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Assisted ventilation in acute exacerbation of chronic obstructive pulmonary disease

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ABSTRACT In the UK, over three million people suffer from COPD, and over 30,000 people die as a result each year. Acute exacerbations of COPD are a particularly heavy burden to patients, and to the Health Service. Patients often present with AHRF, and this presentation accounts for 20% of all COPD admissions. Non-invasive ventilation is of proven efficacy in the management of AHRF associated with an exacerbation of COPD. Systematic reviews and meta-analysis have shown that the use of NIV in addition to standard medical therapy significantly reduces in-hospital mortality, the need for invasive ventilation, and the length of stay in hospital, when compared with standard medical therapy alone. Non-invasive ventilation is associated with greater improvements at one hour in pH, $PaCO_2$, and respiratory rate.

Ideally, patients who require NIV should be able to protect their airway, be co-operative with (and tolerant of) the technique, and be otherwise medically stable. It must be remembered that COPD with AHRF patients who survive treatment with NIV have a high risk of subsequent death and life-threatening events. At the same time the reported outcome for patients admitted with AHRF secondary to COPD tends to be worse in the group not treated with NIV. However, it is not sufficiently poor to render IMV inappropriate for COPD populations as a whole.

A decision on the appropriateness of intubation and mechanical ventilation if NIV fails should be taken before NIV is initiated and this decision should be taken by senior medical staff with input from a critical care physician if necessary. Non-invasive ventilation should not be used as a substitute for tracheal intubation when the latter intervention is clearly more appropriate. In addition, it is suggested that patients with a pH <7·25, or who are candidates for intubation, should be managed on ITU if at all possible, and should certainly have critical care input in their management.

KEYWORDS COPD, exacerbation of COPD, non-invasive ventilation

LIST OF ABBREVIATIONS Acute hypercapnic respiratory failure (AHRF), chronic obstructive pulmonary disease (COPD), non-invasive ventilation (NIV), invasive mechanical ventilation (IMV), continuous positive airway pressure (CPAP), respiratory rate (RR), British Thoracic Society (BTS), non-invasive positive-pressure ventilation (NIPPV), inspiratory positive air pressure (IPAP), expiratory positive air pressure (EPAP), arterial blood gases (ABG), high dependency unit (HDU), intensive therapy/care unit(ITU/ICU), arterial oxygen saturation (SaO_2)

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EPIDEMIOLOGY OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE

Chronic obstructive pulmonary disease is a leading cause of morbidity and mortality worldwide. It is the sixth leading cause of adult deaths, and is expected to become the third leading cause by 2020. Around 80–90% of all cases can be attributed directly to smoking.

In the UK over three million people suffer from COPD and more than 30,000 individuals die as a result each year. The condition is responsible for approximately 10% of emergency admissions to hospital and costs the Health Service in the UK an estimated £500 million per year (2001 figures).

Acute exacerbations of COPD are a heavy burden to the Health Service and patients presenting with AHRF account for approximately 20% of all COPD admissions. Between one-fifth and one-third of patients admitted with AHRF secondary to an acute exacerbation of COPD will die in hospital, and this is despite advances in the

techniques of supported ventilation.

Factors associated with an increased mortality risk are:

- older age;
- raised $PaCO_2$;
- lower pH (<7·25);
- the need to progress to intubation and mechanical ventilation; and
- a history of repeated acute exacerbations of COPD.

NON-INVASIVE VENTILATION

The provision of ventilatory support via non-invasive ventilation has become increasingly popular over the past decade. It is of most proven benefit in COPD but has also been used effectively in decompensated respiratory failure associated with chest wall disease and in obstructive sleep apnoea. Its role in cardiogenic pulmonary oedema is less well established, although it can be used as second-line treatment for a patient with this condition who fails to respond to CPAP and standard therapy.

Non-invasive ventilation is particularly beneficial in the treatment of AHRF, associated with severe exacerbations of COPD. Acute hypercapnic respiratory failure is defined by the presence of moderate to severe acidosis (pH <7·35), hypercapnia ($PaCO_2$ >6 kPa), and a RR of >24 breaths per minute.

A great deal of research has been directed at investigating the optimal use of NIV, and recent guidelines have been produced by the BTS to aid both expert and non-expert physicians.

ROLE OF NIV IN ACUTE EXACERBATIONS OF COPD

The most common type of NIV used to treat AHRF is NIPPV. Non-invasive positive-pressure ventilation provides a combination of pressure support and positive end-inspiratory pressure. The most common NIPPV device used in recent randomised controlled trials has been the bi-level pressure support machine, which uses two different positive pressures, IPAP and EPAP applied to the airway via a mask (either facial or nasal). Room air is entrained and supplemental oxygen is provided as required to achieve an inspired oxygen concentration (FiO_2) up to 35%.

The IPAP component:

- Is capable of creating an inspiratory positive airway pressure of 20–30 cm H_2O (although a fairly standard initial setting will be 12–20 cm H_2O);
- Also provides ventilation.

The EPAP component:

- Is usually set to create an expiratory positive airway pressure of 4–5 cm H_2O; higher pressures are rarely tolerated;
- Recruits under-ventilated lung, thereby improving the ventilation/perfusion ratio;
- Eliminates exhaled air via expiratory port, thereby reducing re-breathing.

EVIDENCE FOR USE

Clinical trials have reported variable degrees of benefit with NIV and, unsurprisingly, the success of the technique is influenced by individual patient characteristics, the location of ventilation, and the expertise of clinical personnel. Systematic reviews and meta-analysis have shown that NIV works in AHRF secondary to acute exacerbation of COPD and NIV in addition to standard medical therapy, compared with standard medical therapy alone, significantly reduces:

- in-hospital mortality;
- the need for intubation and invasive ventilation; and
- duration of stay in hospital.

Non-invasive ventilation is also associated with greater improvements at one hour in pH, $PaCO_2$, and respiratory rate. These results were confirmed in a UK hospital multi-centre randomised controlled trial that demonstrated the clinical benefit accruing from the use of NIV in patients with COPD who were mildly or moderately acidotic. This study was conducted in the setting of a general ward in a District General Hospital.

WHICH PATIENT?

Ideally, patients who require NIV should be capable of protecting their airway and should be cooperative and otherwise stable medically. Recent studies have suggested that patients with initially mild exacerbations of COPD may not benefit from NIV. Non-invasive ventilation is particularly useful in acute or acute on chronic respiratory failure due to exacerbation of COPD when the $PaCO_2$ is >6 and the pH is 7·25–7·35 (H^+ 45–56 mmol/L) despite standard therapy and controlled oxygen.

CONTRAINDICATIONS

A careful review of the patient's condition is required before commencement of NIV. This treatment modality is not appropriate in end-stage disease or for patients with (multiple) severe co-morbidity. However, NIV may be considered as a 'ceiling of care' when progression to intubation is deemed inappropriate.

Many contraindications are relevant and clinical experience is vital when deciding the appropriateness of assisted ventilation for an individual patient.

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Absolute contraindications are:

- facial trauma/burns;
- fixed obstruction of upper airway; and
- vomiting.

While relative contraindications include:

- recent facial, upper airway, or upper gastrointestinal tract surgery;
- an inability to protect the airway;
- life-threatening hypoxaemia;
- haemodynamic instability;
- severe co-morbidity;
- impaired consciousness;
- confusion/agitation;
- bowel obstruction;
- copious respiratory secretions;
- focal consolidation on chest radiograph; and
- undrained pneumothorax.

MONITORING

Regular clinical assessments are mandatory and include review of:

- chest wall movement;
- co-ordination of respiratory effort with the ventilator;
- accessory muscle recruitment;
- heart rate;
- respiratory rate;
- patient comfort; and
- mental state.

Continuous oxygen saturation monitoring is required and supplemental oxygen should be given with the aim of SaO_2 between 85 and 90%.

Arterial blood gases should be taken ideally at 0, 1, and 4 hours, and at intervals thereafter as required.

Any change in FiO_2 or ventilator setting should be followed by a review of oxygen saturation, ABG, and clinical assessment after one hour.

IS YOUR PATIENT IMPROVING?

Clinically, early improvement will be manifested by a decrease in breathlessness and an increasingly alert mental state, together with improvements in pH and $PaCO_2$. A lack of progress towards correction of these parameters is associated with failure of NIV.

A recent study in an emergency department in Switzerland looked at factors associated with failure of NIV. They defined failure as the requirement of endotracheal intubation at any time. Mortality in the failure group was found to be significantly higher when compared with patients who were not intubated. In this study there was an overall failure rate of 31% and independent factors associated with NIV failure were a pH <7·25 and RR >20 per minute after one hour of NIV.

Failure later in the course of a patient's admission after a period of successful NIV is associated with a poor prognosis and 'late failure' is more common in those with a low activity of daily living score, in the presence of medical complications, and in those with a lower pH on admission.

It is important to have a clear management plan of what to do if NIV fails and this calls for the experience of a senior physician. If intubation is a viable proposition, early liaison with the ICU is mandatory.

OUTCOME

The immediate outcome for patients treated with NIV is associated with significant reductions in in-hospital mortality, but data regarding long-term follow-up are limited. Chronic obstructive pulmonary disease patients with AHRF who survive treatment with NIV have a higher risk of subsequent death and of life-threatening events when NIV is discontinued as well as after discharge from hospital.

A team in Hong Kong followed a cohort of such patients for a year after discharge. They discovered that 79·9% of their patients had been re-admitted, 63·3% had another life-threatening event, and 49·1% had died. The survivors had spent a median time of 12% of the subsequent year in hospital. It seems therefore that emergency NIV treatment is a harbinger of severe pre-terminal or terminal disease in COPD patients and this may reflect the underlying pathology and morbidity of AHRF in COPD.

A UK study found that the median length of survival for a NIV-treated group was 16·8 months, compared with 13·4 months in a standard medical therapy control group.

HOW TO SET UP NIV

The following is a quick guide to setting up NIV and is taken from the BTS guidelines.

1 Decide a management plan if the trial of NIV fails. This should involve discussion with senior medical staff and the plan should be clearly documented in the hospital records.
2 Decide where the trial of NIV should take place (ICU, HDU, or ward).
3 Consider informing ICU.
4 Explain NIV to the patient.
5 Select a mask to fit the patient and hold it in place for the first few minutes.
6 Set up the ventilator as shown in Table 1.

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7 Attach pulse oximeter to patient.
8 Commence NIV, holding the mask in place for the first few minutes.
9 Secure the mask in place with straps/headgear.
10 Re-assess after a few minutes.
11 Adjust settings if necessary.
12 Add oxygen if SpO_2 <85%.
13 Instruct the patient on how to remove the mask and how to summon help.
14 Clinical assessment and check ABG at 1–2 hours.
15 Adjust settings/oxygen if necessary.
16 Institute an alternative management plan if $PaCO_2$ and pH have deteriorated after 1–2 hours of NIV on optimal settings. If no improvement, consider continuing NIV and reassess with repeat ABG after 4–6 hours. If no improvement institute the alternative management plan.

INVASIVE MECHANICAL VENTILATION IN AN ACUTE EXACERBATION OF COPD

The reported outcome for patients admitted with AHRF secondary to COPD after intubation tends to be worse than for patients treated with NIV. However, the outcomes of IMV are not sufficiently poor to render IMV universally inappropriate for patients with COPD. A one-year survival of 44–66% has been recorded, and this may reflect the fact that patients receiving IMV tend to be more ill than those treated with NIV.

A decision on the suitability of admission to ICU for IMV should be based on the severity of the underlying COPD, the potential reversibility of the precipitating cause of the exacerbation, the patient's quality of life, and the presence of severe co-morbidity. This decision should be made by senior medical staff in consultation with ICU physicians at an early stage. Non-invasive ventilation should not be used as a 'holding measure' if the patient requires IMV and if this form of ventilation is considered appropriate for an individual patient.

ADVANTAGES OF NIV OVER IMV

- A fundamental advantage of NIV comes from the avoidance of tracheal intubation with its associated mortality and morbidity including the very real risk of ventilator associated pneumonia.

Mode	Spontaneous/timed
EPAP	4–5 cmH_2O
IPAP	12–15 cm H_2O (to be increased as tolerated to a maximum of 20 cm H_2O)
Triggers	Maximum sensitivity
Back up rate	15 breaths/min
Back up I:E ratio	1:3

TABLE 1 Ventilator set up.

- Non-invasive ventilation can be used in clinical areas other than ICU at an early stage.
- Patients can eat and communicate relatively normally.
- Nebulised medications can be administered more easily.
- Physiotherapy and expectoration are easier to achieve.

KEYPOINTS

- Non-invasive ventilation should be considered the intervention of choice in patients with decompensated AHRF secondary to COPD who have failed to respond to standard medical therapy unless immediate intubation is required and is appropriate.
- Non-invasive ventilation offers a variety of benefits including:
  a. reduced mortality;
  b. reduced need for intubation;
  c. greater improvements at one hour in pH, $PaCO_2$, and respiratory rate;
  d. a shorter duration of stay in hospital.
- The one-year morbidity and mortality of patients treated with NIV for AHRF is poor. At one-year post-treatment, 80% have been re-admitted, 63% have had another life-threatening event, and 50% have died.
- Ideally patients who require NIV should be able to protect their airway, be co-operative, and be otherwise medically stable.
- Non-invasive ventilation should not be used as a 'holding measure' if the patient requires IMV. Early decisions should be made by senior staff in conjunction with the ICU if necessary.

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PAST PRESIDENTS

The Maclagan Dynasty

In the history of the College, there have been several instances when succeeding generations of one family have been Fellows, even Presidents. Few have been Presidents of both the Royal College of Physicians and Surgeons of Edinburgh before or since the MacLagan dynasty.

David Maclagan (1785–1865)

Educated at the Royal High School of Edinburgh and Edinburgh University, he graduated MD in 1805, his thesis entitled *De Sanitate tuenda* before spending some time at St George's Hospital London. By this time the Napoleonic Wars were at their height. Wellington and combined forces of Britain, Spain and Portugal were facing Napoleon's generals in the Iberian Peninsula (1808–1814). David enlisted as Assistant Surgeon, alongside Alexander Lesassier, the nephew of James Hamilton, President of the RCPE and Professor of Midwifery, Edinburgh. He went to Portugal in 1809, and in 1810 became staff surgeon to the 25,000-strong 9th Portuguese Brigade under the command of Colonel Manley Power, seeing service at the battles of Badajoz (1812) Salamanca (1812) and Nive (1813) and was subsequently awarded the Peninsular Medal with six clasps and promoted to 'Physician to the Forces', with a military career much more distinguished and honourable than that of Lesassier. Records show that, in addition to the horrific wounds, major infections must have challenged him and his staff.

Whether or not he was at Waterloo in 1815 is not known. He returned to Edinburgh and set up in surgical practice in 1816, being elected FRCSEd in that same year, and becoming President in 1826. In 1828 he was elected a Fellow of the Royal Society of Edinburgh and appointed Surgeon-in-Ordinary to Her Majesty in Scotland in 1838. Edinburgh was unique at that time in having a Chair of Military Surgery (1806–55), and David joined the second incumbent, Professor Sir George Ballingall (1780–1855), as a lecturer.

At the age of 63 years, by then famous as a lecturer and a surgeon with a thriving practice, he changed his career and became a physician. He was later elected President of the Royal College of Physicians of Edinburgh in 1856. He had seven sons, three of whom followed him into medicine. One, Douglas, did so with great distinction.

Andrew Douglas Maclagan (1812–1900)

The eldest of David's seven sons, he was born in Ayr in 1812 after his father had returned from the Peninsular War. It has been said that he was baptised by the same minister who had baptised Robert Burns, but that is very unlikely.

Douglas, like his father, went to Edinburgh's Royal High School and University, gaining his LRCSE in 1831, followed by his FRCSEd and MD in 1833. After visiting Paris, Berlin and London he returned to Edinburgh as an assistant to his father who by this time was a famous surgeon and academic. He must soon have realised that surgery was not his forte and he gave it up to lecture on *Materia Medica* in Edinburgh's Extra-Mural School of Medicine.

He was appointed by the Crown to the Chair of Medical Jurisprudence in 1862, three years before his father died. He became an authority on the analysis of poisons and, as a result, was involved in many famous court cases.

Although he had not worked as a surgeon for many years, he served as President of the Royal College of Surgeons of Edinburgh 1859–1861 and as President of the Royal College of Physicians of Edinburgh 1884–87. The Maclagan dynasty continued, with two of his sons becoming doctors. Could any doctor wish for a better epithet: '...not a great physician but a splendid man – a fine musician, raconteur, wit, polished, courteous and lovable'?

Derek Doyle
Obituaries Editor, The Journal *RCPE*

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