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NON-INVASIVE VENTILATION AND THE PHYSIOTHERAPIST: CURRENT STATE AND FUTURE TRENDS

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Respiratory physiotherapy aims to improve the efficiency of ventilation, aid the removal of secretions, and improve functional capacity by the use of physical means in patients with respiratory disorders. This is often achieved using some form of positive pressure therapy. Non-invasive ventilation (NIV) is a ventilation technique whereby ventilatory support can be provided to a patient with respiratory problems without the need for an endotracheal or tracheostomy tube. Physiotherapists involved in the care of patients with respiratory impairment are increasingly involved in the use of NIV in routine clinical practice as the aims of both NIV and respiratory physiotherapy frequently overlap. Understanding how the technique works and how to apply it appropriately in a range of clinical circumstances will become mandatory in order to manage patients with respiratory failure effectively and appropriately.

Keywords: Exercise training, non-invasive ventilation, respiratory failure, secretion clearance

Physiotherapy emphasises the use of physical approaches in the prevention and treatment of disease and disability,[1] and forms an integral part of the management of patients with respiratory insufficiency. The aims of respiratory physiotherapy are to: (i) reduce breathlessness and the work of breathing; (ii) improve efficiency of ventilation; (iii) mobilise and aid expectoration of secretions; and (iv) maintain or improve exercise tolerance and functional ability.[2] To achieve these aims, physiotherapists have frequently used positive pressure devices. More recently, non-invasive ventilation (NIV) has been introduced into the routine respiratory management of appropriately selected patients presenting with both acute and chronic respiratory failure.[3] As a therapy in its own right, or in conjunction with other physiotherapeutic techniques, NIV offers the opportunity to enhance treatment programmes and improve patient outcomes. In this paper, we will review the basic principles of NIV, outline the ways in which physiotherapists are currently using NIV in the clinical setting, and discuss those areas where future research is required.

BACKGROUND TO NIV

With NIV, positive pressure is delivered to the airways and lungs via an interface that covers the nose, nose and mouth, or mouth alone, avoiding the need for an invasive endotracheal or tracheostomy tube. Pressure preset devices (as opposed to volume) that deliver a set inspiratory pressure, have become widely popular due to lower cost, simplicity of operation and comfort of delivered flow. The best known are the bilevel machines, where the operator sets the inspiratory (IPAP) and expiratory (EPAP) pressures that are delivered to the patient. The difference between these two pressures is the amount of inspiratory or pressure

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support the patient receives from the device. Cycling between IPAP and EPAP may be patient triggered, machine triggered, or a combination of the two; additional oxygen can also be added into the circuit.

Non-invasive mask ventilation was first introduced in its current form to treat patients with chronic hypercapnic respiratory failure requiring assisted ventilation during sleep. Physiotherapists played a pivotal role in introducing this technique and demonstrating its clinical usefulness.[4–8] Support of breathing during sleep produced improvements in nocturnal and awake blood gases, and led to better day-time function, exercise tolerance and quality of life. The clinical success of this technique in chronic respiratory failure saw its subsequent application in patients presenting with acute hypercapnic respiratory failure. Again physiotherapists were among the pioneers using NIV in this context,[9–12] and now NIV is considered an integral part of the management of moderate to severe acute exacerbations of chronic obstructive pulmonary disease (COPD).[13,14] Increasing evidence suggests that NIV may also be of benefit in other patient groups which physiotherapists manage, *i.e.* acute on chronic respiratory failure,[15] weaning from mechanical ventilation,[16] and in selected patients with hypoxemic respiratory failure.[17]

MANAGING ACUTE RESPIRATORY FAILURE WITH NIV

Acute hypercapnic respiratory failure

In the management of patients with acute hypercapnic respiratory failure, NIV is set up to reduce the work of breathing and to promote a more advantageous pattern of breathing, thereby improving gas exchange and reducing the need for intubation.

To achieve a successful outcome, appropriate patient selection is required to ensure resources are not wasted on a patient who will respond to standard medical therapy alone or used in patients where endotracheal intubation is clearly more appropriate.[15] There is evidence to suggest extra time is required initially to set the patient up appropriately, and then adjust settings to achieve the maximal benefit from therapy.[18,19] Staff involved in initiating therapy should have the time and skills to coach the patient in the technique, allay any anxieties the patient or their families may have, and ensure the equipment is adjusted appropriately to maximise effectiveness whilst minimising side effects. The patient needs basic monitoring of blood gases, oximetry, respiratory and heart rates, along with some indication of patient–machine synchrony, with someone available to identify any problems that can occur and to act accordingly. Problems include leak and pressure areas, while less common (but important) adverse effects such as pneumothorax or abdominal distension can arise and must be dealt with immediately. However, once therapy is established, it has been shown that the workload for staff is no greater than for those patients receiving standard care.[18]

While physiotherapists have many of the professional attributes and skills essential to the successful management of patients requiring NIV, in practice the extent of this input appears to be highly variable, depending on staffing levels, expertise and degree of interest. A survey of physiotherapy practice in European intensive care units found that almost half of the respondents reported that physiotherapists were involved in the implementation and supervision of NIV.[20] In more recent data from the British Isles,[21] 91% of respondents reported physiotherapy involvement in the management of patients using NIV. The contribution of those physiotherapists who were involved in the management of patients using NIV in patient care appeared to be primarily focused on the treatment of patients once they had been established on therapy (97%). Around two-thirds reported involvement in assessing patients for NIV, and around half were involved in implementing the technique.[21] Since secretion retention during NIV use can be a major reason for the failure of this technique in acute patients,[22] physiotherapists need to be familiar with how to apply and remove the mask and how to alter settings to allow the patient to participate more actively in airway clearance.

Chest physiotherapy during NIV use

Various airway clearance techniques such as breathing exercises, postural drainage and other mechanical aids are used clinically to treat patients on NIV,[21] but there is limited information to support their efficacy. Applying the active cycle of breathing techniques (ACBT) to patients with acute hypercapnic respiratory failure receiving NIV has been shown to reduce the time NIV was required (5 versus 6.7 days), although no significant differences in the total duration of NIV or length of ICU stay could be shown.[23] In patients with acute exacerbations of COPD who required NIV and had large amounts of bronchial secretions, Bellone and co-workers[24] found a significant improvement in the amount of sputum expectorated in those randomly assigned to use positive expiratory pressure (PEP) and assisted coughing compared to those assigned to use assisted coughing alone. Total time required to wean the patients from

NIV was significantly shorter in those who received PEP. No information about length of ICU or hospital stay in the two groups was provided. These preliminary results suggest that additional secretion clearance techniques are not only feasible but also potentially valuable in reducing the time NIV is required in patients with acute respiratory failure. Larger trials focusing on patients with secretion retention are needed to see if these improvements can produce shorter ICU and hospital stays, as this could have significant cost and resource implications.

Postoperative patient management

Physiotherapists frequently use positioning, mobilisation or breathing exercises to improve lung volumes and alter expiratory flows in postoperative patients with the aim of facilitating the removal of secretions and reducing atelectasis.[25,26] For some time, physiotherapists have been involved in using periodic CPAP to prevent or treat postoperative complications.[27] There is minimal information about the uses or advantages of NIV over periodic CPAP or breathing exercises in postoperative patients. In morbidly obese patients undergoing gastric surgery, use of bilevel support in the first 12–24 h following surgery was found to result in a more rapid improvement in pulmonary function compared to standard care;[28,29] no benefit in reducing pulmonary complications or length of stay was shown. Those patients with co-morbidities such as pre-existing pulmonary problems were excluded from both studies. In contrast, use of bilevel support in patients who developed hypoxemic respiratory failure following lung resection showed improved clinical outcomes, with a significant reduction in the need for intubation and mortality rates[30] compared to standard care that included chest physiotherapy. One study looked at periodic bilevel use and compared this to periodic CPAP and incentive spirometry (IS) in patients following coronary artery bypass grafting.[31] Both NIV and CPAP reduced the degree of pulmonary restriction occurring postoperatively compared to IS, and fewer patients treated with these two modalities developed mild or moderate atelectasis compared to the IS group (15% versus 30%). No differences in the length of ICU stay occurred. While the above studies strongly suggest that bilevel use can minimise the restrictive defect that occurs in the postoperative period in patients undergoing major abdominal or thoracic surgery, there is little current evidence that prophylactic use impacts positively on outcomes in terms of ICU or hospital stay, avoidance of intubation or cost of care. In patients where respiratory problems develop, early intervention with NIV may have a role. Further studies are needed to determine what 'dose' of NIV is most effective, as well as studies comparing this therapy alone or in conjunction with other physiotherapeutic techniques.

CHRONIC RESPIRATORY FAILURE AND NIV

It is unknown to what extent physiotherapists are currently involved in the management of non-invasive domiciliary ventilation services. Physiotherapists, working in neuromuscular clinics, pulmonary rehabilitation programmes and respiratory wards are well positioned to identify patients who may benefit from domiciliary ventilation. Physiotherapy measurements along with a symptom profile can alert clinicians about patients who warrant further investigation of nocturnal hypoventilation or day-time respiratory failure. There is scope for physiotherapists to extend their role, developing specialist skills performing blood gases, or interpreting investigations such as sleep studies or nocturnal respiratory monitoring.

A significant proportion of patients requiring domiciliary nocturnal ventilation will have a primary neuromuscular diagnosis. While NIV may off-load the inspiratory muscles, improving ventilation and sleep quality at night, the problem of weak expiratory muscles with a poor cough and reduced ability to clear secretions will remain. This renders these individuals susceptible to recurrent chest infections and pneumonias, a major cause of morbidity and mortality. In patients with respiratory muscle weakness, assessment of cough effectiveness is necessary; it is important that these patients and their caregivers are provided with appropriate training from physiotherapists in the use of assisted cough and airway clearance techniques. Breath stacking, manual inflation, and abdominal thrusts have been recommended for use in these patients,[32] as well as mechanical insufflation–exsufflation.[33] There are currently no data from randomised trials comparing efficacy and outcomes between different chest clearance techniques in patients with neuromuscular disorders.

NIV AS A STAND-ALONE METHOD TO IMPROVE SECRETION REMOVAL

Some patients may spontaneously clear secretions once NIV has been optimised but others may need additional physiotherapy input to facilitate airway secretion clearance. In order to maximise the benefit from physiotherapy airway clearance treatment, optimal bronchodilator management that may be administered through the NIV circuitry is advisable prior to

Fig. 1. Use of mouthpiece and nose clips during ACBT.

treatment. Humidification can be added to the NIV circuit, although theoretically this may add resistance and interfere with machine triggering or pressure delivery. However, this does not appear to happen in practice. Heated humidifiers are preferred to the use of heat moisture exchangers, as the latter may increase dead-space, increase the work of breathing and reduce the efficacy of NIV.[34] Postural drainage may not be possible in a spontaneously breathing breathless patient. However, once breathlessness is controlled through the use of NIV, it may be re-introduced into physiotherapy treatment if deemed appropriate without adverse effects.[7] A mouthpiece and nose clips rather than mask interface may be more suitable for airway clearance treatment at the same time as providing pressure relief to facial structures.

One of the most commonly used airway clearance regimens is the ACBT[35] and this cyclical method of treatment can be adapted for use with a patient using NIV (Fig. 1). Figure 2 illustrates how the components of ACBT can be replicated during treatment. There is some evidence that physiotherapists in Britain use NIV as a positive pressure device to augment sputum clearance, and that NIV settings are altered in order to enhance sputum clearance.[21]

The majority of evidence for airway clearance with NIV is in randomised, cross-over trials in cystic fibrosis. Three trials have compared a single treatment session of airway clearance with NIV to airway clearance without NIV with a total of 62 participants; these studies included adults and children with all disease severities in both acute and chronic states. NIV for airway clearance was compared to PEP,[36] FET[37] or ACBT.[38] These short-term studies found that NIV was more effective than other airway clearance regimens in patients with more severe disease who had difficulty clearing sputum. The long-term effect of NIV used for airway clearance has not yet been established.[39]

NIV TO IMPROVE EXERCISE CAPACITY

Patients with restrictive chest wall disorders

Dyspnoea and reduced exercise tolerance can be a major issue for patients with chronic respiratory failure, reducing activity, and impacting adversely on quality of life. Use of nocturnal non-invasive ventilatory support has been shown to improve awake blood gases, daily movement,[40] the endurance of both respiratory and peripheral muscles,[41] and exercise capacity.[42] While the available evidence suggests nocturnal ventilation can impact positively on day-time exercise tolerance and activity, the role of NIV during exercise

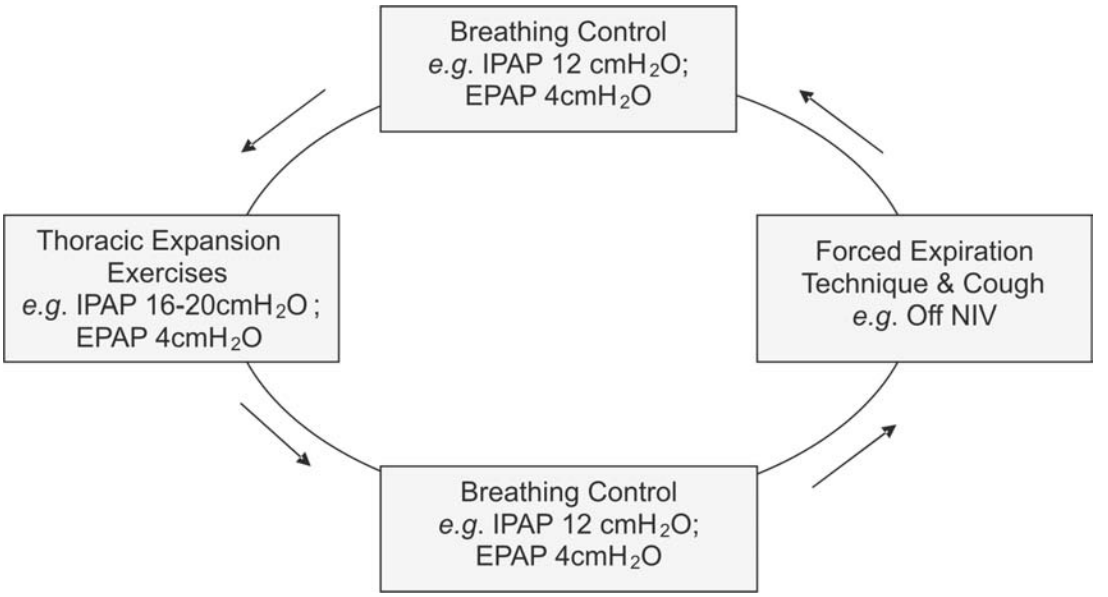

Fig. 2. Replication of ACBT during NIV in patients with cystic fibrosis using evidenced-based parameters from NIV.[39]

training in improving exercise performance is unclear. One study found that NIV applied during exercise in patients with pulmonary tuberculosis sequelae was able to support ventilation sufficiently to reduce breathlessness and improve exercise endurance time by 80%.[43] In contrast, Highcock and colleagues[44] found that while ventilation could be increased during exercise with NIV in patients with severe congenital scoliosis, it did not produce an improvement in exercise capacity; in fact, performance was impaired compared to unburdened walking. These contradictory findings highlight some of the issues that still need to be addressed. The role of NIV as an adjunct to formal pulmonary rehabilitation programmes in patients with restrictive thoracic disorders requires further investigation to determine to what degree this approach is practical and effective.

Patients with COPD

Exercise training forms an important part of the management and rehabilitation of patients with COPD. However, in those with severe disease, dyspnoea and high work-of-breathing may limit the degree of exercise intensity that can be achieved, thereby reducing the beneficial effects from participating in these programmes. A randomised, controlled trial to evaluate the addition of domiciliary nasal ventilation to pulmonary rehabilitation in patients with severe COPD found that NIV used for sleep augments the benefits of exercise training with significant improvements in exercise tolerance and quality of life compared to those patients receiving exercise training alone.[45] Several physiological studies[46–48] and a systematic review[49] have shown that NIV used acutely during exercise can reduce inspiratory effort, decrease breathlessness, and increase exercise tolerance in patients with COPD. However, to date, there are limited data[50] to support the notion that these acute improvements if applied during exercise training on a regular basis can produce better rehabilitation outcomes. In clinical practice in Britain, exercise is part of physiotherapy management for patients on NIV although not all physiotherapists used NIV specifically during exercise.[21]

At present, a large number of questions remain as to the clinical usefulness of NIV as an adjunct to exercise training. Physiotherapists need to be involved in addressing these questions to determine what place NIV has in promoting and improving exercise capacity in patients with COPD.

CONCLUSIONS

NIV is being increasingly accepted as first-line therapy in a range of patients presenting with acute respiratory failure. As the technique moves out of the ICU and HDU areas and onto the general medical and respiratory wards, physiotherapists will become increasingly involved in caring for patients requiring this therapy. Those working in primary and community environments will also begin to encounter NIV

more frequently as the technique becomes a standard part of the management of patients with chronic respiratory failure. Opportunities to incorporate advances in healthcare technology such as telemedicine to monitor patients at home also exist, and could be further developed by physiotherapists in association with other members of the health care team.[51] Therefore, understanding how NIV works, its potential uses and limitations are becoming an essential skill for any physiotherapist working with patients with respiratory failure. Physiotherapists are well placed to assist in the management of patients using NIV – either implementing and following up patients, or integrating other physiotherapy techniques with NIV use to enhance both the acute and chronic care of patients with respiratory failure. Given the undergraduate and postgraduate training in respiratory physiology, knowledge and use of equipment designed to aid inspiratory efforts and promote secretion clearance along with clinical expertise in handling sick and complex patients, physiotherapists are well positioned to contribute significantly to the management of patients using NIV. However, the profession needs to develop specialist skills in assessing and setting up patients on NIV if they want to expand their role.[21] They also need to establish strategies and devise business plans to ensure continued participation in the development and marketing of NIV services. Finally, the profession needs to ascertain whether profession-specific guidelines are necessary to complement existing generic NIV guidelines.

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