Thorax

Editorials

Domiciliary ventilation in chronic obstructive pulmonary disease: where are we?

The introduction of non-invasive nasal positive pressure ventilation (NIPPV) in the late 1980s has been a major advance in the home management of patients with chronic hypercapnic respiratory failure due to chest wall and neuromuscular disease.[1–3] Nasal ventilation is considerably easier to administer than previously used negative pressure techniques, and this has enabled many more patients to be offered long term domiciliary ventilation with correction of arterial blood gases, control of nocturnal hypoventilation, and improvement in quality of life. This success with NIPPV has stimulated renewed interest in its use at home in patients with chronic obstructive pulmonary disease (COPD). However, is there sufficient evidence for benefit, and which group of patients with COPD should be selected for domiciliary NIPPV?

Patients with severe COPD exhibit marked abnormalities of ventilation overnight which causes derangement of blood gas tensions and may contribute to the progressive deterioration seen in this group.[4,5] Long term domiciliary oxygen therapy (LTOT), when used for 15 or more hours per day, has been shown to have physiological benefit and improves survival in patients with hypoxic COPD.[6,7] It has therefore been suggested that ventilatory support at home may confer further advantages when used in addition to LTOT.

Physiological considerations

Evidence is emerging that the mechanisms underlying the sustained change in daytime blood gas tensions with ventilation is related to reversal of nocturnal hypoventilation and improvement in carbon dioxide responsiveness. Withdrawal of non-invasive ventilation in patients with chest wall and neuromuscular disease results in deterioration in symptoms and nocturnal hypoventilation, but has no effects on respiratory muscle function.[8,9] A study of NIPPV in patients with COPD showed that those patients whose blood gas tensions improved had associated increased chemosensitivity to carbon dioxide, although no effects were observed on respiratory muscle strength.[10]

It has been suggested that the respiratory muscles of patients with COPD are subject to fatigue. Several investigators have shown that the application of non-invasive ventilation, using both positive and negative pressure techniques, may produce significant reductions in electromyographic (EMG) activity of the diaphragm and work of breathing.[11–14] However, no long term controlled study has yet shown an improvement in measures of ventilatory muscle strength with the addition of assisted ventilation.

Patients with hypoxic COPD also have sleep disruption, although the effects of supplemental oxygen therapy on sleep quality have been variable.[15,16] Although some of these patients may have coincident sleep apnoea, sleep disruption is not usually caused by the effects of upper airway obstruction. Patients with COPD may be seen to arouse during episodes of oxygen desaturation, although sleep disruption is also present in patients with COPD who do not desaturate at night.[17] Hypercapnia is worsened overnight with the addition of supplemental oxygen therapy and this increase in the arterial carbon dioxide tension ($PaCO_2$) may contribute to arousals and thus impaired sleep quality. Control of nocturnal hypercapnia through nasal ventilation may improve sleep quality and result in improved neuropsychological performance and quality of life.

Early experience of ventilation in patients with COPD

Positive pressure ventilation through a tracheostomy had been widely used in France, although many patients had been treated only when they deteriorated on LTOT at a late stage in their disease history. Robert and colleagues showed that patients with COPD had a worse prognosis than those with other conditions who required assisted ventilation, such as kyphoscoliosis.[18] The survival in their patients with COPD treated by tracheostomy was similar to that achieved in the MRC long term oxygen trial.[7] However, another multicentre study from France showed an improved survival for the first four years after the start of ventilation compared with that of the MRC group.[19] This suggested that assisted ventilation in patients with COPD should perhaps be used at an earlier stage in the natural history of the condition to obtain increased benefit.

Negative pressure ventilation, although effective in patients with chest wall and neuromuscular disease, has been less successful in patients with COPD, mainly due to poor patient tolerance and compliance with the technique.[20,21] A study from Montreal reported 184 patients with COPD who were randomised to receive either active negative pressure ventilation or sham treatment.[13] There were no significant benefits in the active group with respect to any of the outcome measures, and thus negative pressure ventilation was ineffective for resting respiratory muscles in patients with stable COPD. Compliance with the technique was poor, with 63 patients either not using the respirators at all or stopping before completing the 12 week study

period, and the hours of ventilator use were below the minimum expected in many patients. However, even in those patients where compliance was satisfactory there was no dose-response effect, suggesting that resting the respiratory muscles alone is not sufficient to produce sustained functional improvements.

NIPPV in patients with COPD

Early uncontrolled studies showed that arterial blood gas tensions improved in patients with COPD treated with NIPPV, together with an improvement in sleep quality.[3 22 23] However, in these studies compliance with ventilation was not as good as in patients with restrictive chest disease. Patients who showed benefit were those who also had significant daytime hypercapnia and in whom nocturnal hypercapnia could be successfully reduced by overnight ventilation.[10] A randomised crossover study of nasal ventilation using the BiPAP (Bi-level Positive Airway Pressure; Respironics Inc, Murrysville, Pennsylvania, USA) ventilator in 19 patients with COPD reported no changes in any physiological variables except in neuropsychological function.[24] Although these patients had severe airflow obstruction, they showed lesser degrees of hypercapnia, with some patients in the normocapnic range.

We have recently reported a randomised crossover study of nasal pressure support ventilation plus oxygen therapy compared with domiciliary oxygen therapy alone in 18 hypercapnic patients with COPD.[25] The aim of this study was to investigate the effect of the addition of NIPPV to patients already established on LTOT, with each patient receiving NIPPV plus oxygen or oxygen alone for three month periods in random order. There were significant improvements in daytime arterial blood gas tensions, overnight $Paco_2$, total sleep time, and sleep efficiency, suggesting that control of hypoventilation with NIPPV is effective and leads to improved sleep quality. There were correlations between the daytime and overnight $Paco_2$ values, suggesting that the patients who showed the greatest reduction in nocturnal hypercapnia with ventilation are likely to gain the greatest benefit from the treatment.

Previous studies have not shown any benefit of LTOT with respect to quality of life. The combination of NIPPV with oxygen therapy produced significant improvements in symptoms, impact, and total quality of life scores compared with oxygen alone. There was no change in the activity component in the two study groups and no change in six minute walking distance after ventilation. A study involving patients with restrictive ventilatory disorders showed that quality of life was related to sleep quality, and thus the improvement in sleep time in the patients with COPD may lead to parallel changes in quality of life.[26]

Compliance in this study was much better than in previous studies of non-invasive ventilation in COPD, with 14 of the 18 patients completing the study and only one being withdrawn because of inability to tolerate the equipment. All had nasal ventilation initiated as inpatients, allowing them maximum support and education, and it is possible that improved compliance may have been due to the greater degree of hypercapnia present and consequent benefit achieved with ventilation.

In a French series of 50 patients with COPD who received NIPPV, a significant decrease in $Paco_2$ was found in long term survivors over two years, again emphasising the importance of control of hypoventilation in the outcome of NIPPV.[27] The probability of continuing nasal ventilation and thus survival was lower in patients with COPD (56%) than in those with kyphoscoliosis (80%) and sequelae of tuberculosis (76%). In a UK series of 33 patients with COPD treated with NIPPV over a five year period the probability of continuing ventilation was lower at 43%,[28] which is comparable to survival achieved with LTOT.[6 7] Patients with bronchiectasis had a worse outcome than those with COPD. However, patients included in this series were at the severe end of the spectrum of chronic respiratory failure and most were deteriorating despite LTOT. It is likely that NIPPV was instituted too late in the natural history of the condition to achieve optimum benefit.

Volume or pressure preset ventilators in COPD?

Both volume preset ventilators in the assist control mode and pressure limited equipment (mainly the BIPAP nasal ventilator) have been used to provide ventilation in patients with COPD. In a study comparing four different pressure and volume preset nasal ventilator systems in patients with stable chronic respiratory failure, all were found to be suitable for delivery of NIPPV and equally acceptable to patients, with no significant differences in efficacy.[29]

Various types of ventilators are available for NIPPV in patients with COPD, and the choice will depend on local experience, cost, and patient acceptance. Volume preset ventilators have an advantage in delivering a preset tidal volume with each assisted breath, but there is no compensation for mouth leaks, while pressure cycled ventilators automatically compensate for leaks.

Ventilators can also be adjusted to deliver nasal pressure support ventilation (NPSV). This has advantages over assist control NIPPV in that the ventilation is entirely patient initiated without a preset respiratory rate, and ventilatory support is only delivered if the machine is triggered. The use of NPSV maintains the patient's respiratory cycle and reduces respiratory muscle activity.[30] NPSV may be more comfortable if dyspnoea is a problem or if respiration is irregular, as occurs in COPD and especially when using nasal ventilation during weaning.[31] A study comparing NPSV with NIPPV in patients with nocturnal hypoventilation showed that these two modes were equally effective and that the patients were able to trigger the ventilators adequately.[32]

Recommendations for NIPPV in COPD

There is now sufficient evidence for the use of NIPPV, together with LTOT, in selected patients with COPD who require careful assessment for suitability.[23 25] Patients must have daytime hypercapnia and documented nocturnal hypoventilation that can be reversed with the ventilator. Patients with the most effective reduction of hypercapnia during the night will be expected to achieve most benefit from the addition of NIPPV.[25] Patients with COPD with hypercapnia and considerable sleep disruption will be particularly suitable for long term ventilation as sleep quality has been shown to improve with NIPPV.

Patients chosen for home NIPPV must be appropriately motivated and prepared to accept the ventilator at home. An acclimatisation period as an inpatient is useful to allow careful adjustments of the settings to maximise patient comfort. Compliance is frequently affected by complications related to the nasal mask but, although these are common at the start of ventilation, most resolve with specific attention.[33] In some patients with COPD the presence of intrinsic positive end expiratory pressure (PEEP) may produce asynchrony between the ventilator and the patient's respiratory efforts.[34] Care must be taken during the initiation of NIPPV to ensure adequate capture of the ventilation.

There is considerable debate as to which point in the natural history of hypercapnic COPD should NIPPV be commenced. Studies that have shown benefit of NIPPV

in COPD recruited mainly stable patients. However, patients are often referred for further management when blood gases are deteriorating, despite optimum management. In a study of patients with advanced hypercapnic COPD and hypoxaemia refractory to oxygen therapy, addition of NIPPV to LTOT produced no clinical improvement.[35] This suggests that chronic NIPPV should be used at an earlier stage in the natural history of the condition, before rapid clinical deterioration occurs.

The results of a multicentre European study on longer term outcome and survival with nasal ventilation in COPD, compared with supplemental oxygen alone, are awaited. Meanwhile, there is now sufficient clinical evidence to justify the use of nasal ventilation in selected patients with hypercapnic COPD complicated by nocturnal hypoventilation.

Correspondence to: Dr J A Wedzicha.

Respiratory Care Unit,
London Chest Hospital,
Bonner Road,
London E2 9JX, UK

J A WEDZICHA
D J MEECHAM JONES

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