving dressings may be used to reduce the chance of sores developing in sensitive areas such as the bridge of the nose.

What mode to use?

· CPAP is ideal for type I respiratory failure where CO_2 elimination is not a problem.

· BiPAP is used to augment CO_2 removal as well as improving oxygenation (type II respiratory failure). There are three mode options when using BiPAP:

1. **Spontaneous** (PSV in VIVO 40) – the machine will detect and support spontaneous breaths in patients with good respiratory drive (similar to pressure support).

2. **Timed (PCV in VIVO 40)** – the machine will provide mandatory breaths at a set frequency in patients with inadequate spontaneous respiration (similar to controlled mandatory ventilation).

3. **Spontaneous** / **timed** – the machine will support spontaneous breaths, but if the patient does not breathe for a set period, they will be given a mandatory breath.

Which initial pressure settings to use for BiPAP© spontaneous mode?

- Commonly the IPAP is set to 10 cmH_2O and the EPAP to 5 cmH_2O. The response to these pressures should determine future changes.
- Gradually increase IPAP by 2 each time over 15-20 min
- Do not go higher than 20cms
- Gradually increase EPAP by 2 each depending on the response
- Increase to a maximum of 10cm

Please do not change two parameters at a time !!!

If higher pressures are required leakage around the mask is usually a problem or conventional invasive ventilation is indicated.

What FiO_2 to choose?

· Choose an initial FiO_2 slightly higher to that the patient received prior to NIV.

· Adjust the FiO_2 to achieve a SaO_2 that you deem appropriate for their underlying disease. Generally SaO_2 above 92% is acceptable.

If a patient is hypoxic while breathing 100% oxygen on a CPAP circuit, their hypoxia will not improve if they are placed onto a BiPAP circuit (in spite of the increased ventilatory assistance) because the FiO_2 will drop significantly.

Similarly if a patient starts to work harder on a BiPAP circuit they may become more hypoxic due to a drop in FiO_2 caused by increased gas flow through the breathing circuit.

Other parameters:

Rate: Set rate according to the age of the child

Rise time: The amount of time it takes the machine to go from the lower (expiratory) to the higher (inspiratory) pressure. Usually set up at 0.2 sec.

Timed inspiration: 1.5 sec (only active in a timed breath)

I:E: A function of respiratory rate, VT, inspiratory flow and inspiratory time.
Initial setting is usually1:2.

Alert patients are more comfortable with shorter inspiratory times and high inspiratory flow rates.

Consider increasing I:E ratio in low pO2 conditions.

How to monitor the patient's response to NIV?

· The most useful indicator is how the patient is clinically- check the work of breathing/ respiratory rate/ heart rate

· Blood gases are useful to assess changes in oxygenation and CO_2 clearance.

How to tell if NIV is not effective?

· Again, this is largely based on how the patient is looking clinically

If the patient is getting increasingly tired, or their blood gas is deteriorating despite optimal settings, then they will probably need tracheal intubation and mechanical ventilation. It is important to recognise this as soon as possible so that management may be planned before the patient collapses.

Changing parameters:

Low pO2:

- Increase IPAP if signs of hypoventilation (tidal volume low)
- Increase EPAP to allow longer gas exchange
- Increase supplemental oxygen

High pCO2:

- Check mask fitting
- Increase IPAP

Low pO2 and pCO2 high:

- indicates hypoventilation

pO2 acceptable but pCO2 remains high:

- increase IPAP
- Increase back up rate

Only alter one parameter at a time and observe/ note patient response

How to set Alarm Parameters:

High Pressure: Set the high pressure alarm 3-4 cm. above prescribed IPAP pressure

Low Pressure: Set the low pressure alarm 3-4 cm. below the prescribed IPAP pressure

Low rate: Set the low rate alarm below the patients actual respiratory rate but above the set back up rate

Low min volume: Set the low minute ventilation alarm to 3-4 L below the displayed patient minute ventilation

Treatment failure while on Non-invasive ventilation:

Is the treatment of the underlying condition optimal?
• Check medical treatment prescribed and that it has been given
• Consider physiotherapy for sputum retention

Have any complications developed?
• Consider a pneumothorax, aspiration pneumonia, etc

Paco2 remains elevated:
• Adjust FiO2 to maintain SpO2 between 85% and 90%
• Is there excessive leakage?
• Check mask fit
• If using nasal mask, consider chin strap or full-face mask
• Is the circuit set up correctly?
• Check connections have been made correctly
• Check circuit for leaks
• Is re-breathing occurring?
• Check patency of expiratory valve (if fitted)
• Consider increasing EPAP (if bi-level pressure support)
• Is the patient synchronising with the ventilator?

• Observe patient
• Adjust rate and/or IE ratio (with assist/control)
• Check inspiratory trigger (if adjustable)
• Check expiratory trigger (if adjustable)

Conclusion:

Each patient should have a back up/ contingency plan in situ prior to commencement of non-invasive BiPAP. This should include a decision regarding the appropriateness of invasive mechanical ventilation which should be clearly recorded in the patient's notes.
Ensure appropriate medical treatment is maximised before instituting BiPAP , for example supplementary oxygen, antibiotics, physiotherapy should all have been considered.

References:

1. British Thoracic Society guideline for Non-invassive ventilation
2. Oxford Handbook of Critical Care
3. Jaarsma AS, Knoester H, van Rooyen F, et al. Biphasic positive airway pressure ventilation (PeV+) in children. Critical Care 2001;5:174-177
4. Pribble CG & Berg MD. Pneumothorax as a complication of bilevel positive airway pressure (BiPAP) ventilation. Clinical Intensive Care 2000;http://www.informaworld.com/smpp/title~content=t713693205~db=all~tab=issueslist~branches=11 - v1111(3):145-147
5. Non-invasive ventilation in the Intensive care Unit. Anaesthesia UK 21/01/2007.
6. Non-invasive ventilation in the ICU. Anaesthesia UK 04/12/2006.