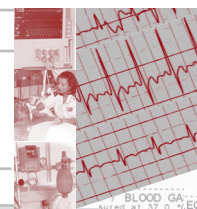


# Non-invasive mechanical ventilation



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Non-invasive ventilation (NIV) is a modality of providing airway and pulmonary support in both acute and chronic diseases of the lung. The method of mechanical ventilation without the use of an endotracheal tube was developed over a century ago, but its utility has only been explored recently with advances in technology. NIV is the method of choice when there is a desire to avoid the inherent complications that arise from using artificial airway supports such as endotracheal tubes and tracheostomies. NIV can be used in the intensive care unit and in the outpatient setting in appropriately selected patients. Adult and paediatric critical care and respiratory divisions have a wealth of experience in successful use of NIV. The history, use and experience will be discussed along with recommendations for initiating NIV.

Non-invasive ventilation (NIV), the delivery of mechanical ventilation without the use of airway devices such as endotracheal (ET) or tracheostomy tubes, had its roots in the early 1800s. In fact, NIV preceded the era of advanced yet invasive techniques that most think of as mechanical ventilation today. Non-invasive ventilation can be provided with either negative or positive pressure, can be given in a variety of different ways, and can be utilised in acute care, chronic care and home situations.

## Historical aspects

The earliest known ventilators, developed during the late 19th century,<sup>1</sup> were the 'body or tank' type that used negative pressure to create air movement from the environment into the patient's lungs. Further refinements were made by Woillez (1876) with the development of the first workable 'iron lung' and Alexander Graham Bell (1889), who developed an iron lung for a newborn infant.<sup>2</sup> In the 20th century, an 'epidemic' in the use of negative-pressure ventilation occurred as a result of a polio epidemic and this method of providing artificial respiration was credited with saving numerous lives.<sup>3-5</sup> These ventilators were referred to as 'iron lungs', and old prototypes still exist in museums and basements of many health care facilities. Other forms of ventilators during this era included rocker beds and the pneumobelt, where intermittent abdominal pressure was applied to facilitate air exchange in the lung.<sup>5</sup> A further improvement in medical technology was the advent of positive pressure to administer anaesthesia (intermittent positive-pressure ventilation or IPPV), which led to the development of intensive care units (ICUs) during the 1960s. Continuous positive airway pressure (CPAP), initially used for the treatment of acute pulmonary oedema, became popular in the 1980s

for management of obstructive sleep apnoea. CPAP is now commonly used in ICUs for the management of acute respiratory failure.

## Goals of therapy

Why would one use NIV? The desire to avoid complications associated with an ET tube or tracheostomy is the main consideration. An intact upper airway with preservation of airway defence mechanisms is paramount in the prevention of infectious complications. In addition, the patient with an intact upper airway retains the ability to eat, swallow and verbalise. Mechanical ventilation is more comfortable without a tube in place and can be utilised outside the intensive care setting.<sup>6</sup> NIV can facilitate the discontinuance of ongoing ventilatory dependence and treat chronic respiratory failure in numerous diseases such as neuromuscular disorders and chronic lung disease. Ultimately, the goal of NIV is to avoid intubating the airway with an artificial device.

In the acute situation its goals are to relieve those symptoms associated with increased work of breathing and to correct blood gas abnormalities.

## Indications

NIV can be used for acute and chronic respiratory failure. In the acute situation it has been used to manage respiratory failure due to acute exacerbations of chronic obstructive pulmonary disease (COPD), cystic fibrosis, asthma, pulmonary oedema, pneumonia and hypoxaemia.<sup>7-11</sup> COPD is the largest diagnostic category that has been managed with NIV in ICUs. Patients must be carefully selected for NIV. In general, patients in respiratory distress or impending respiratory failure may benefit from a trial of NIV. Increased work of breathing, as noted by use of accessory breathing

muscles or tachypnoea (especially in the paediatric patient) can be relieved by NIV.<sup>12-14</sup> People with sleep apnoea are the best known diagnostic group of patients who benefit from nocturnal NIV, and increasingly patients with neuromuscular disease experience improved quality of life when NIV is used to augment breathing during sleep.<sup>15-17</sup> Patients who are at high risk of aspiration or have copious secretions, unstable cardiovascular disease or extreme anxiety may not tolerate NIV and as such should not be given a trial of this mode of ventilation.

## Mechanisms

NIV is delivered via negative pressure (negative-pressure ventilation; NINPV) or positive pressure (positive-pressure ventilation; NIPPV). With NINPV a cuirass or shell spans the chest wall, and a vacuum is applied to alter the volume dimensions of the ribcage to allow for air exchange. NIPPV is generally used with either a mask (nasal, oral, oronasal or facial) or a mouthpiece and positive pressure (or a set volume) is administered.

Why NIV works, especially intermittently, is subject to numerous theories.<sup>18,19</sup> Some propose that augmenting muscle function relieves respiratory muscle fatigue.<sup>18,19</sup> Others comment that lung compliance is improved and atelectasis resolved, improving gas exchange and muscle mechanics.<sup>18,19</sup> Whatever the mechanism, NIV has found a permanent place in the management of respiratory failure.

## Disease-specific uses

**COPD** is the largest diagnostic category that has been studied using NIV in acute respiratory failure.<sup>20</sup> The reported success rate in preventing intubation ranges from 58% to 93% in non-randomised trials and historical studies.<sup>21-27</sup> The reported benefits of NIV in COPD include decreases in the length of time for which ventilation is required and in length of stay in the ICU and hospital. Numerous randomised controlled trials have been completed in this diagnostic group of patients. Methods of providing support include volume ventilation with a mask or pressure ventilation with oronasal or nasal masks. These modes of ventilation were successful in improving gas exchange and blood gases. In COPD exacerbations, the use of NIV improved vital signs, avoided airway intubation, and decreased hospital length of stay along with morbidity and mortality.<sup>28-34</sup>

**Asthma.** NIV in acute asthma has not been formally studied. Some studies examining the role of NIV in COPD have included some asthmatics, but the numbers are small and formal conclusions as to the benefit of NIV in acute asthma cannot be made.<sup>35</sup>

**Cystic fibrosis.** There are no controlled trials for the use of NIV in cystic fibrosis (CF), although many

CF centres are reporting anecdotal data on its benefit in both acute exacerbations and long-term management.<sup>36-39</sup>

**Restrictive lung diseases.** This group includes patients with neuromuscular disorders (e.g. Duchenne's muscular dystrophy) and chest wall deformities (including scoliosis). There is a lack of good studies examining the usefulness of NIV in these patients, although improvement in quality of life and decreased hospitalisation rates have been reported.<sup>16,40-42</sup> Bach in the USA has developed a protocol using NIV along with cough assist devices in these patients, avoiding tracheostomy and the inherent morbidity associated with its use.<sup>43-46</sup>

**Pulmonary oedema.** A number of trials have looked at the use of NIV in the management of acute cardiogenic pulmonary oedema. Most have been non-randomised, non-controlled trials and have studied the difference between using CPAP and bi-level positive-pressure ventilation (BiPAP). These studies have concluded that CPAP can be considered as initial therapy in respiratory distress or failure but that caution must be exercised in the presence of acute myocardial infarction.<sup>47-53</sup>

**Pneumonia.** Although routine use of NIV has not been advocated in otherwise healthy individuals who develop community-acquired pneumonia, some studies have shown it does decrease intubations and length of ICU stay. No change was noted in the overall mortality or hospital stay except in patients with underlying lung disease. Routine use of NIV therefore cannot be recommended until further studies are completed.<sup>54,55</sup>

**Other.** The use of NIV in immunocompromised patients has been aimed at reducing the infectious complications of ET tubes or tracheostomies. The overall success rate of NIV in AIDS patients with *Pneumocystis carinii* pneumonia is promising.<sup>56</sup> Additionally, NIV can reduce the need for airway intubation and complications after lung transplantation.<sup>57</sup> Non-infectious reasons for using NIV include relief of upper airway obstruction and facilitation of weaning from invasive mechanical ventilation in the acute care setting.<sup>58</sup>

## Long-term use

NIV is beneficial in the outpatient setting as a long-term treatment for chronic respiratory failure.<sup>40,59</sup> NIV is used for management of chronic respiratory failure secondary to chronic lung disease and for management of sleep disorders. In addition, some advocate long-term NIV to prevent complications related to restrictive lung disease.<sup>43</sup>

## Complications

Common complications of NIV include mask irritation, eye irritation, sinus congestion, oronasal drying, gastric

distension, inability to suction, skin breakdown, and claustrophobia. Mid-facial hypoplasia has been reported in very young children whose faces are still growing (anecdotal reports).<sup>60</sup> NINPV complications include lack of airway support and patient accessibility problems because of the cuirass or shell that covers the chest.

## Follow-up and monitoring

Patients using NIV require comprehensive long-term management by a dedicated team of professionals.<sup>61</sup> The respiratory physician, nurse clinician specialist and paediatric respiratory therapist are at the forefront of the team managing patients who require ongoing respiratory support. Other team members include physiotherapists, occupational therapists, carers in the home and representatives at school, and other personnel unique to the child's life and needs. Children are followed up at least quarterly until stable then twice yearly. Detailed record keeping is essential and includes the diagnosis, why NIV was initiated, type and mode of ventilation, recent blood gas values, chest radiography, and other laboratory studies that may be necessary.

## Local experience

In Winnipeg, Canada, the Section of Pediatric Respiriology has a long history of ventilating children both in ICUs and in the home setting. Initially, in the 1980s, all children who were ventilated at home required a tracheostomy tube. Now mask (non-invasive) ventilation is the preferred mode of delivering mechanical ventilation in the outpatient setting and is increasingly used in the paediatric ICU for acute respiratory distress/failure. Our Technology Dependent Clinic currently has 58 paediatric patients mechanically ventilated in the outpatient setting, 30 of whom receive NIV (none receive NINPV). Most patients on NIV are those with sleep-related breathing disorders (predominately obstructive sleep apnoea), followed by those with chronic lung disease secondary to bronchopulmonary dysplasia or following viral-induced lung injury (adenoviral pneumonia). Other criteria for initiating NIV in the outpatient setting include degenerative/progressive neuromuscular disorders and cystic fibrosis in end-stage lung disease.

NIV use in cystic fibrosis, as mentioned earlier, has not been formally studied, but Winnipeg Children's Hospital has ventilated 15 patients in the outpatient setting with NIV in the past 14 years. CPAP or BiPAP was initiated in end-stage lung disease with evidence of chronic respiratory failure and chronic compensated respiratory acidosis. The initiation of NIV in this diagnostic group has been beneficial, as shown in the stabilisation of pulmonary function, improved survival, and improved quality of life.

## Conclusion

NIV has been available in the management of respiratory failure for over a century. Improvements in its delivery have increased its usefulness in both the acute care and outpatient settings, and further refinements to improve the patient/machine interface will only amplify its use. NIV has utility in a multitude of situations but is most helpful in acute-on-chronic respiratory failure. Further research is necessary to properly determine those disorders that are most amenable to treatment by NIV and determine the most appropriate use of this old technology.

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