

NIV - CONTINUOUS POSITIVE AIRWAY PRESSURE (CPAP)



“The Empress of Austria”, lithographic print, C. De Grimm, Vanity Fair, 5th April 1884

This is Elizabeth, Empress of Austria. She was the wife of the second last Austro-Hungarian Habsburgh Emperor, Franz Joseph. She had an obsession for very tight fitting corsets as can be seen in De Grimm's depiction of her in hunting and riding costumes. It was apparently common knowledge around some of her favorite hunting grounds in England that before a hunt, a tailor would be employed to lace up her satin, moiré or leather corsets, then sew her skirt into it so as to remove the even the slightest suggestion of a crease or wrinkle. A belt would then be pulled tight to complete the proceedings, the whole process taking up to one hour. A belt of hers was on display at the Great London Exhibition of 1860-61. It measured just 16 inches! What mattered to the Empress was a perfect fit. She established the corseted look as the fashion trend for the age. However women of the mid nineteenth to early twentieth centuries soon discovered that to look as good as an Empress a price had to be paid. A common female "ploy" of the age to attract the attention of the opposite sex was the "planned" or "controlled" faint occurring at just the opportune moment. By wearing corsets of the type worn by the Empress, however many discovered to their horror that some of their faints were no longer planned or controlled, and could occur at the most inopportune moments!

In the early 21st century corsets are no longer the fashion, however for our patients who present in acute pulmonary oedema we can supply them with a "medical corset" to reduce their venous return so that in short time we can have them looking good as an Empress. For this to occur however, their facemask must have no leaks and hence be of a "perfect fit". We must be aware, however that the potential price we may pay is a precipitous fall in our patient's venous return, resulting in a most inopportune "faint".



"Empress Elizabeth Riding", oil on canvas, John Charlton (1849-1917)

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Introduction

Non-invasive ventilation (NIV) is a method of delivering oxygen by positive pressure mask that allows for the prevention or postponement of invasive tracheal intubation in selected patients who present with severe acute respiratory distress/ failure.

There are two primary modalities of NIV:

- **Continuous Positive Airway Pressure (CPAP):**
 - ♥ This provides for a continuous fixed value of positive airway pressure throughout the patient's respiratory cycle.
- **Bi-level Positive Airway Pressure (BIPAP):**
 - ♥ Here the inspiratory positive airway pressure (**IPAP**) is set at a higher level than the expiratory positive airway pressure (**EPAP**).

CPAP appears to be more effective in saving lives and reducing the need for intubation in selected patients presenting in **acute cardiogenic pulmonary oedema**.

BIPAP appears to be more effective in saving lives and reducing the need for tracheal intubation in selected patients with acute decompensation in **COPD**.

Summary of terminology:

CPAP:	Continuous Positive Airway Pressure
BIPAP:	Bi-level Positive Airway Pressure
IPAP:	Inspiratory positive airway pressure
EPAP:	Expiratory positive airway pressure
Pressure Support:	The difference between the level of inspiratory positive pressure and the expiratory positive pressure, (i.e. IPAP - EPAP).
NIV:	Non-invasive ventilation; is ventilation delivered without an orotracheal tube or tracheostomy tube, as well as negative pressure devices.
NIPPV:	Non-invasive positive pressure ventilation - this differs from the term NIV only by its exclusion of negative pressure ventilation devices. Due to the rarity of use of negative pressure devices however, NIPPV and NIV in practice are used interchangeably.

The following refers primarily to the modality of face mask delivered CPAP.

Physiology

The physiological benefits of CPAP include the following:

1. Provision of 100 % oxygen
2. Reduction in the work of breathing
3. Recruitment of alveoli
4. Reduction in venous return
5. Reduction in afterload. ²

Indications

NIV by the CPAP modality has the following indications:

Proven benefit:

1. Acute cardiogenic pulmonary oedema
2. Obstructive sleep apnoea

Possible benefit:

3. Exacerbation COPD
 - Including hypercapnic acute respiratory failure, though this is better treated with BIPAP.
4. Non cardiogenic pulmonary oedemas.
5. Acute asthma
6. Chest trauma, especially flail segments.
7. Other forms of hypoxic respiratory failure, e.g. pneumonia

Contraindications

1. Uncooperative patients
2. Significant hypotension
3. Unconscious patient

- A mildly reduced conscious state is only a relative contraindication, but these patients will require constant and close observation from an experienced staff member.

4. Pneumothorax

Complications

1. Vomiting:

- If the patient vomits, aspiration of gastric contents may occur.

2. Excessive impairment of the venous return:

- Cardiac output may be reduced due to the increase in intrathoracic pressure, as a result of impaired venous return, especially in preload sensitive patients.

3. Hypotension:

- CPAP levels should ideally be kept at or below 25 cm H₂O in order to avoid significant haemodynamic complications.¹

4. Barotrauma:

- Resulting in pneumothorax, which may progress to tension pneumothorax if unrecognized.

5. Mask intolerance.

6. Skin and mucosal necrosis, including epistaxis.

7. Raised intracranial pressure and raised intraocular pressure.

8. Aerophagia, with gastric insufflation (distention) and increased risk of aspiration.

Clinical assessment

There are no universally accepted criteria for commencing NIV in patients who present to the ED with acute respiratory distress, each of the many studies that have been done having unique inclusion and exclusion criteria.

Each case therefore is assessed on its own merits.

Considerations will include:

1. Ruling out of any clear absolute contraindications.

- This may include prior Advanced Care directives. These however most often relate to “do not intubate” directives, and a trial of NIV will still be reasonable in many instances.
2. Establishing (as far as possible in the setting of emergency presentations) the probable underlying pathology.
 3. Assessing for significant respiratory distress:

Again criteria for this are not absolute and no single factor will definitively decide the issue, but rather the overall clinical picture.

In *general* terms important considerations will include:

- Patient exhaustion
- Vital signs:
 - ♥ Pulse > 100
 - ♥ Respiratory rate > 30.
- Pulse oximetry:
 - ♥ SaO₂ < 90 %
- ABGs:
 - ♥ Note that baseline ABGs, recording O₂ therapy is desirable, but *not essential* and should *never delay* treatment when this is clearly necessary.
 - ♥ In less acute presentations, serial ABGs may be a useful guide to the response to medical treatment, or the lack thereof, indicating a trial of NIV should be considered.

Increasing hypoxia, hypercarbia and acidosis, as well as chronically raised bicarbonate levels are all important parameters.

- ♥ PaO₂ < 60 mmHg with the patient on 60% O₂ (8 L/min by face mask)
- ♥ PaCO₂ >45 mmHg and rising despite treatment.
- ♥ pH < 7.35
- ♥ Bicarbonate > 30 mEq/L

Management

1. Initiation of CPAP:

This is done on the clinical assessment of each individual case as described above.

Many patients with cardiogenic pulmonary oedema will have Advanced Care Directives that include wishes such as “not for ICU” or “not for intubation”.

CPAP, however may still provide a relatively simple and non-invasive treatment option for some of these patients. It may enable them to survive their acute illness in some cases, in others the modality can provide significant relief from the distress of hypoxia and exhaustion, and so in this regard may be used in a palliative sense.

2. Settings:

In general terms for acute cardiogenic pulmonary oedema, commencement settings are commenced at:

- **10 cm H₂O and 100% oxygen concentration.**

Current literature suggests that the maximal limit of pressure settings should be **25 cm of H₂O** (regardless of the mode of NIV being used).¹

- In general terms the FiO₂ should be adjusted to maintain an SaO₂ of at least 90 % (i.e. PaO₂ >80mmHg).

3. Monitoring:

All patients undergoing NIV will require close one to one direct observation by nursing staff experienced in the use of the device.

Close monitoring be required in regard to:

- All vital signs
- SaO₂
- Conscious state
- Tidal volumes (Vt) and minute ventilation (VE).
- The pressure gauge:

♥ This should be observed to ensure that the set CPAP level approximates the actual level measured on the on the pressure

gauge. If the pressure gauge is lower the circuit must be checked for leaks.

- ECG
- Patient comfort/ anxiety levels
- Signs of patient exhaustion/ tiring.
- For patients in whom serial ABGs are considered to be desirable, an arterial line will be useful to avoid the need for repeated distressing needling.
- Checking for pressure areas from the mask at least 2 hourly.

4. Sedation:

Constant **explanation** and **reassurance** to the patient, is a vital and important aspect of NIV in the acutely unwell patient.

These patients can suffer considerable anxiety, and this can be exacerbated by a tight fitting mask.

Judicious small titrated doses of IV opioids can help in assisting these patients. Note that these agents in the past were advocated for their venodilation effects in APO. However this effect is minor and is far better achieved with nitrate medication. The main benefit of IV opioids in the setting of APO will be in the anxious patient not responding to verbal reassurance, to assist them in tolerating the face mask required for their CPAP.

5. Nil by mouth:

Patients should generally remain nil orally while being stabilized in the ED, other than essential oral medication because of the risk of aspiration, or if the patient should subsequently require intubation.

Although NIV may be removed for short periods of time, this should be for as brief a period as possible. The patient must be closely observed during such periods.

6. Adjunctive therapies:

In the specific case of acute cardiogenic pulmonary oedema, it is important to note that IV titrated nitrates form the second cornerstone of treatment

In those with other comorbidities, nebulized bronchodilator medications can also be given via the CPAP circuitry.

7. Failure of CPAP:

Patient deterioration despite CPAP therapy will require either a decision to initiate more aggressive therapy (i.e. intubation and mechanical ventilation) or a decision to palliate the patient.

Indications of NIV failure may include:

- Deterioration in conscious state
- Increasing agitation
- Deterioration in vital signs:
 - ♥ Decreasing blood pressure
 - ♥ Increasing respiratory rate
 - ♥ Increasing pulse rate
- Deteriorating respiratory status:
 - ♥ Inability to maintain satisfactory oxygenation ($\text{PaO}_2 < 80$ mmHg or $\text{SaO}_2 < 90$ %)
 - ♥ A rising PaCO_2
 - ♥ Physical exhaustion

Note: The possibility of a complication of the NIV therapy, e.g. pneumothorax, aspiration or impaired venous return should additionally always be kept in mind

8. Weaning of CPAP:

Weaning from CPAP can commence once the patient is stable and there is improvement in the patient's clinical status, including their vital signs.

A suggested method is shown below in **appendix 1**

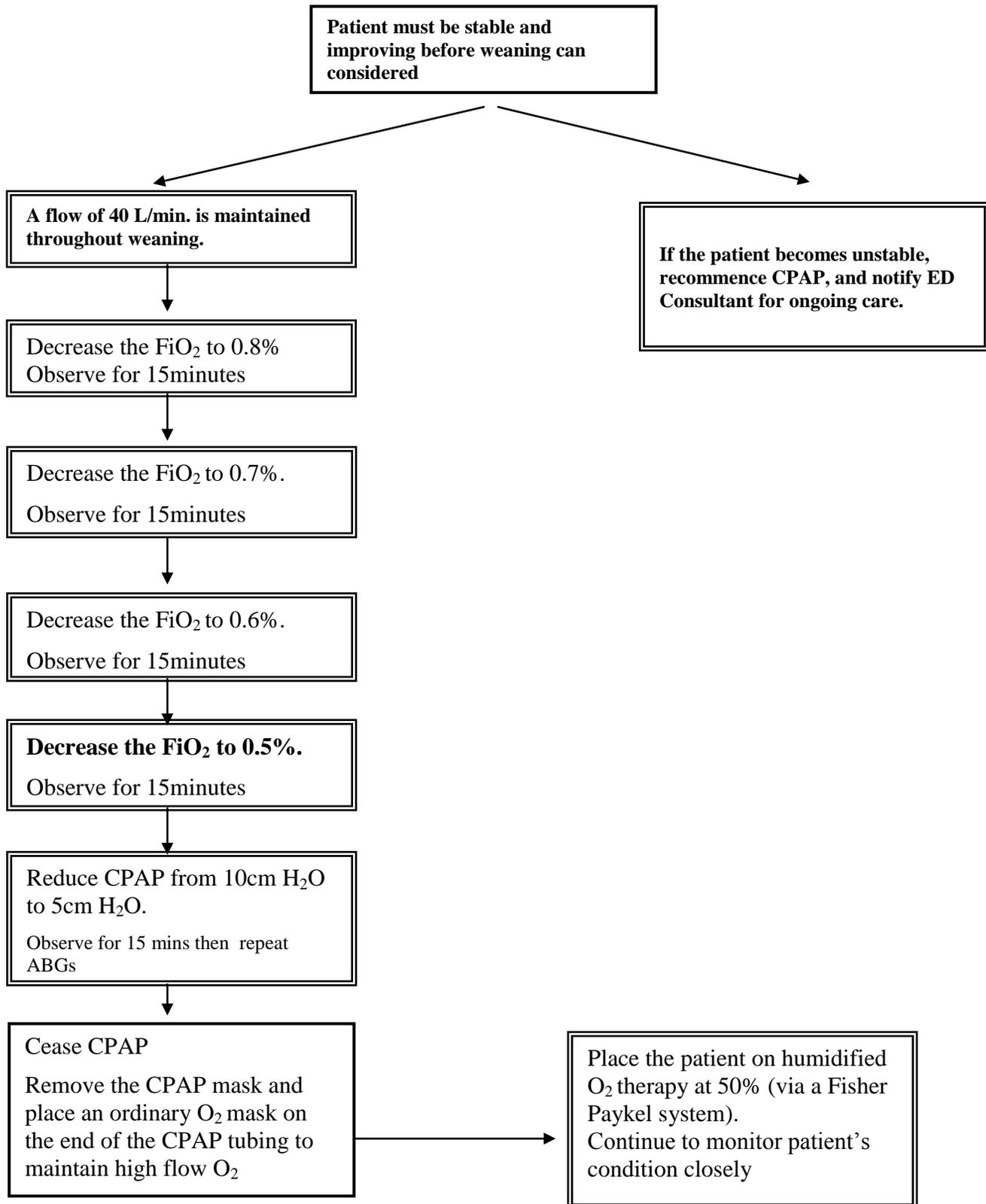
Disposition:

Acute cardiogenic pulmonary oedema, (or more specifically "flash APO" in North American parlance), can be rapidly lethal, but it is also a fairly "effervescent" process, in the sense that it will often rapidly dissipate - despite the alarming presentation - providing NIV can be instituted in a timely enough manner.

Therefore in distinction to exacerbations of COPD or of asthma where NIV is much more likely to be required for a much longer period of time, acute cardiogenic pulmonary

oedema will often settle over several hours of CPAP under close observation in the ED. Patients can often be weaning off their CPAP within the ED, in distinction to patients with COPD or asthma who will more often require admission to a High Dependency Unit for *ongoing* NIV.

Appendix 1: Weaning from CPAP:



References:

1. Torres J.D et al. Non-invasive ventilation, Update on Uses for the Critically Ill Patient, vol 1 no. 2. EM Critical Care, August 2011
2. Fessler HE, Brower RG et al Mechanism of Reduced LV Afterload by Systolic and Diastolic Positive Pleural Pressure. April 1988
3. Bersten AD, Holt MD, Acute Cardiogenic Pulmonary Edema, Current Opinion in Critical Care 1995; 1: 410-419.

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