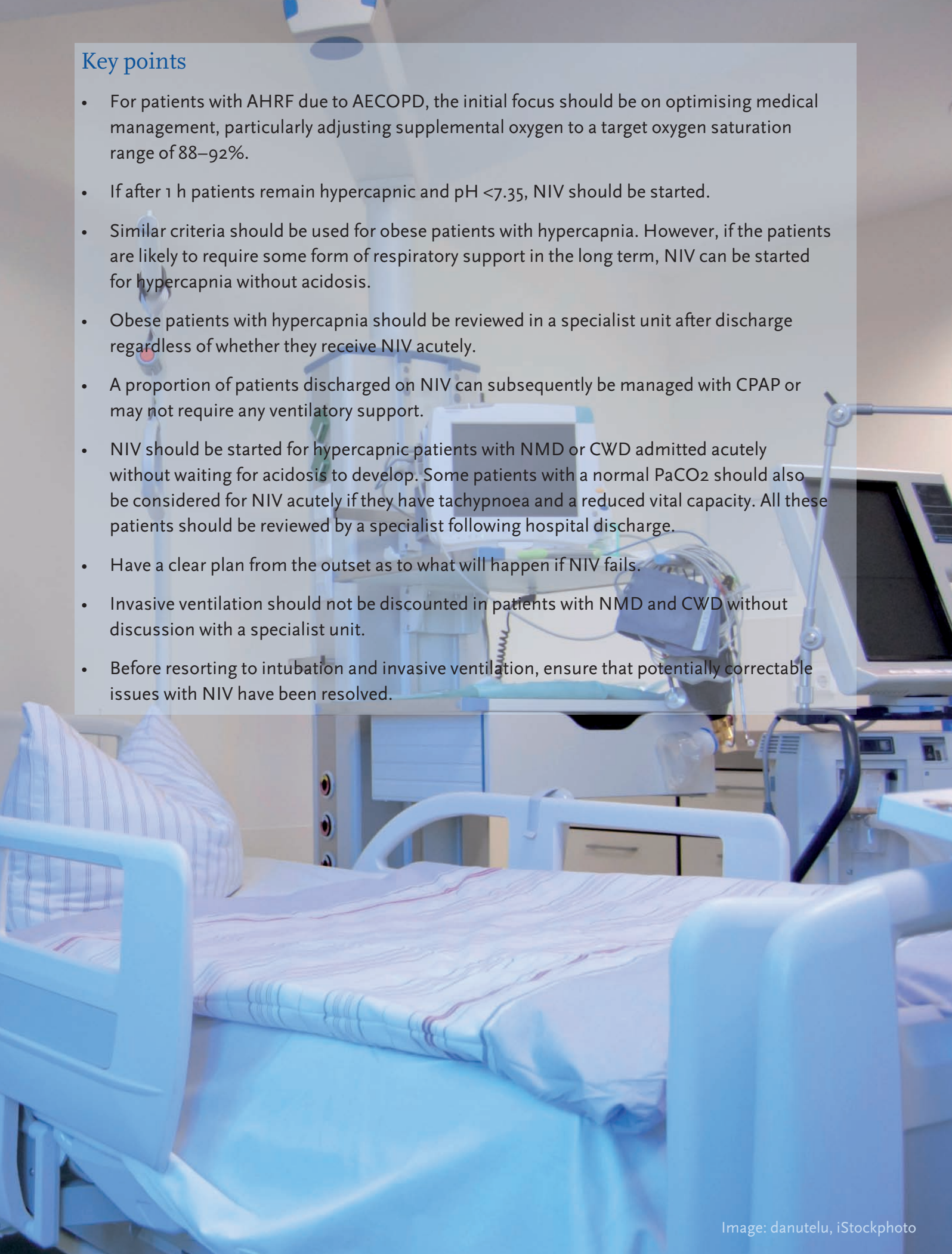
Key points

- For patients with AHRF due to AECOPD, the initial focus should be on optimising medical management, particularly adjusting supplemental oxygen to a target oxygen saturation range of 88–92%.
- If after 1 h patients remain hypercapnic and pH <7.35, NIV should be started.
- Similar criteria should be used for obese patients with hypercapnia. However, if the patients are likely to require some form of respiratory support in the long term, NIV can be started for hypercapnia without acidosis.
- Obese patients with hypercapnia should be reviewed in a specialist unit after discharge regardless of whether they receive NIV acutely.
- A proportion of patients discharged on NIV can subsequently be managed with CPAP or may not require any ventilatory support.
- NIV should be started for hypercapnic patients with NMD or CWD admitted acutely without waiting for acidosis to develop. Some patients with a normal $PaCO_2$ should also be considered for NIV acutely if they have tachypnoea and a reduced vital capacity. All these patients should be reviewed by a specialist following hospital discharge.
- Have a clear plan from the outset as to what will happen if NIV fails.
- Invasive ventilation should not be discounted in patients with NMD and CWD without discussion with a specialist unit.
- Before resorting to intubation and invasive ventilation, ensure that potentially correctable issues with NIV have been resolved.



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Noninvasive ventilation in the management of acute hypercapnic respiratory failure

Educational aims

- To discuss the role of noninvasive ventilation (NIV) in the management of acute hypercapnic respiratory failure in various conditions.
- To discuss the common problems encountered during NIV.
- To provide practical considerations for setting up and delivering an optimal NIV service.

Summary

Noninvasive ventilation (NIV) is considered the standard of care in the management of acute hypercapnic respiratory failure secondary to chronic obstructive pulmonary disease. It can be delivered safely in any dedicated setting ranging from emergency and medical admissions departments to high-dependency and intensive care units. It reduces the demand for invasive mechanical ventilation, decreases in-hospital mortality and shortens hospital stay. The way the NIV service is delivered will depend on the model of hospital care and this varies greatly from country to country. Adequately trained staff and appropriate monitoring facilities, available around the clock, are important. A successful outcome is dependent on good patient selection and the correct implementation of NIV.

Statement of Interest
M.W. Elliott has received honoraria from Resmed and Philips Respironics; has received travel expenses from Curative Medical; and holds stock or stock options in Curative Medical and GSK.

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Noninvasive ventilation (NIV) in the management of acute hypercapnic respiratory failure (AHRF) due to an acute exacerbation of chronic obstructive pulmonary disease (AECOPD) has been one of the major advances in respiratory care over the last

decade. It refers to the provision of ventilatory support through the patient's upper airway using a well-fitting mask. Invasive ventilation refers to the provision of ventilatory support bypassing the upper airway using a tracheal tube, laryngeal mask or tracheostomy. Reported survival rates with invasive mechanical ventilation are between 20% and 50% [1]. Endotracheal intubation (ETI) is associated with a wide range of complications, including ventilator-associated pneumonia (VAP). For every day intubated, the patient has a 1% risk of developing VAP, resulting in increased morbidity and mortality [2, 3]. Other issues include difficulty weaning from invasive ventilation, with a diagnosis of COPD being the best predictor of weaning difficulty [2], the need for sedation and increased healthcare costs.

NIV has many potential advantages. Patients can be managed outside the intensive care setting, a potentially distressing environment for many patients, also reducing the pressure on intensive care unit (ICU) bed occupancy and healthcare costs. Ventilatory support can be intermittent, allowing for gradual weaning. With NIV, infection risk is reduced [4]. Patients can cooperate with physiotherapy, receive nebulised medications normally, expectorate, and communicate with family and staff.

However, NIV does have limitations. Inappropriately prolonged NIV may delay intubation and ventilation, resulting in a worse outcome [5]. The mask interface may be uncomfortable and claustrophobic, such that some patients cannot tolerate it. Around 2% of patients develop pressure sores, usually over the nasal bridge, which may make further NIV difficult [6].

Table 1. *Indications for NIV*

1	Hypercapnic respiratory failure secondary to AECOPD
2	Chest wall deformity/neuromuscular diseases
3	Obesity hypoventilation syndrome/decompensated obstructive sleep apnoea
4	Chest trauma
5	Weaning
6	Cystic fibrosis/bronchiectasis As a bridge to transplantation[#]
7	Palliative care

[#]: NIV shold be considered when patients are awaiting lung transplant. This is only for acute hypercapnic respiratory failure; use of NIV in chronic hypercapnic respiratory failure is beyond the scope of this article.

Indications for NIV

NIV has been used in a wide range of conditions (table 1). A number of contraindications have been described but these should be considered relative rather than absolute. It is important to note that most are theoretical and based upon the fact that they were exclusion criteria in randomised controlled trials rather than because there has been positive evidence of harm. Some more recent experience, such as in coma [7] and following upper gastrointestinal surgery [8], shows that NIV can be used successfully in these situations. The clinical setting is also important; if NIV is the ceiling of care, and therefore the only treatment option, acceptance of a relative contraindication is appropriate, whereas it may not be if intubation is considered appropriate. It is better, therefore, to consider these as situations requiring special care rather than contraindications *per se*. There are some situations (table 2), however, in which NIV is almost never appropriate, such as severe fixed upper airway obstruction requiring tracheostomy, and severe facial burns/trauma or anything that renders it impossible to fix an interface.

NIV is best considered as complementary, rather than an alternative, to invasive ventilation, lying between no ventilatory support, and ETI and ventilation. Its aim is usually to prevent respiratory failure progressing to the point at which patients will require intubation. There are four scenarios in which NIV may be used:

- in patients at an earlier stage of respiratory failure than that at which ETI would be considered;
- as a trial with a view to early intubation if NIV fails;
- as a ceiling of treatment in patients who are deemed high risk/unfit for invasive ventilation; and
- for patients who develop respiratory failure post-extubation or to facilitate weaning from invasive ventilation (this will not be discussed in this article).

Most of the randomised controlled trials have been performed in patients with

AECOPD and recommendations for the use of NIV in other conditions are largely based upon the experience in COPD. NIV is used in patients with acute cardiogenic pulmonary oedema (CPO); although patients may become hypercapnic, this usually resolves quickly and patients do not have chronic hypercapnic respiratory failure and, therefore, CPO will not be discussed in this article.

NIV in COPD

An acute exacerbation of COPD is one of the commonest causes of emergency admission to hospital [9], with most severe patients likely to have exacerbations requiring hospital admission [10]. Acute exacerbations are important events in the natural course of disease [11], leading to a worsening in lung function and health-related quality of life [12, 13]. An AECOPD requiring hospitalisation has a poor prognosis, with an in-patient mortality rate of 7.7% [14] and a median survival of 3.6 years from the first admission [15]. A retrospective audit of 1400 admissions with AECOPD revealed that 34% were readmitted and 14% died within 3 months [16]. The initiation of NIV can be considered in a number of clinical areas.

NIV in the ICU

The first randomised controlled trail (RCT) of NIV for AHRF due to AECOPD was conducted in the ICU. Brochard *et al.* [17] compared NIV with standard treatment in 85 patients with AECOPD. 42 patients were randomly assigned to receive standard therapy and 43 patients to receive NIV. The two groups had similar clinical characteristics on admission to the hospital. The use of NIV significantly reduced the need for endotracheal intubation (26% in the NIV group *versus* 74% in the standard-treatment group, $p<0.001$). The frequency of complications was significantly lower in the NIV group (16% *versus* 48%, $p=0.001$) and the mean±SD hospital stay was significantly shorter for patients receiving NIV (23±17 *versus* 35±33 days, $p=0.005$). The in-hospital mortality rate was also significantly reduced with NIV (9% *versus* 29%, $p=0.02$). The benefits of NIV have been confirmed in a large number of other RCTs in many different countries and healthcare systems [18]. In no trial has NIV been shown to be inferior to standard therapy. In all of these studies, patients deemed to need ETI were excluded.

Table 2. *Situations requiring special care with NIV*

1	Recent upper airway/gastrointestinal tract surgery
2	Inability to protect airway
3	Haemodynamic instability
4	Impaired consciousness/coma
5	Vomiting
6	Bowel obstruction
7	Undrained pneumothorax
8	Confusion/agitation

Conti *et al.* [19] compared NIV and mechanical ventilation with ETI in 49 patients with an AECOPD who failed standard medical treatment. Patients were randomly allocated to NIV (n=23) or ETI and mechanical ventilation (n=26). Not surprisingly, their patients were sicker than those reported in previous studies, as evidenced by a mean pH of 7.2. There were two important messages from this study. Firstly, in these sicker patients, NIV was no worse than ETI and mechanical ventilation. Secondly, in those who could be managed successfully with NIV, there was an advantage both in the short term (reduced duration of ICU stay) but also in the year after hospital discharge (fewer readmissions and patients needing *de novo* long-term oxygen therapy). The intubation rate of 52% in the NIV group was higher than in other RCTs, which is not surprising, given that these were a sicker group of patients. In common with other studies, some patients were still excluded, including those intubated prior to transfer to the ICU, or those with respiratory arrest or pauses.

NIV outside the ICU

General wards

Following the success of NIV in the ICU, because sedation and paralysis are not needed, and because NIV can be initiated at an earlier stage in the natural history of the evolution of respiratory failure before ETI and mechanical ventilation are considered appropriate, the use of NIV on general wards has been investigated in a number of studies. In the largest, it was confirmed that delivery of

NIV on a general ward is feasible [20]. In this multicentre UK trial comparing NIV with standard therapy, early institution of NIV reduced treatment failure, defined by prior criteria, to 15% from 27% and hospital mortality was halved (20% *versus* 10%, $p<0.05$). This approach was very cost effective [21]. In a *post hoc* subgroup analysis, the outcome was worse in patients with pH <7.30. Thus, sicker, more acidotic patients should be monitored more closely.

Emergency department and acute admissions unit

This will be the first point of contact for majority of the patients. The use of NIV can be considered here but the main focus at this stage should be to optimise medical treatment. Approximately 20% of patients with an AECOPD are acidotic on arrival in the emergency department and 20% of these patients correct their pH with optimal medical therapy alone [22]. Overoxygenation is a very important cause of acidosis and hypercapnia. A study from Australia showed a higher mortality in patients given uncontrolled oxygen during ambulance transfer compared with those in whom it was titrated to an oxygen saturation of 88–92% [23]. It has been shown that controlled oxygen delivery is underemphasised and overlooked in ambulance and nursing staff education [24]. The use of high-flow oxygen contributes to an increased length of stay, more frequent admission to a high-dependency unit and greater use of NIV among patients who achieve a higher arterial oxygen saturation [25]. Patients who are found to be acidotic on arrival should be given oxygen, targeting an oxygen saturation of 88–92% [26]. Other medical treatment, such as nebulised bronchodilators, steroids and antibiotics, should be administered if indicated. Studies in the emergency department in patients with mild or no acidosis have not shown any benefit from NIV [27]. However, NIV may be started in the emergency room in patients with very severe acidosis.

Following medical therapy, patients should be reassessed and the following simple algorithm (fig. 1) should guide the clinical decision on NIV.

NIV in AHRF secondary to obesity hypoventilation

The increasing prevalence of obesity is alarming. The World Health Organization estimates that by 2015, ~10% of the global population will be obese [28]. Obesity hypoventilation syndrome (OHS) is defined by a body mass index (BMI) >30 $kg \cdot m^{-2}$ and chronic alveolar hypoventilation leading to

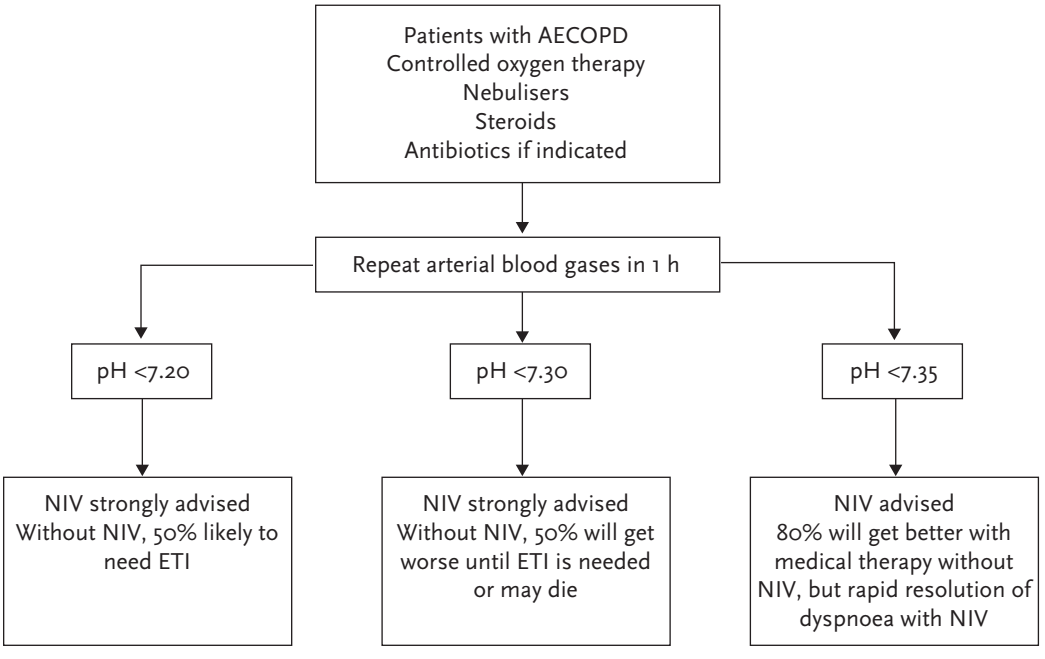

Figure 1
Algorithm to guide the clinical decision on NIV.

daytime hypercapnia (arterial carbon dioxide tension ($PaCO_2$) >6 kPa), after exclusion of all other obstructive or restrictive diseases, chest wall disorders (CWDs) and neuromuscular diseases (NMDs) [29]. In developed nations, approximately one-third of patients with a BMI $\geqslant$35 kg·m^{-2} have chronic respiratory failure [30]. AHRF in obese patients is an increasingly common cause of hospitalisation and admission to ICUs. There is a paucity of data regarding the use of NIV in of AHRF in obese patients.

RABEC *et al.* [31] showed that AHRF in obese patients can be treated with NIV, with an improvement in $PaCO_2$, and in the majority of cases (39 out of 41, 95%), ETI was avoided. DUARTE *et al.* [32] reported outcomes in 50 morbidly obese patients with acute respiratory failure treated with mechanical ventilation. 33 (66%) patients were treated with NIV, of whom 21 avoided intubation and 12 required intubation. Mean BMI for the NIV success group was significantly less than for the NIV failure group (46.9±8.9 and 62.5±16.1 kg·m^{-2}, respectively; p=0.001). Hospital mortality for the invasive ventilation and NIV failure group was increased compared with those successfully managed with NIV. Though not a randomised controlled study, it showed that NIV could be used with benefit. CARRILLO *et al.* [33] compared the outcome with NIV, using a similar protocol (NIV initiated when pH <7.35 and PCO_2 >45 mmHg (6 kPa)), in patients with AHRF due to OHS (n=173) or COPD (n=543). Patients with OHS had less late NIV failure (7% *versus* 13%, p=0.037), a lower hospital mortality (6% *versus* 18%, p=0.001) and a higher 1-year survival (OR 1.83, 95% CI 1.24–2.69; p=0.002). However, survival adjusted for confounders (adjusted OR 1.41, 95% CI 0.70–2.83; p=0.34), NIV failure (6% *versus* 11%, p=0.11), length of stay and hospital readmissions were similar in both groups. Among patients with COPD, obesity was associated with less late NIV failure and hospital readmission. The authors concluded that patients with OHS could be treated with NIV with similar efficacy and better outcomes than patients with AECOPD, and using the same criteria for initiation.

Despite the limited RCT evidence, NIV has become the main modality of ventilatory assistance for these patients. Similar criteria to AECOPD should be used to determine when NIV should be started. In addition, however, some patients with OHS will require domiciliary respiratory support with NIV or continuous positive airway pressure (CPAP); these include those with significant chronic symptoms or comorbidities, particularly cor pulmonale. In these patients with hypercapnia, it is reasonable to start NIV even if the patient is not acidotic. Not all patients who require NIV for AHRF due to obesity require long-term ventilation; a proportion can be managed with CPAP and others can be weaned completely [34].

NIV in extrapulmonary restrictive lung diseases

Extrapulmonary restrictive lung diseases are caused by deformities of the thoracic rib cage or by NMDs, both of which restrict lung expansion. This results in a restrictive lung function characterised by reduced vital capacity, total lung capacity and functional residual capacity. CWD is caused by kyphoscoliosis, thoracoplasty, flail chest, ankylosing spondylitis and Klippel–Feil syndrome. Ventilatory failure is rare in the absence of severe deformity or when scoliosis develops after the age of 7 years unless there is associated NMD (paralytic scoliosis) [35]. The risk of hypercapnic respiratory failure increases when the vital capacity falls below 1–1.5 L [35]. In NMD, respiratory muscle involvement is universal in certain conditions but can occur in almost any generalised muscle disease (table 3). It is suggested that the possibility of respiratory muscle involvement be considered in every patient with generalised muscle disease. Transient ventilatory failure can also be seen in polymyositis, critical care polyneuropathy, Guillain–Barré syndrome and cold ischaemic phrenic nerve damage following cardiothoracic procedures.

There have been no randomised controlled trials evaluating the role of NIV in AHRF in these patients but because of its beneficial effects in the domiciliary setting, because these patients usually tolerate NIV well and because of potential difficulty weaning these patients from invasive ventilation, a trial of NIV would usually be considered in patients with AHRF due to these conditions. The combined approach of optimal medical therapy, physiotherapy, suction, cough assist device, airway clearance techniques and a stint of NIV can be very

Table 3. Respiratory muscle involvement in muscle diseases

Inevitable	Duchenne muscular dystrophy Amyotrophic lateral sclerosis
Frequent	Acid maltase deficiency Limb girdle muscular dystrophy types 2C, 2D, 2F, 2I Nemaline myopathy Myotonic dystrophy
Occasional	Emery–Dreifuss muscular dystrophy Minicore myopathy Becker muscular dystrophy Bethlem myopathy
Rare	Facioscapulohumeral muscular dystrophy Mitochondrial myopathy Central core disease Limb girdle muscular dystrophy 1, 2A, B, G, H Oculopharyngeal muscular dystrophy Distal myopathy

effective in avoiding ETI and MV. Indeed, VIANELLO *et al.* [36] have shown that the outcome with NIV is better than with invasive ventilation in NMDs. If patients do require ETI, they should be extubated and weaned to NIV as soon as possible. Most patients with NMD developing AHRF will benefit from long-term domiciliary ventilatory support, particularly if they remain hypercapnic by day or night.

The specific issues encountered during NIV in these patients are as follows.

- Patients with bulbar weakness or those who cannot maintain head posture may develop upper airway obstruction, and this may particularly pose a problem during sleep. This is characterised by increased mask leak along with reduced chest expansion. The head position can be altered and/or the expiratory positive airway pressure can be titrated up.
- There is a significant risk of aspiration in patients with bulbar weakness. Aspiration can be of retained oral secretions or during eating and drinking. The potential risk can be evaluated by a swallowing assessment performed at the bedside and, in some cases, may need a detailed speech and language evaluation. Alternate feeding methods, such as a nasogastric tube in the short term or gastrostomy in the long term, can be considered if the patient is found to be at high risk of aspiration.
- Sputum retention and mucus plugging due to a reduction in the ability to cough are common. These patients need specialist chest physiotherapy, usually including cough assist devices [37] and mucolytics. Occasionally, therapeutic bronchoscopy may be required if the above measures prove ineffective.
- Unexplained or persistent tachycardia ($>$110 beats·min^{-1}) should lead to a cardiological assessment, including an ECG and echocardiography, as some patients will have an underlying cardiomyopathy.

There has been nihilism regarding the use of invasive ventilation in these patients but, as life can be prolonged and quality of life maintained by domiciliary NIV, an opinion from a specialist unit should be obtained before a decision is made not to intubate the patient (in the absence of a valid advance directive).

Ideally, invasive mechanical ventilation and tracheostomy should have been discussed with the patient and their carers in advance with a tailored care plan in place. Advanced cardiopulmonary failure with pulmonary hypertension and manifestations of right heart failure are not necessarily markers of "end-stage" disease, as these features often regress when ventilatory failure is controlled with domiciliary nocturnal ventilation. If in doubt, invasive mechanical ventilation is strongly advised when NIV is considered inappropriate from the outset or the patient deteriorates with NIV.

By the time hypercapnia develops these patients usually have a marked reduction in respiratory reserve and most will require domiciliary NIV. Even if the patient is not acidotic, NIV is usually indicated if the patient is hypercapnic. It should also be considered in some patients with a reduced vital capacity and tachypnoea even if the patient is normocapnic; unless the cause of the respiratory decompensation is addressed, these patients will tire and develop hypercapnia. An admission with AHRF should lead to long-term specialist review.

Practical considerations

Setting up and delivering an NIV service

Location

An NIV service should be designed to meet local needs. Where NIV is delivered will

depend on local circumstances. In some hospitals, all acute NIV will be delivered in the ICU, whereas in others, it will be in a specialist NIV unit; but in all cases, close relationships with the ICU are important, as a subset of patients will inevitably need to be transferred to the ICU in the case of NIV failure and some patients will need to be stepped down to an NIV unit for ongoing respiratory support.

Staffing and training

NIV success depends on adequate staff and appropriate training. It has been shown that as experience with NIV increases, treatment failure in sicker patients decreases [38]. Lack of knowledge and expertise amongst clinicians and inadequate respiratory therapist training are important reasons for NIV failure [39]. Therefore, regular training sessions both for clinicians and other staff are mandatory. The training programme should address:

- knowledge of the causes of hypoxaemic and hypercapnic acute and chronic respiratory failure;
- criteria for NIV treatment, and knowledge of when NIV should be used with special care or is contraindicated;
- treatment options prior and during NIV, and other options in case of NIV failure;
- interpretation of arterial blood gases;
- identifying the signs of worsening respiratory failure; and
- the ability to troubleshoot problems and recognise treatment failure.

The staff should also be trained in the use of all ventilators and mask interfaces used on the unit. A designated clinician should have overall responsibility. A local protocol and troubleshooting guide should be implemented. Clinical outcomes should be audited.

NIV can be a time-consuming procedure; there are no clear evidence-based recommendations as to who should deliver NIV (medical staff, nurses, physiotherapists or respiratory therapists) but, regardless, nurses must be fully trained as they are usually the only healthcare professionals responsible 24 h per day. A nurse to patient ratio of 1 to 2 or 3 is ideal.

Monitoring during acute NIV

There are no RCTs of different types of monitoring but some studies have shown which parameters impact upon outcome from NIV. Careful observation of the patient is important. Each NIV-delivered breath should be associated with adequate chest expansion and outward movement of the abdomen. The duration of the breath should match the patient's effort. Leak should be minimised by inspection and feeling around the mask. A reduction in the use of accessory muscles indicates effective NIV support.

The following parameters should be monitored.

- Clinical evaluation including respiratory rate, heart rate, consciousness level and urine output
- Continuous pulse oximetry
- Arterial blood gases (before initiating NIV, followed by 1-, 4- and 6-hour measurements, if ventilator settings are not altered): transcutaneous carbon dioxide monitors are increasingly being employed, as current monitors are more accurate, easier to use and have a quicker response than older devices; however, they do not give information about pH and, as with any noninvasive device, care should be taken if unexpected results are given
- Noninvasive blood pressure monitoring
- Ventilator settings, inhaled oxygen fraction and magnitude of leaks: more advanced ventilators provide pressure and flow waveforms, and estimates of various ventilatory parameters; these can be very useful for experienced operators
- Time on the ventilator
- Side-effects

Parameters should be recorded and reviewed regularly, and changes to the ventilator settings, mask, time on NIV, *etc.* be made depending on patient progress. Clinical targets

Table 4. *Typical initial ventilator settings for patients with AHRF*

IPAP	12–15 cmH_2O (to be increased as tolerated by 2 cmH_2O, up to 20 cmH_2O in the first instance)
EPAP	4–5 cmH_2O (can be increased up to 10 cmH_2O)
Oxygen	0.5–4 L

IPAP: inspiratory positive airway pressure; EPAP: expiratory positive airway pressure.

Equipment required

- NIV machine: usually one type to facilitate staff training. Devices designed for home use are cheaper and easy to use but more advanced ventilators specifically designed for acute NIV, providing more sophisticated integrated monitoring and the ability to deliver high concentrations of oxygen, are preferable if sicker patients are to be treated.
- Disposable ventilator circuit, oxygen tubing and exhalation port, if not integrated into the mask.
- Masks: usually, full face masks are required acutely, but some patients will only tolerate a nasal mask. A selection should be available but not so many different types that staff cannot develop adequate experience with any one type.
- Humidifiers.

should be pre-set and communicated to nursing staff. Breaks in NIV should be made for oral medication, meals and drinks. Ideally, nebulised drugs should be delivered during times off NIV but can be given during NIV by using a T-piece in the circuit. Alternatively, a spacer and metered-dose inhaler can be used.

Clinical predictors of response and acute NIV success

A reduction in respiratory rate and improvement in $PaCO_2$ and pH within 4 h of starting NIV are useful predictors of success [40]. Worsening of these parameters is an indication of failure of NIV, and ETI and invasive mechanical ventilation should be considered. CONFALONIERI *et al.* [41] showed that if pH <7.25 and respiratory rate >35 persisted, this was likely to predict NIV failure. In clinical practice, a failure to stabilise PCO_2 should warrant clinical review, and should lead to a change in medical therapy, adjustment of

Table 5. *Common problems encountered in patients on NIV*

Problem	Solution
Mask leaks	Adjust headgear tension Change mask type
Persistent hypoxaemia	Increase ventilatory support Increase oxygen entrainment, usually little value from increasing to >4 L·min^{-1} Change to ventilator with oxygen blender
Asynchrony between patient and ventilator	Check for mask leak Check ventilator settings, particularly timing parameters; if pressure support, consider reduction
Hypocapnia/respiratory alkalosis	Reduce level of ventilatory support
Confusional state/aggressive behaviour	Maybe a role for sedation in a well-monitored environment
Nasal problems: rhinitis/nose bleeds/nasal congestion	Humidification Nasal steroids Short-term topical decongestants (beware of rhinitis medicamentosa)
Gastric distension	Check synchrony Reduce IPAP Consider wide-bore nasogastric tube
Respiratory rate and pH not improving despite resolution of any of the issues outlined above	Increase level of IPAP/pressure support

IPAP: inspiratory positive airway pressure.

ventilator settings or pressures and a change of interface if not already considered before proceeding to invasive mechanical ventilation.

Resuscitation status

Prior to commencing NIV, a decision should be made as to what will be done if the patient deteriorates despite NIV or does not tolerate it. Ideally, this should be discussed with the patients and their family in advance. It should be reviewed on a regular basis; late failure with NIV generally carries a poor prognosis [42, 43].

Duration of acute NIV and weaning

The duration of NIV should usually be as long as possible on day 1, with a minimum of 6 h. Once acidosis has improved, the use of NIV can be tapered, based on clinical need, over the next 2–3 days. This is dependent on the degree of hypercapnia, rate of improvement on NIV, patient tolerance and motivation.

There are no randomised controlled studies comparing different approaches to weaning from ventilator support. Most large studies have used NIV for $\geqslant$3 days, with a gradual reduction in the time on NIV. Some patients will refuse to accept NIV when feeling less breathless and more alert. NIV should usually be continued until pH is normal, and respiratory distress and tachycardia have resolved. There is no evidence to support any specific $P_{a}CO_2$ target but it is reasonable to continue intermittent NIV until the $P_{a}CO_2$ has stabilised, as close to the normal range as possible.

Troubleshooting during acute NIV

NIV is the mainstay of treatment but not a universal remedy for patients with AHRF. Success is dependent on patient selection, the underlying pathology and expertise with NIV. If NIV is clearly failing to improve or palliate a patient's symptoms and no reversible factors have been identified, NIV should be stopped and alternative treatment considered, *i.e.* invasive ventilation or palliation.

Failure of NIV may be:

- primary, usually intolerance of the mask; or
- secondary, usually later, in patients initially successfully established on NIV but with advanced disease.

The clinical outcome in patients with secondary failure is generally poor [42]. Assuming medical therapy is adequately optimised, the common problems encountered in patients who are on NIV are listed in table 5.

Conclusion

NIV plays a pivotal role in the management of AHRF due to various disorders. It is recognised as the gold standard in AECOPD. NIV has a role in the management of acute ventilatory failure in other conditions, such as OHS and extrapulmonary restrictive lung diseases. Adequate numbers of well-trained staff are key to success.

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