



Mechanical Ventilation at Home

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Introduction

In the past, patients with respiratory failure who needed ventilatory support would require the use of an artificial airway (e.g. endotracheal tube or tracheostomy tube) for mechanical ventilation in the intensive care unit (ICU). For the unfortunate patients who could not be weaned from mechanical ventilation, few of them could return home because of the complexity of technologies and intensive nursing care involved in home mechanical ventilation (HMV) via an artificial airway.

Advances in technologies have revolutionised mechanical ventilation. Nowadays, dedicated non-invasive ventilators are available to provide ventilatory support in selected patients with acute respiratory failure, using specially designed facial mask (e.g. nasal mask or oro-facial mask). Meta-analysis of randomised controlled trials (RCTs) have shown that non-invasive positive pressure ventilation (NIPPV) is superior to standard treatment in selected cases of chronic obstructive pulmonary disease (COPD) with acute hypercapnic respiratory failure (AHRF), in terms of intubation rate, treatment failure, length of hospital stay and mortality. NIPPV is therefore now considered the first line treatment in hypercapnic exacerbation of COPD in suitable patients.

In contrast to the ICU-type mechanical ventilator, NIPPV machines are generally more compact and light-weight. Moreover, as artificial airway is not required and often only nocturnal ventilatory support is needed, it becomes feasible to support patients with chronic respiratory failure by HMV using NIPPV machine. Throughout the world, HMV is increasingly employed to treat patients suffering from chronic hypercapnic respiratory failure. Diseases that have been treated by HMV include thoracic cage disorders, neuromuscular disorders, COPD and various other causes of nocturnal hypoventilation syndrome. The cumulative number of patients being put on HMV has increased tremendously in Europe and the United States. The rapid growth of HMV has been attributed to (1) increased awareness and experience with the indications and technologies, (2) the availability of affordable NIPPV machines, (3) pressure to reduce hospital stay, and (4) improved life expectancy in treated patient.

There has been an explosive growth of the use of HMV in Hong Kong. The rate of HMV use grows as a cubic function of time in Hong Kong in recent years¹. It is therefore timely to review the indications and controversies regarding the use of HMV in chronic respiratory failure.

Chronic respiratory failure, nocturnal hypoventilation and NIPPV

Excellent review exists on the pathophysiology of chronic hypercapnic respiratory failure². Patients with chronic hypercapnic respiratory failure due to restrictive and obstructive lung diseases frequently have further deterioration in gas exchange during sleep (nocturnal hypoventilation), as a result of reduced minute ventilation, especially during rapid eye movement (REM) sleep. The central ventilatory control may adapt to the transient rise in PaCO₂ during sleep by raising its CO₂ set point. A vicious circle is set up, permitting further rise in PaCO₂ and progressive respiratory failure. NIPPV during sleep may be able to break the vicious circle by preventing the rise in PaCO₂, resetting the CO₂ sensitivity of the central ventilatory controller, reducing respiratory muscle fatigue and improving atelectasis. Positive airway pressure can also help to 'splint' the upper airway in patients who have concomitant obstructive sleep apnoea.

Restrictive lung diseases, neuromuscular disorders and obesity hypoventilation syndrome

Examples of restrictive lung and neuromuscular disorders with chronic respiratory failure that have been successfully treated with home NIPPV include kyphoscoliosis, post-tuberculous fibrothorax, post-polio myelitis, Duchenne muscular dystrophy, etc. Obesity hypoventilation syndrome (OHS) is a syndrome composing of extreme obesity, alveolar hypoventilation, and the patient very often has concomitant obstructive sleep apnoea. NIPPV has evolved to become the mainstay of ventilatory support in OHS. The 36-month continuation rate of NIPPV in respiratory failure due to restrictive lung and neuromuscular disorders is 56 - 80%.

Treatment with NIPPV is felt to have dramatically improved the prognosis of this group of patients, such that RCT is considered unethical by most authorities. The accepted indications for home NIPPV in this group of patients are (1) presence of relevant symptoms (e.g., fatigue, headache, morning headache, etc.), and (2) PaCO₂ ≥ 45 mmHg, or nocturnal SaO₂ ≤ 88% for 5 consecutive minutes, or in progressive neuromuscular disease, a maximal inspiratory pressure < 60 cm H₂O or FVC < 50% predicted².

COPD

COPD is the 5th leading cause of death in Hong Kong from 2001 - 2003. Currently, only long-term oxygen therapy





(LTOT) has been documented to prolong survival in COPD. Uncontrolled studies suggested that home NIPPV might reduce hospital admissions, reduce clinic visits, improve blood gases and save costs in severe hypercapnic COPD patients. However, results from RCTs are conflicting. Early studies suggested that home NIPPV was not superior to standard treatment in stable severe COPD. On the other hand, Meecham-Jones *et al* found that NIPPV + LTOT significantly improved daytime blood gases, nocturnal gas exchange and sleep quality in severe COPD³. A long-term RCT on home NIPPV in severe COPD showed that home NIPPV significantly reduced dyspnoea ratings, improved psychomotor coordination and decreased hospital admissions at 3 month, though reduction in hospital admissions was no longer evident by 6 months⁴. In the most recent RCT, home NIPPV + LTOT was shown to significantly improve gas exchange, dyspnoea score and quality of life; there was also a trend to reduced hospital and ICU admissions⁵. In a meta-analysis, home NIPPV was found to consistently improve maximal inspiratory pressure (P_{imax}) only⁶. Mortality was not improved in all the above studies.

It is currently believed that home NIPPV may not be beneficial in non-selected cases of severe COPD. However, it has been found in a recent study that COPD patients who survived AHRF after treatment with acute NIPPV had a high risk of readmission and life-threatening events in the ensuing year⁷. At one year after discharge, 80% had been readmitted for respiratory diagnoses, 63% had another life-threatening event and 49% had died, mainly due to respiratory failure. Survivors spent a median of 12% time hospitalised in the subsequent year. A significant proportion of survivors required repeated NIPPV for recurrent AHRF. Another study showed that in COPD patients who declined intubation for AHRF and were treated with acute NIPPV, these outcomes were even worse, with a 1-year survival of only 30%⁸. In the future, COPD patients who survived an episode of AHRF might form a selected group for further RCTs of home NIPPV. Hospital readmissions, recurrent AHRF and death are important endpoints to be examined in future studies.

Pending evidence from further RCTs, the following indications are considered acceptable to commence home NIPPV in patients with severe COPD: (1) relevant symptoms, and (2) PaCO₂ ≥ 55 mmHg or PaCO₂ 50 - 54 mmHg and nocturnal SaO₂ ≤ 88% for 5 consecutive minutes while receiving LTOT ≥ 2LPM or has episodes of recurrent AHRF (≥ 2 per year)². It must be emphasised that these indications are consensus by experts. Mortality benefit of home NIPPV for COPD has not yet been documented by RCT.

HMV in Hong Kong

A survey in 2002 estimated that there were about 2.9 HMV users per 100,000 populations in Hong Kong, a rate lower than those of the European countries of 4.5 - 20 per 100,000¹.

There has been an explosive rise in HMV users in recent years in Hong Kong. Nearly half of the HMV users in Hong Kong were patients with severe COPD and 95% of them were using NIPPV as their form of HMV. A continuation rate of about 70% was recorded at 36 months of follow-up; the major cause of discontinuation was death. This continuation rate compared favourably to overseas series¹.

For the COPD patients who were started on home NIPPV in Hong Kong, the commonest indications were recurrent life-threatening respiratory failure (65%) and failure to wean (24%)¹. These figures suggest that, although home NIPPV is not proven by RCT to have survival benefits, respiratory physicians sometimes find it compelling to try the technology on some of the difficult-to-manage severe COPD patients. This practice is in keeping with prevailing guidelines, but more data from RCTs are clearly needed.

Conclusion

HMV with NIPPV has promising potential in treating chronic hypercapnic respiratory failure. There has been tremendous growth of HMV use in Hong Kong and all over the world. Home NIPPV has been established to be the mainstay of treatment in OHS and many causes of restrictive lung and neuromuscular disorders. More research is urgently needed for home NIPPV in severe hypercapnic COPD patients. Appropriate selection of patients and clinically relevant outcomes are important in future RCTs.

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