Inspiring Change: a report on acute non-invasive ventilation

ABSTRACT

The British Thoracic Society audit of non-invasive ventilation has shown that mortality rates are higher than expected and increasing. The National Confidential Enquiry into Patient Outcome and Death undertook a detailed analysis of data from 432 patients treated with acute non-invasive ventilation to identify how clinical aspects of non-invasive ventilation treatment could be improved. The study 'Inspiring Change' was published in July 2017. This review summarizes some of the important findings and associated recommendations that will improve treatment of patients and help to reduce mortality rates.

The term non-invasive ventilation is used to describe the technique of providing patients with advanced respiratory support using a mask interface as opposed to invasive ventilation (provided via an endotracheal tube or tracheostomy). The advantage over invasive techniques is that a face mask is generally well tolerated and does not require general anaesthesia or sedation to aid patient comfort.

Artificial ventilation improves elimination of carbon dioxide (CO_2) and non-invasive ventilation can therefore be used to treat acute hypercapnic (acidotic) respiratory failure. A number of studies have shown the benefit of non-invasive ventilation in particular for chronic obstructive pulmonary disease exacerbations. These have been reviewed recently (Osadnik et al, 2017). National Institute for Health and Care Excellence (2016) guidance for chronic obstructive pulmonary disease recommends that non-invasive ventilation should be available in all hospitals that admit these patients. Most acute hospitals have therefore established services to deliver this treatment over the last two decades.

Several cycles of a national audit of non-invasive ventilation run by the British Thoracic Society have shown deteriorating results with mortality rates increasing progressively, most recently to 34% (Davies, 2013), and outcomes which vary depending on the location where non-invasive ventilation is delivered and the underlying diagnosis. This audit raised a number of questions about the organization of services providing non-invasive ventilation and about the clinical care delivered to patients.

This article describes some of the findings and recommendations of a study 'Inspiring Change' (Juniper et al, 2017) published by the National Confidential Enquiry into Patient Outcome and Death (NCEPOD). This study was designed to answer the questions raised by the national non-invasive ventilation audit (Davies, 2013).

The aim of the study was to identify the avoidable and remediable factors in process of care for patients treated with acute non-invasive ventilation, including:

- Prompt recognition of ventilatory failure and rapid initiation of non-invasive ventilation
- Appropriate documentation and management of ventilator settings to correct respiratory failure
- Escalation of treatment decisions and planning including admission to critical care.

Study population and design

There were 9299 patients identified from clinical coding who were treated with non-invasive ventilation between 1 February and 31 March 2015. A sample of 678 cases (limited to five cases per hospital) was selected for inclusion via a 'clinician questionnaire' completed by the consultant responsible for the patient at the time of discharge. Photocopied case note extracts were reviewed in detail by a multidisciplinary group of clinicians (advisors). Data in the report are from 353 sets of notes and 432 clinician questionnaires.

Of the patients studied, 43.1% were male. The average age was 71.1 years for male and 72.3 years for female patients. More than four out of five cases were brought to hospital by ambulance. The primary diagnosis on admission was chronic obstructive pulmonary disease in just under 70% of cases. The majority (53.1%) had two or more co-morbid conditions and 56.8% had a frailty score (Rockwood et al, 2005) of six or more, meaning they were at least moderately frail, needing help with outdoor activity, housekeeping or climbing stairs.

Study findings

The mortality rate in the cases reviewed was 34.6%. The study helped to identify a number of key areas where

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> “All patients treated with acute non-invasive ventilation must have a treatment escalation plan in place before starting treatment.”

both organizations and clinicians can improve the care of patients treated with non-invasive ventilation, making a total of 21 recommendations. The areas outlined below, with their associated recommendations, reflect the findings that are most relevant to staff involved in the delivery of non-invasive ventilation.

Oxygen therapy

For patients with chronic obstructive pulmonary disease, a target oxygen saturation of 88–92% is recommended (O'Driscoll et al, 2008) as higher levels of oxygenation can precipitate acute hypercapnic ventilatory failure, and therefore the need for non-invasive ventilation. On arrival in hospital, 133/283 (47%) patients had an oxygen saturation above 92%. Of the peer reviewed cases, there were 84/312 (26.9%) where oxygen toxicity was considered to have contributed to the hypercapnia. It was most common for excess oxygen to be administered before the patient arrived in hospital but there were 38 cases where excess oxygen was given in the emergency department. In the 158 cases where the oxygen delivery device was recorded, only 27 (17.1%) used a venturi device. Better use of controlled oxygen therefore has the potential to improve care of these patients and reduce the need for non-invasive ventilation.

Recommendation

In line with current British Thoracic Society guidelines (O'Driscoll et al, 2008), patients with known chronic obstructive pulmonary disease, or other known risk factors for hypercapnic respiratory failure, should have an oxygen saturation of 88–92% maintained both before admission and on admission to hospital. The device used for oxygen delivery, the concentration of oxygen administered and the target saturation should be documented in the relevant patient record.

Escalation planning

Non-invasive ventilation does not result in the required improvement of respiratory acidosis in approximately a third of patients (Davies, 2013). Guidelines therefore recommend that a plan for the action to be taken in the event of treatment failure is documented at the start of treatment. Such a plan was not made in 128/352 (36.4%) of cases reviewed.

Data from the clinician questionnaire showed that an escalation plan was made during the hospital admission in 302/432 (69.9%) cases. When a decision was made, in 183 (60.6%) cases, invasive ventilation was considered inappropriate. Even when escalation was considered, no specific decision about invasive ventilation was made in 51/302 (16.9%) cases.

There was a group of 66/351 (18.8%) patients where reviewers considered that non-invasive ventilation was not appropriate. In 27 of these cases, this was because the patient had an advanced or terminal illness and 24 of these patients died.

While patients were receiving non-invasive ventilation, signs of deterioration (rising respiratory rate, falling level of consciousness, worsening acidosis or agitation) were common, being seen in 145 out of 345 (42%) cases. A referral to critical care was made in 156 out of 328 (47.6%) cases.

Treatment plans are therefore of great importance when initiating non-invasive ventilation.

Recommendation

All patients treated with acute non-invasive ventilation must have a treatment escalation plan in place before starting treatment. This should be considered part of the prescription for acute non-invasive ventilation and include plans in relation to:

1. Escalation to critical care
2. Appropriateness of invasive ventilation
3. Ceilings of treatment.

This should take into account:

1. The underlying diagnosis
2. The risk of acute non-invasive ventilation failure
3. The overall management plan.

Delay in starting non-invasive ventilation

Once CO_2 levels have started to rise, small further changes in ventilation lead to a much larger rise in CO_2 levels. A slightly raised level combined with even mild acidosis (pH<7.35) is therefore important. In 96 out of 350 (27.4%) cases, delay in starting treatment was identified. In 41 of these cases, the delay was the result of a failure to recognize that non-invasive ventilation was needed.

There were also 28 cases where the delay was caused by a need to transfer the patient to another clinical area to start treatment. Many hospitals have a model of service whereby treatment is started as soon as the need for non-invasive ventilation is identified before transferring the patient on non-invasive ventilation for ongoing treatment.

Better recognition of the need for non-invasive ventilation as well as better organization of services therefore has the potential to improve the care of non-invasive ventilation patients.

Recommendation

Treatment with acute non-invasive ventilation must be started within a maximum of 1 hour of the blood gas measurement that identified the need for it, regardless of the patient's location. A service model whereby the non-invasive ventilation machine is taken to the patient to start treatment before transfer for ongoing ventilation will improve access to acute non-invasive ventilation.

> All patients receiving acute non-invasive ventilation should receive, as a minimum, daily consultant review while they remain on ventilation. This consultant must be competent in the management of acute non-invasive ventilation.

Non-invasive ventilation management

Ventilation is a specialist procedure and specialist input would be expected for this group of patients. The majority of patients (219/348; 62.9%) were reviewed by either a respiratory or critical care specialist. Specialist input was valuable as it resulted in treatment changes in 151/284 (53.2%) patients. In about half of these cases (72 patients) these changes were in ventilator management. In patients reviewed by a respiratory consultant the majority (78.1%) had started non-invasive ventilation before this review.

Improving the elimination of CO_2 depends on the application of a high enough level of inspiratory pressure. An inspiratory pressure target of 20–30 cmH_2O or greater is recommended (British Thoracic Society/Intensive Care Society Acute Hypercapnic Respiratory Failure Guideline Development Group, 2016) to deliver adequate ventilation. Ventilator settings were not adequately documented in 180/350 (51.4%) cases. Where the settings were recorded, in 120/266 (45.1%) the inspiratory pressure remained below 20 cmH_2O throughout the ventilation episode. Overall ventilator management was rated as inappropriate in 112/264 (42.4%) cases.

Recommendations

All patients treated with acute non-invasive ventilation must be discussed with a specialist competent in the management of acute non-invasive ventilation at the time treatment is started or at the earliest opportunity afterwards. Consultant specialist review to plan ongoing treatment should take place within a maximum of 14 hours.

All patients receiving acute non-invasive ventilation should receive, as a minimum, daily consultant review while they remain on ventilation. This consultant must be competent in the management of acute non-invasive ventilation.

Documentation of all changes to ventilator settings is essential and the use of a standardized proforma is recommended.

All staff who prescribe or make changes to acute non-invasive ventilation must have the required level of competency as stated in their hospital operational policy. A list of competent staff should be maintained.

Monitoring the response to non-invasive ventilation

Treatment with non-invasive ventilation identifies a group of high risk patients. As outlined above, about a third of them die and there is a similar risk of treatment failure.

The presence of respiratory failure is identified by blood gas analysis. Resolution of acidosis and improvement of CO_2 are markers of improved ventilation and therefore response to treatment. Blood gas analysis is recommended to assess response to ventilation (British Thoracic Society/Intensive Care Society Acute Hypercapnic Respiratory Failure Guideline Development Group, 2016). In the patients studied, ventilation was effective at improving CO_2 and pH levels. pH improved slowly, taking on average over 21 hours to return to normal. During the first 4 hours of treatment there was no difference in the CO_2 or pH levels in survivors compared with patients who died. There was room for improvement in blood gas sampling. In 107/331 (32.3%) cases, this was considered to be done too infrequently.

Physiological monitoring, using the National Early Warning Score (NEWS), is recommended for use in all hospital patients (Royal College of Physicians, 2015) to assess illness severity and identify at-risk patients. A respiratory rate of 25 breaths per minute or more is used as a NEWS trigger for at least hourly vital signs monitoring. The national non-invasive ventilation guideline (British Thoracic Society/Intensive Care Society Acute Hypercapnic Respiratory Failure Guideline Development Group, 2016) also uses a respiratory rate of 25 breaths per minute as a flag to identify patients at increased risk.

At the start of non-invasive ventilation, 128/254 (50.4%) patients had a respiratory rate of 25 breaths per minute or above, 418/432 (96.8%) were receiving oxygen and 136/259 (52.5%) had an oxygen saturation of 91% or below. Patients who died had, on average, a higher respiratory rate and higher heart rate than patients who survived throughout the first 4 hours of non-invasive ventilation. In 104/311(33.4%) cases reviewed, the vital signs were not monitored with the appropriate frequency.

Alongside blood gas analysis, vital signs monitoring is therefore a key part of assessing severity of illness in patients treated with non-invasive ventilation. In this high risk group of patients, provision of the level of monitoring needed is likely to require an enhanced level of staffing.

Recommendation

All patients treated with acute non-invasive ventilation must have their vital signs recorded at least hourly until the respiratory acidosis has resolved. A standardized approach such as the National Early Warning Score is recommended.

Conclusions

Patients requiring non-invasive ventilation have a high risk of treatment failure and of death. Better management of oxygen therapy and decision making about the appropriateness of non-invasive ventilation including escalation plans will improve the care these patients receive.

Despite the relative simplicity of some machines used for non-invasive ventilation, delivery of effective non-

KEY POINTS

- Patients treated with non-invasive ventilation are severely ill with a high risk of treatment failure and death.
- When the need for non-invasive ventilation is identified by blood gas measurement, treatment must be started within 60 minutes.
- Patients treated with non-invasive ventilation need their vital signs monitored at least hourly.
- While on non-invasive ventilation, patients require at least daily specialist review.
- To ensure patient safety, treatment with non-invasive ventilation should take place in a clinical area with enhanced staffing ratios.

invasive ventilation is not simple. Competence requires specialist knowledge and experience to recognize when treatment changes are needed, and when escalation of treatment would be more appropriate.

In order to treat patients safely, specialist review is required, as is an enhanced level of care with frequent monitoring of their response to ventilation by staff with the skills to provide the care they need.

A number of factors is associated with non-invasive ventilation treatment success or failure. These are listed in *Table 1*. These factors should be used to help with decision making about the appropriateness of non-invasive ventilation as a treatment, to decide the best location to provide this and to facilitate discussions with patients and their relatives about the overall goal of treatment.

All doctors who care for patients treated with non-invasive ventilation should be familiar with the recommendations of the NCEPOD report. Many of the recommendations do not require major changes in clinical practice and should be simple to implement. Organizations should also put systems in place to ensure that services are available to support this group of patients. If these recommendations are implemented, outcomes for this complex group of patients will improve. **BJHM**

Conflict of interest: none.

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Table 1. Factors associated with non-invasive ventilation treatment success and failure

Better prognosis	Mortality (%)	Worse prognosis	Mortality (%)
Early non-invasive ventilation (<24 hours)	25.1	Late non-invasive ventilation (>24 hours)	55.4
Started in emergency department or acute medical unit	27.0	Started in general or respiratory ward	41.7
Chronic obstructive pulmonary disease	25.1	Non-chronic obstructive pulmonary disease	49.0
Initial pH 7.26–7.35	25.8	Initial pH <7.26	40.3
Frailty score 1–5	23.7	Frailty score 6–9	42.3
Respiratory rate <26 breaths per minute	23.1	Respiratory rate 26+ breaths per minute	37.5
Heart rate <100 beats per minute	24.8	Heart rate 100+ beats per minute	39.3
No pneumonia	24.8	Pneumonia	44.4
Appropriate non-invasive ventilation	27.0	Inappropriate non-invasive ventilation	63.3
Non-invasive ventilation success	5.9	Non-invasive ventilation failure	81.7
Previous non-invasive ventilation	23.3	No previous non-invasive ventilation	36.6

From Juniper et al (2017)