Defining the terms for NIV

Noninvasive ventilation (NIV) can be delivered using two types of Ventilators: Bilevel ventilators which use a patient circuit that incorporates an intentional leak to remove CO₂ and ventilators which use a patient circuit which includes an exhalation valve to separate inspiration from expiration preventing CO₂ rebreathing. CPAP is also used for some respiratory failure patients mainly to improve oxygenation.

Trigger variable

The variable that determines the start of inspiration. Pressure, volume, flow or time may be measured by the ventilator and used as a variable to initiate inspiration.

Cycle variable

Inspiration ends when a specific cycle variable (pressure, volume, flow or time) is reached. This variable must be measured by the ventilator and used as a feedback signal to end inspiratory flow delivery, which then allows exhalation to begin.

Intrinsic PEEP

"Under mechanical volume-controlled ventilation, the intensive care patient can develop intrinsic positive end-expiratory pressure (PEEP); that is, the passive expiration is terminated by the following inspiration before the alveolar pressure comes to its physical equilibrium value." ¹

Pressure Support (PS)

The delta pressure plateau setting used when providing pressure support ventilation. When using a bilevel ventilator this is established by setting the IPAP and EPAP: IPAP-EPAP = PS.

From the Editor

Noninvasive ventilation (NIV) has been used for more than 20 years to manage acute respiratory failure in intensive care settings and in the home for people with chronic respiratory failure. Its uses are gradually being extended as NIV devices become more adaptable and portable, giving patients with chronic conditions greater mobility.

In this edition of ResMedica we take a global look at NIV therapy today. We’ve spoken to clinicians from France, Australia, England and the US and have found that the use of NIV is being explored and extended wherever possible. Where NIV can be used instead of tracheotomy, its advantages are well-documented—reducing complications such as nosocomial pneumonia, improving patients’ survival and quality of life.² The new, lighter devices give mobility even to those who are reliant on 24-hour ventilation. This mobility itself may assist in improving breathing. Dr Amanda Piper, coordinator of the Respiratory Failure Service and Home Ventilation Program, Royal Prince Alfred Hospital, Sydney tells us of research into the effects of using NIV during exercise for selected patients.

We have also interviewed Louie Boitano, respiratory therapist at the University of Washington Medical Center in Seattle. His clinic provides respiratory support for neuromuscular patients with progressive developing respiratory insufficiency, using NIV in all cases except where there is severe bulb or cognitive dysfunction.

We have looked in some detail at the situation in France, where comprehensive guidelines on its use have been developed. An interview with Dr Lode from the Pediatric Emergency Medical Unit, Hôpital Robert Debré, Paris gives us an insight into using NIV with children in acute situations. Two case studies from France show how NIV can be used instead of tracheotomy, its advantages are well-documented—reducing complications such as nosocomial pneumonia, improving patients’ survival and quality of life.

We would like to offer our thanks and appreciation to all of the people who generously gave their time and expertise to participate in this edition of ResMedica: Louie Boitano, Dr Amanda Piper, Noella Lode, Dr Anita Simonds and Nick Wilcox. We would also like to give a very special thanks to Susan Sortor-Leger and the team in the ResMed France office for their huge contribution to this edition.

Breathe Well.

Sherrill Burden, Global Editor
Providing the best survival and quality of life: An interview with Louie Boitano

Louie.Boitano MSc, RRT is a respiratory therapist in the Departments of Respiratory Care, and Pulmonary and Critical Care Medicine at the University of Washington Medical Center in Seattle, Washington. His MSc is in biology with an emphasis in physiology. His areas of specialization are neuromuscular respiratory pathophysiology and the application of noninvasive respiratory aids for neuromuscular diseases affecting respiratory function. He is co-principal with Dr. Joshua Benditt in the Northwest Assisted Breathing Center, a center of excellence for research and training in the noninvasive respiratory support of neuromuscular respiratory insufficiency within the University of Washington School of Medicine. His clinical responsibilities include outpatient diagnostic testing and respiratory case management of neuromuscular patients with developing respiratory insufficiency, as well as clinical research in neuromuscular respiratory insufficiency and respiratory muscle aids. He is a member of a number of neuromuscular respiratory advocacy working groups: Medical advisory board for the International Ventilator Users Network; Muscular Dystrophy Association Pulmonary Subcommittee and American College of Chest Physicians Neuromuscular Respiratory Subcommittee.

Could you please briefly describe your work at the University of Washington?

I am a respiratory therapist who works in the Pulmonary Clinic in the University of Washington Medical Center in Seattle, Washington. My responsibilities include diagnostic testing, the initiation and management of respiratory therapies including ventilation, airway management, secretion clearance, aerosol therapies and oxygen therapy. I work with Dr. Joshua Benditt who has a neuromuscular respiratory clinic supporting adult patients with neuromuscular induced respiratory limitation. I also work in clinical research in neuromuscular respiratory care and cystic fibrosis.

We make every effort to use NIV except in cases of severe bulbar or cognitive dysfunction where NIV is either not tolerated or not effective.

You were recently one of the key speakers at the ‘Towards a Brighter Future’ conference in Sydney, Australia, organised by the Duchenne Foundation. What were the highlights of the conference for you?

The ‘Towards a Brighter Future’ conference was a combined clinic, patient-family education program. The program provided clinicians and family of muscular dystrophy and spinal muscular atrophy patients with up-to-date information on the progress of research in the genetics and pathophysiology as well as directions of research in the development of therapies. There were also presentations and workshops for both patients and families addressing the clinical and home care of neuromuscular patients. Often families of neuromuscular patients do not have access to information on advances in the clinical care of neuromuscular patients. Programs such as this one, supported and organized by the Duchenne Foundation, provide families with the information they need to be both an advocate and provide the best care for their family member with neuromuscular disease.

In what circumstances do you use NIV? That is, what are the main types of patients (indications) in which you would begin ventilation with NIV? In what type of environment (clinic, home, hospital)?

As respiratory clinicians in an adult outpatient setting, our goal is to provide timely respiratory support for neuromuscular patients with progressive developing respiratory insufficiency. The timeliness in providing support is based upon comprehensive serial neuromuscular respiratory assessments including pulmonary function testing and a directed assessment of history and symptoms of developing respiratory insufficiency. Our orientation of support is in the use of noninvasive respiratory aids. We make every effort to use NIV except in cases of severe bulbar or cognitive dysfunction where NIV is either not tolerated or not effective.

In the US, NIV for patients with neuromuscular or chest wall disease that affects respiratory function is provided by payer support when either their measured vital capacity is less than 50% of predicted, their maximum inspiratory pressure is less than negative 60 cm H2O or their carbon dioxide greater is greater than 44 mm Hg. Patients who produce test results that do not qualify them for NIV but are found to have symptoms of sleep-disordered breathing are referred for polysomnography testing with pressure titration as needed. Neuromuscular induced respiratory insufficiency is usually initially manifested as nocturnal hypoventilation. Noninvasive bilevel pressure support ventilation has been clinically shown to provide a noninvasive means of support for a variety of neuromuscular patient populations with developing nocturnal hypoventilation and for long-term chronic progressive respiratory insufficiency where bulbar function is preserved.

For neuromuscular patients with chronic progressive insufficiency when nocturnal bilevel pressure ventilation alone is no longer sufficient we will start portable daytime mouthpiece ventilation. In our practice mouthpiece ventilation is best supported by using volume-cycled ventilation in assist/control mode. Primary indications for starting daytime mouthpiece ventilation are developing daytime hypercarbia or developing shortness of breath. Mouthpiece ventilation provides a noninvasive means of supporting ‘as needed’ daytime portable ventilation which complements nocturnal mask ventilation. The neuromuscular patient with adequate bulbar function can trigger a ventilator breath by making a sip effort on the mouthpiece. Mouthpiece ventilation can also support both hyperinflation and cough augmentation when the patient is able to do breath-stacking maneuvers by receiving multiple breaths from the ventilator, by making repeated sip efforts. This means of ventilation provides the patient with an independent means of ventilation and cough augmentation to clear secretions without the continuous attendant care required for tracheostomy ventilation.

This means of ventilation provides the patient with an independent means of ventilation and cough augmentation to clear secretions without the continuous attendant care required for tracheostomy ventilation.

Do you also use intubation? In what circumstances?

Intubation is indicated when NIV is no longer effective as in the case of acute respiratory failure or for interventional procedures requiring general anesthesia. In these cases most neuromuscular patients can be extubated to NIV either after treating the cause of acute respiratory failure once the patient is stable or under a pre-determined peri-operative care plan and with the support of mechanical cough augmentation therapy. We have also decannulated neuromuscular patients to NIV who have previously undergone tracheotomy for acute respiratory failure, who have been stabilized, and where there are no contraindications to decannulation.

Could you briefly describe how your service is organized for implementing NIV? Do you have written protocols? Who implements NIV?

We use what has been termed as wide span bilevel pressure support (pressure support > 10 cm H2O) for neuromuscular induced hypoventilation. Initial bilevel pressures of 10–12 cm H2O with a Spontaneous/Control Mode backup rate of 10–12 bpm are used in conjunction with a patient self-directed four step desensitization protocol aimed at helping the patient to adapt to NIV support. Patients are seen in the clinic for instruction in the use of bilevel pressure ventilation, a review of the four step desensitization protocol, and for an initial trial of therapy where initial bilevel pressures, rise time and trigger/cycle sensitivities are determined. The patients are also given the opportunity to trial different ventilated masks. A specific prescription of bilevel pressure ventilation settings and mask type is then sent to a durable medical equipment provider who will provide the equipment to the patient. When the patient is able to use NIV through the night, IPAP is then titrated to an initial target pressure support of 10 cm H2O.

What type of monitoring do you routinely use for patients on NIV?

We use nocturnal oximetry studies as a means of evaluating nocturnal mask ventilation support. Our patients are asked to bring their bilevel pressure ventilators to the clinic during their visits. We download their ventilator memory or memory cards to evaluate the effectiveness of their bilevel pressure settings and mask ventilation. Patients who are considered to be on optimal bilevel pressures but express symptoms of sleep-disordered breathing are referred for polysomnography with pressure titration. The patients are specifically identified as having neuromuscular induced respiratory insufficiency so that a protocol of transcutaneous CO2 monitoring is also used to determine optimal bilevel pressure support.

Could you describe the progress of patients on NIV?

Because we are an adult neuromuscular respiratory clinic, we see neuromuscular patients transitioning with congenital and hereditary neuromuscular disease and patients with adult onset neuromuscular disorders—including amyotrophic lateral sclerosis (ALS) and post-polio syndrome—as well as spinal cord injury and diaphragmatic paralysis patients. Transitioning pediatric patients generally have slower progressive forms of neuromuscular disease that require semiannual clinical evaluation with initiation of respiratory support as needed. Often type II spinal muscular atrophy patients and some muscular dystrophy patients will require mechanical cough augmentation therapy before they will need to start NIV.
Providing the best survival and quality of life: An interview with Louie Boitano

Continued>

Spinal cord injury patients often have more stable respiratory insufficiency and can be started on appropriate noninvasive respiratory therapies that may not require continuous follow-up respiratory management. ALS patients generally have a more rapid course of developing respiratory insufficiency requiring clinic visits every three or four months, or more frequently, to adequately monitor their progressive insufficiency and to provide timely support. In our experience, ALS patients with bulbar onset disease are the most difficult to support by noninvasive means because of upper airway instability and sialorrhea whereas distal onset disease patients can be supported very well, depending on their rate of progressive respiratory insufficiency.

When patients are referred to you or another specialist are they evaluated and treated early?

Patients transitioning from pediatric neuromuscular clinics are often on noninvasive bilevel pressure and may also be using mechanical cough augmentation. The American Thoracic Society consensus guidelines on the respiratory care of Duchenne muscular dystrophy and, more recently, the Center of Disease Control guidelines as well as European guidelines for spinal muscular atrophy have provided templates of care that have helped clinicians to start earlier, more comprehensive respiratory monitoring and to provide timely respiratory support for pediatric neuromuscular patients.

Do patients have any choice in their ventilator? Do patients have to pay for their ventilator?

Patients generally do not have a choice in the type of ventilator they will receive. The physician generally determines the type of ventilator bilevel pressure, volume-cycled). Patients do have a choice in the type of mask they wish to have and generally in the need for heated humidification. In the US, ventilators are supported by the patient’s respective payer. Patients who have the means will sometimes purchase a second ventilator which is not usually supported by the payer.

Do specialists give patients any ‘take home’ information and if so what?

The availability of ‘take home’ information for neuromuscular patients is dependent upon the specific clinic program. We have specific patient education information for the therapies that we provide including CPAP and bilevel pressure ventilation, manual hyperinflation and cough augmentation, home oximetry monitoring for respiratory infection and for mouthpiece ventilation. We believe strongly in the education of our neuromuscular patients and their families in regard to their respective disease progression and the therapies available to them. Educating the patient and their family allows them to make the best personal decisions regarding their understanding and choice of therapy support.

Anything else you would like to mention about your use of NIV?

Although the primary target of therapy for bilevel pressure ventilation is sleep-disordered breathing, I would submit that the neuromuscular patient population with respiratory insufficiency has received the greatest benefit from this therapy both in terms of quality of life and survival.

“Although the primary target of therapy for bilevel pressure ventilation is sleep-disordered breathing I would submit that the neuromuscular patient population with respiratory insufficiency has received the greatest benefit from this therapy both in terms of quality of life and survival.”

Using NIV in acute respiratory failure – French guidelines and training

Patients with certain types of acute respiratory failure benefit from treatment with noninvasive ventilation (NIV) rather than intubation. NIV can often begin sooner, reduce infection rates and have fewer side effects. Guidelines from French medical societies identify training as an essential requirement for operating NIV devices and establish protocols for NIV use. Since early 2008 ResMed France has been conducting practical workshops for ER physicians and paramedics in the use of NIV.

Randomized controlled trials have shown that NIV is an effective response to acute respiratory failure in patients with chronic obstructive pulmonary disease (COPD), acute respiratory failure and pulmonary edema. Unlike invasive ventilation, NIV can be initiated outside the intensive care unit (ICU) and can be made available to patients who might not be admitted to the ICU. It should begin early but does not need to be provided continuously in order to be effective.

Advantages of using NIV over intubation

ResMed’s campaign to increase the use of NIV ventilation in the Emergency Room (ER) has been in place for almost two years. It resulted from increasing interest to use NIV early in the clinical pathway, especially for COPD and pulmonary edema patients, in an effort to avoid intubation. Once COPD patients in particular are intubated; they often require many days of intensive care and have increased complications and poorer outcomes. Studies have shown that intubation can be avoided in most cases (if NIV commences early enough) and thus decrease complications, length of hospital stay and improve outcomes, including decreased rates of mortality.

Since 2008 many of these patients are intubated in the ER. There is an increasing interest to train the staff to begin NIV whenever possible in the ER or even during transportation to the ER. This is especially true if the ER stay tends to be long, as this increases the likelihood of intubation.

Similarly, using NIV in cases of acute cardiogenic pulmonary edema is associated with reduced need for intubation and a decrease in mortality.

Reducing rates of intubation has been shown to lead to lower rates of complications such as nosocomial pneumonia.

Use of ventilators

In France ventilators are used in ambulances (when there is a physician present) during transport (helicopter, planes) and within the ER. The most common use is for invasive ventilation during trauma, cardiac arrest, other emergencies and for pediatrics. However, NIV is now being used more frequently for COPD and acute pulmonary edema. ResMed’s Elise range of ventilators offers both invasive and noninvasive ventilation, allowing emergency teams to make the choice of NIV where it is suitable. Elise devices are sold to emergency rooms and used in ambulances throughout France, covering the devices’ wide range of potential use, and that the team can become familiar with one ventilator for all use-case scenarios. A 2007 study comparing the Elise 250 with the Dräger Oxylóg 3000 found that the Elise 250 was easier to use, leading to fewer errors and therefore increased reliability.

Guidelines for using NIV

Three major French medical societies—ISRLF Société de Réanimation Langue Française, SFAR: Société Française d’Anesthésie et Réanimation, SPLF: Société de Pneumologie Langue Française—dealing with emergency, anaesthesia and the respiratory system held the NIV in Acute Respiratory Failure consensus conference in 2006 and developed a set of guidelines for using NIV in cases of acute respiratory failure (ARF). The guidelines cover: when NIV should and should not be used; the clinical criteria for initiating NIV, and the modes to use; what is required for NIV treatment; the criteria for success, and the risks.

According to the guidelines, NIV should be provided when there is:

- COPD in acute decompensation
- Severe Cardiogenic Pulmonary Edema

They also recommend that NIV should probably be offered:

- in cases of acute hypoxemic respiratory failure in the immunosuppressed patient
- post-operatively in thoracic and abdominal surgery
- in an invasive ventilation weaning strategy for COPD
- to prevent ARF after intubation
- where there is decancellation of chronic respiratory failure in patients with restrictive disorders and cystic fibrosis.

The guidelines also list contraindications for using NIV:

- In unsuitable environments, where there is insufficient experience and skill in the clinical team
- Non-compliant patient, agitation, refuses the technique
- Imminent intubation (except when used for pre-oxygenation).
- Acute respiratory fatigue.
- Shock, life-threatening ventured arrhythmias.
- Severe hypoxemia.
- Immediately after a cardio-respiratory arrest.
- Non-indwelled pneumothorax.
- Obstruction of the upper airway (except OSA, laryngo-tracheomalacia).
- Severe unstoppable vomiting.
- Haemorrhage in the upper digestive tract.
- Severe cranio-facial trauma.
- Acute traumatic tetraplegia during the initial phase.

Training

Lack of training is known to be one of the main reasons why clinicians fail to use NIV and the French guidelines list ‘lack of training’ as a contraindication. Since 2008 ResMed France has been running practical workshops to introduce clinicians to NIV using Elise ventilators. In 2009, over 400 clinicians (92 physicians, 149 paramedical personnel attended the training program in order to...
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Using NIV in Acute Respiratory Failure—French Guidelines and Training

Using NIV modes

There are two main ventilation modes recommended for NIV:

- PS+PEEP
- CPAP

NIV with the ventilation mode PS+PEEP is recommended for:

- COPD decompensation with respiratory acidosis and a pH<7.35. CPAP should not be used.
- ARF in the intrapulmonary-suppressed: as first line treatment of ARF (PaCO2 < 250 mmHg with pulmonary infiltrates).
- Neuromuscular disorders: The clinical signs of ARF or a hypercapnia of 45 mmHg are the formal indications for NIV (Include noninvasive techniques for secretion clearance).
- Ocular Fibrosis (children and adults).

NIV with either the ventilation mode PS+PEEP or CPAP is recommended for:

- Cardiogenic Pulmonary Edema: in association with optimal medical treatment that does not delay the specific treatment for an acute coronary syndrome.
- When there are signs and symptoms of acute respiratory distress without waiting for the results of the blood gases.
- When there is hypercapnia with a PaCO2>45 mmHg.
- When there is no response to medical treatment.

PS+PEEP Ventilators with a PS+PEEP mode should have:

- settings for inspiratory trigger, rise time, maximum inspiratory time, cycle/expiratory trigger.
- measured expired tidal volume and treatment pressures.

The PS+PEEP mode is the most commonly used mode for ARF. This mode allows the clinician to progressively increase the PS level beginning with around 6 to 8 cm H2O until the optimal level is reached to improve ventilation and achieve patient comfort.

- An expired tidal volume of around 8 to 8 ml/kg is recommended.
- The level of PEEP used most often is around 4 to 10 cm H2O depending on the indication for NIV.
- A peak inspiratory pressure not more than 20 cm H2O is recommended to avoid the risk of air in the stomach and high leaks.

PEEP

- improves oxygenation
- reduces the inspiratory work associated with intrinsic PEEP
- stabilizes the upper airways.

Starting NIV

Within an emergency setting, the recommendation in France for starting NIV is that:

- the team is trained in NIV use
- there is a clear protocol for its use
- the patient is supported in a semi-sitting position at 45°
- a transparent full face mask is used
- there is the ability to intubate if needed

The interface chosen for the patient plays an important role in the tolerance and efficacy of NIV. Multiple sizes and models should be made available. A full face mask is recommended as the first choice and is the interface mainly used during NIV in ARF.

Humidification may be necessary:

- when there are leaks
- when supplemental oxygen is used
- when a patient is congested
- in the presence of high nasal resistance.

Starting NIV

•  an expired tidal volume of around 6 to 8 ml/kg is optimal level is reached to improve ventilation and achieve the Ps level (beginning with around 6 to 8 cm H2O).

- measured expired tidal volume and treatment pressures.

NIV with the ventilation mode PS+PEEP should have:

- when there is hypercapnia with a PaCO2 > 45 mmHg.
- when there are leaks
- when supplemental oxygen is used
- when there are signs and symptoms of acute respiratory distress without waiting for the results of the blood gases.

Case study 1: Using NIV in COPD exacerbation in France

Mr B is 60 years old, slightly overweight and has severe COPD. He has a BMI of 30 and is 175 cm tall. He lives at home with his wife of 40 years and is closely monitored by his pulmonologist. His current treatment consists of:

- oxygen therapy at 2L/min, 16%O2
- long action bronchodilators and corticosteroids by inhalation.

His medical profile includes:

- stage III COPD
- ex-smoker: has a 20 pack/year smoking history
- stopped smoking five years ago
- diabetes: non-insulin dependent
- no known allergies.

Recently Mrs B found her husband very lethargic and had to wake him from his afternoon nap. She called the emergency number asking for the paramedics to come quickly. She explained that he had had a fever for two days, with increased coughing and expectation of yellow mucus, and that she couldn’t wake him from his nap.

The emergency team - a physician, nurse and driver arrived soon after. They quickly began to examine Mr B and found the following:

- HR: 130 with sinusoidal rhythm
- BP: 130/80
- Respiratory rate (RR): 42 bpm
- SpO2: 80% with O2 at 2L/min
- Cyanosis of the extremities and lips
- Temperature: 38.6°C
- Sweating+
- Dyspnea stage III with accessory muscle use

- Stemo-clido-mastoid and scalene+

Auscultation: crepitation noted in the lower right lung region
- Expectoration: yellow and abundant
- Blood glucose: 6.2 mmol/L

Diagnosis: decompensation of COPD with possible pneumonia in the right lung base.

The physician explained to the patient and his wife that it would be necessary to go to the hospital but before leaving they felt it best to begin IV and NIV on Mr B.

The team uses ResMed’s Elise 250 and the initial settings for beginning NIV are:

- FiO2: 40%
- PEEP: 5 cm H2O
- PS: 6 cm H2O

- trigger: 3
- Rise time: 1 sec
- Expiration time: 1 sec

They began NIV with these initial settings using a full face mask because Mr B was lethargic and mouth breathing. Due to his wheezing, inline aerosol therapy was also started immediately using bronchodilators. This is preferred over traditional mask aerosol as it is felt that the medication will have better penetration due to increased lung volumes with ventilation. If the appropriate T adapter is not available aerosol treatments can be alternated with ventilation.

Settings are optimised using clinical judgment and monitoring the patient, SpO2, and the values and waveforms on the Elise 250.

After several minutes of ventilation the physician noted that Mr B’s Vte was quite low (~6 ml/kg of ideal body weight). He therefore decided to increase the PS to 8 cm H2O and observe the effect this had on the patient. Vte improved slightly and RR decreased a little, but not enough, so after another few minutes PS was again increased to 10 cm H2O.

Once a good level of PS was achieved, Mr B’s RR decreased considerably to 25 bpm. After a few minutes the physician observed that the patient continued to use his accessory muscles and occasionally was unable to trigger the ventilator. The physician decided to increase the PEEP to 6 then 7 cm H2O thinking the problem was due to intrinsic PEEP. He noted a few minutes later that Mr B stopped using his accessory muscles and had a calm response pattern. At this time Mr B was more awake and able to respond to questions. The physician explained that they were going to transfer him to the hospital where they could treat his lung infection. He also explained that during the transfer Mr B would need to keep the mask on his face as this would help him breathe better.

During the transfer, the patient’s SpO2 progressively improved. Upon arrival he was more comfortable, had less sweating and dyspnea with a RR of 25, Vte of 560 ml, SpO2-89% using an FiO2 of 35%.

It was decided to transfer Mr B to a step-down unit for further follow-up and care. Ventilation was continued.

Mr B stopped using his accessory muscles progressively. Up until now he was more comfortable, had less sweating and dyspnea with a RR of 25, Vte of 560 ml, SpO2-89% using an FiO2 of 35%.

It was decided to transfer Mr B to a step-down unit for further follow-up and care. Ventilation was continued.
What types of patients (indications) do you mostly see?

We look after patients with both acute and chronic respiratory disorders. The acute conditions we most commonly see are COPD and obesity hypoventilation syndrome; chronic respiratory conditions include sleep-related respiratory failure, neuromuscular disorders and chest wall deformity.

In what circumstances do you use NIV in the home/in a hospital setting?

It depends on the diagnosis. Where the patient presents to hospital with an acutely raised CO2 and respiratory acidosis, we will be looking at NIV to prevent intubation or as a weaning therapy. For most of these individuals, NIV is a temporary therapy to get them over the acute phase of their respiratory problem. For patients with chronic respiratory failure, therapy will be used at home on a long-term basis. The need for NIV use is based on blood gases, symptoms and breathing abnormalities occurring during sleep. Some people with chronic respiratory failure will present acutely, and once they are stabilised we undertake investigations to determine the cause of their respiratory problems and the nature of any underlying sleep-disordered breathing (SDB) and implement therapy accordingly.

Do you use CPAP as well?

Our program deals with patients needing home ventilation, usually bilevel therapy. There is another team in our unit which deals solely with CPAP therapy. However, there can be a crossover where patients may need bilevel ventilatory support initially, but once daytime CO2 and respiratory drive improve, a switch to CPAP therapy alone may be possible, and we supervise this.

Do you also use intubation?

No, we operate out of a ward setting and wherever possible we try to avoid intubation. One aspect of our work involves assisting patients to wean from invasive ventilation, using non-invasive ventilation techniques either in the short or long term. Intubation or tracheostomy can often introduce additional problems in patients with chronic respiratory failure, especially in the presence of neuromuscular or chest wall dysfunction, so other factors need to be addressed and include the ability to cough and deep breath effectively, improving mobility, weight management, attention to nutrition and swallowing.

Anything else you’d like to add?

In recent years, there has been a huge swing towards pressure-targeted devices to manage chronic hypercapnic respiratory failure. This is certainly justified based on cost, comfort and convenience. However, it is important for clinicians not to overlook the advantages and benefits of volume-targeted ventilation in selected individuals. This is particularly important for patients with neuromuscular disorders, who are now living longer despite considerable and progressive respiratory muscle weakness. The type of ventilator and features needed to meet their respiratory needs will change with time, and this must be recognised by clinicians. Setting up volume-targeted ventilation requires a slightly different skill set to pressure-targeted devices and it is important that clinicians don’t lose these skills. An effective ventilation program needs to be able to identify and set up the right device to meet the respiratory needs of the individual patient.

“Recent work has really highlighted the importance of identifying abnormal gas exchange during sleep as early as possible to avoid the patient slipping into uncompensated respiratory failure from an apparent minor clinical event.”

You have also written about the effects of NIV on exercise training. What were the main findings from your research?

This work from Giuseppe Menzauro, a PhD student I am supervising. The technique is not appropriate for routine clinical use, but in selected patients we have found important improvements in exercise duration using NIV during exercise and mobilisation. We have applied it in both our outpatient rehabilitation programs and for inpatient early mobilisation, to improve breathing, assist the patient to exercise more, and to build their confidence about getting up and moving around. We have also shown that patients who are bed-bound by breathlessness can often become more mobile by using the ventilation mounted on their wheels. We only use this technique with patients who are responsive to therapy—we compare results such as breathlessness and exercise duration during NIV to what can be achieved during exercise bouts and if improvements are seen, NIV during exercise training can be incorporated into their rehabilitation program.

What guidelines do you use/teach in using NIV?

We try to make our guidelines as evidence-based as possible. Once an abnormality in sleep breathing is identified we work with the patient and carers to try to introduce therapy in a timely fashion. For therapy to be effective the patient has to be a willing participant. We do a lot of patient/carer training, introducing the patient to the idea of NIV, identifying what our goals of therapy are and explaining what the patient can expect from therapy. Recently, I have been involved in a working party to develop comprehensive guidelines regarding the assessment, implementation and long-term follow-up of patients requiring NIV. The aim of these guidelines is to improve the baseline level of care that patients with chronic respiratory failure needing NIV receive in New South Wales.

In our unit, the introduction of NIV is based on four major principles:

- Picking the appropriate patient at the appropriate time for therapy.
- Training the patient in how NIV can help them, and how to use the device effectively.
- Ensuring good patient/machine synchronisation, so that therapy is as effective as possible.
- Recognising that NIV is not only one aspect of the overall management of a patient with nocturnal hypoventilation. Other factors need to be addressed and include the ability to cough and deep breath effectively, improving mobility, weight management, attention to nutrition and swallowing.
Australian consensus statement and model of care for home noninvasive ventilation (NIV)

A working group in New South Wales met for the first time in December 2007 to discuss the need to standardize services for adult patients requiring home ventilation within the broad aims of equity of access and outcome. The group has now produced final drafts of a consensus statement and a model of care.

The consensus statement, ‘Domiliary Noninvasive Ventilation in Adult Patients’, was submitted in late 2009 to the Thoracic Society of Australia and New Zealand and the Australian Sleep Association for national input and professional endorsement. Following this peer review process the document will be published and distributed.

Proposed model of care for home noninvasive ventilation

The final draft of the ‘Proposal for an Improved Model of Care for Home NIV Services in NSW’ contains 69 recommendations to NSW Health on how best to optimize services for patients to ensure equity of access to, and outcome from, best practice home NIV services in NSW. The Respiratory Network’s Secretariat conducted a broad and inclusive consultation process, including site visits and face-to-face meetings, with clinical teams involved in the provision of home NIV services in NSW.

For more information contact Nick Wilcox, Manager, Respiratory Network, NSW Agency for Clinical Innovation at nwwilcox@nsccahs.health.nsw.gov.au

Case study 2: Using NIV in Acute Cardiac Pulmonary Edema

Mr C is a 65 year old retired French public employee. He does not do much physical exercise and is slightly overweight. His medical history includes:

- Hypertension: 160/90 on medication
- Hypercholesterolemia being treated with anti-cholesterol medication
- Heart failure treated with diuretics and Beta blockers
- Smoking history: 10 pack/years but stopped smoking 5 years ago.

Recently, Mr C awoke in the middle of the night with severe difficulty breathing and heavy sweating. He decided to call the emergency number.

Upon arrival the medical team found Mr C very agitated and anxious with severe dyspnea and sweating even at rest. He was coughing as soon as he tried to speak. The team found:

- Pulse: 125 sinus rhythm
- ECG: sinus rhythm with signs of left sided heart failure
- BP: 190/110 mmHg
- Respiratory rate (RR): 40 bpm
- SpO2: 80% on room air with cyanosis in the extremities
- Auscultation: loud bilateral crepitations & rales.

Their diagnosis was Acute Cardiac Pulmonary Edema. They started high flow oxygen by mask and a large calibre IV line was inserted to give the patient a bolus of nitrates diuretics. The patient’s respiratory distress did not subside and his SpO2 remained below 90%. Since the emergency team has an Elise 250 with them they decided to start NIV. They chose a full face mask and began with the following settings:

- FIO2: 100%
- PEEP: 5 cm H2O
- PS: 6 cm H2O
- Trigger: 3
- Rise time: 1
- Set apnea ventilation.

The patient’s work of breathing decreased but remained high with some paradoxical breathing efforts. The PEEP was increased to 7 cm H2O. The saturation came up and the patient’s breathing began to calm down. The FIO2 was decreased to 60% with a SpO2 of 93%. The patient appeared much more comfortable and ready for transfer to the hospital.

Adherence to NIV therapy

In 2008 we interviewed Dr Anita Simonds1 about adherence to ventilator therapy. She told us that for most patients, adherence is stable after the first month unless other health problems arise. Here’s what she said about managing nonadherent NIV patients.

In our experience, the best way to tackle nonadherence is to identify underlying difficulties and then to systematically problem-solve.

It always helps to revisit the original sleep studies or investigations that indicated the need for treatment. Patients value these being explained in detail. If the circumstances have changed (eg, significant weight loss in obesity hypoventilation patients), these studies will need to be repeated. Other pathology should be considered, such as restless legs in a heart failure patient with central sleep apnea.

We also check daytime and nocturnal blood gas control to see if ventilator settings require adjustment. Additional data on flow limitation can be helpful to see whether upper airway obstruction is occurring and leading to respiratory arousals. Patients will indicate if the interface is the main issue and this is best dealt with by having a wide variety of interfaces available and skilled staff who can fit these accurately to the patient. It always helps to revisit the original sleep studies or investigations that indicated the need for treatment. Patients value these being explained in detail. If the circumstances have changed (eg, significant weight loss in obesity hypoventilation patients), these studies will need to be repeated. Other pathology should be considered, such as restless legs in a heart failure patient with central sleep apnea.

1. Dr Simonds is a Reader in Respiratory and Sleep Medicine, National Heart and Lung Institute, Imperial College London, UK. The full interview with Dr Simonds can be found in ResMedica #11, 2008.
Looking after the children: An interview with Dr Noella Lode

Dr Lode is responsible for the Pediatric Emergency Medical Unit at the Hôpital Robert Debré in Paris, France. The hospital opened in 1988 and is now the largest pediatric hospital in France. It caters for infants and children, adolescents, women and mothers-to-be. It has 475 beds and cares for more than 30,000 patients hospitalized, with 200,000 consultations, each year. This includes nearly 80,000 children and adolescents. Dr Lode is in charge of medical transport for newborns and children at risk of organ failure (respiratory, cardiovascular, neurological).

Could you briefly describe your work with the Pediatric Emergency Medical Unit at Hôpital Robert Debré?

First I would like to explain the organization of the medical emergency system in France. The public calls a special telephone number, which is 15. Anyone who calls this phone number will first find themselves in contact with a dispatcher. Depending on the situation described by the caller, the dispatcher will decide whether to send the call to one of two physicians: one (physician permanence) who will talk to the patient and give them some advice, or another physician (regulateur du SAMU) who will decide what type of emergency vehicle should be sent to the location—an ambulance or an emergency medical team such as the Red Cross, Fire Department or a special team in France, called the SMUR, in which a physician is part of the team. The first level emergency vehicles contain the necessary equipment to provide oxygen therapy and semi-automatic cardiac defibrillation.

There are five specialized Pediatric Emergency Medical teams (SMUR) in the Paris area. When there is a secondary inter-service transportation request (from one hospital service to another), the service transferring the child makes the request directly to the SMUR and they select the team that is the closest and fastest available for the transfer.

The composition of the SMUR team is as follows:

- an ICU pediatrician (we manage children from 0 to 15 years old)
- a nurse or a pediatric nurse with a minimum of two years experience in neonatology or pediatrics
- a driver/technician with training in the pediatric service
- anyone who is in training is with us (pediatric intern, midwife, emergency room physician).

Physicians are on call 24 hours, nurses and driver/technicians are on-call 12 hours.

Some statistics from our unit at Hôpital Robert Debré in 2009:

- 1472 interventions (with transport by the Fire Department or by parents)
- 1315 transports using SMUR.

The most important task for the emergency team is to stabilize the child before transporting them. For this reason a large majority of care and treatment is done on-site.

The exception to this rule is infants and children with severe trauma pathologies where emergency surgery is needed and the transfer is done immediately so that the infant can go as quickly as possible to surgery.

Other than this situation, practically all the care is done before the child is transferred in the ambulance. This includes physical stabilization, monitoring, scope, perfusion, infusion, volume replacement, drugs. It is very rare that treatment will be added during transportation to the hospital: everything is done beforehand.

Once at the hospital, the child is transferred directly to the ICU or recovery room to provide sufficient monitoring and care.

When do you use ventilation for infants and children? NIV is used most often for broncholitis in infants; today we have very few intubations for broncholitis. For newborns we use CPAP (for example, in neonatal respiratory distress). Otherwise, if oxygen therapy isn’t enough to maintain adequate gas exchange, the patient is intubated.

When do you use invasive vs noninvasive ventilation?

One rule is that a FiO2 > 40% on CPAP is an indication for immediate intubation. Most of the time we tend to use invasive ventilation. With invasive ventilation, it is much easier to resort to NO (nitric oxide) when needed for the newborns and for refractory hypoxemia.

The figures below come from our 2009 department activity report.

**Newborn (0 to 28 days)**

- 308 intubated and ventilated out of 586 transported (53%). All were ventilated using pressure ventilation with the Babylog 8000 (plus 4 infants ventilated using HFOI).
- 6 NIV
- 82 CPAP with the PEEP setting at 0 (depending on the physiology)
- 4 or (maximum) 8 cm H2O. For example, pressure of 8 cm H2O for broncholitis.

**CPAP + NIV = 88 infants = 14% of those transported**

**Young infants (from 1 month to 2 years)**

- 75 intubated and ventilated with about one-third ventilated using the Elise 350. Overall this represents 6% of the 337 young infants transported.
- NIV + CPAP: 25 young infants (of which 21 were for broncholitis)
- Two-thirds with the Babylog and one-third with Elise 350

**Older infants: (from 2 years to 15 years)**

- 52 intubated and ventilated, all with the Elise 350
- 2 NIV (sickle-cell anemia)

When would you suggest clinicians move from NIV to intubation?

This is a difficult question to respond to. First of all, it depends on the clinician and their experience. There are very few consensus conferences available in pediatrics. As a result, we organize meetings between pediatric services and use their respective experience and expertise to decide what treatment options to use for infants and children (invasive ventilation, NIV, CPAP, high concentration oxygen by mask) depending on the various pathologies.

All of this will depend on the clinical evolution of the child in addition to their initial pathology.

At the moment NIV in older children has few indications.

What type of monitoring do you routinely use when ventilating children?

Routinely and systematically we use: ECG with pulse, Respiratory rate, non-invasive blood pressure, temperature, SpO2 and transcutaneous PaO2 and CO2.

If infants ≤ 3 months we place the transcutaneous probe on the chest, otherwise we place it on the inside of the forearm. If the child is intubated, we use expired CO2. For children with trauma injuries we systematically use expired CO2 as it is very important to closely control their level of CO2 between 30 and 40 mmHg.

In your experience are there additional considerations when using ventilation for pediatric purposes?

NIV in pediatrics has evolved exponentially. CPAP has been used for more than 20 years. The evolution of medications such as surfactants and corticosteroids along with the increased use of CPAP has significantly helped in decreasing the intubation duration for children.

The most impressive change concerns infant broncholitis and what is now practically a systematic use of NIV in these children during the acute phase.

The use of NIV depends mainly on the team, its training, the clinician experience and logistical considerations such as patient environment. NIV is very time-consuming (set-up, tolerance, patience) so physicians sometimes prefer to transfer patients using high concentrations of oxygen through the mask before starting NIV once in the intensive care unit.

Starting NIV for a child in the pre-hospital environment requires at least 30 minutes more time before the transportation to the hospital can begin. For each clinician this requires individual case-by-case clinical judgment.

In my experience, the most impressive evolution is the use of NIV in infants with broncholitis. In pediatric ICU, NIV is more and more used in interstitial pneumonia in immunodepressed patients, acute chest syndrome in sickle-cell disease and in some situations of status asthmaticus.

Anything else you would like to mention about your use of NIV?

The most challenging aspect of NIV is the problem we have finding masks that work with the ventilators we use. We frequently have to adapt existing masks. As an example we sometimes have to use adult nasal masks as infant full face masks. We would really appreciate more work in this area.

Interview by Cedric Latier. Translated by Susan Sertor Leget
Noninvasive ventilation: Key research articles


A wide variety of ventilators and modes can be used to deliver noninvasive ventilation (NIV). To navigate successfully through the many options, the clinician must first have a clear understanding of the goals of mechanical ventilation: namely, safety, comfort, and timely liberation. Examining the specific objectives associated with these goals, we can distinguish priorities for NIV. This paper reviews the methods of achieving those objectives by reviewing the characteristics of ventilation modes and how those characteristics are measured in performance evaluation studies. This review provides the basis for a simple procedure for selecting the most appropriate NIV technology for the patient and the environment of care.


New features of mechanical ventilators are frequently introduced, including new modes, monitoring techniques, and triggering techniques. But new rarely translates into any measurable improvement in outcome. We describe 4 new techniques and attempt to define what is a new invention versus what is innovative—a technique that significantly improves a measurable variable. We describe and review the techniques and attempt to define what is a new invention introduced, including new modes, monitoring techniques, and triggering techniques. New advances in respiratory mechanics.


OBJECTIVE: To evaluate current practice of mechanical ventilation in the ICU and the characteristics and outcomes of patients receiving it. DESIGN: Pre-planned sub-study of a multicenter, multinational cohort study (SAPS 3). PATIENTS: 13,322 patients admitted to 299 intensive care units (ICUs) from 36 countries. INTERVENTIONS: None. MAIN MEASUREMENTS AND RESULTS: Patients were divided into three groups: no mechanical ventilation (MV), noninvasive MV (NIV), and invasive MV. More than half of the patients (63% [CI: 62.2–63.9%]) were mechanically ventilated at ICU admission. FIO2, VT and PEEP used during invasive MV were on average 50% (40–80%), 8 ml/kg actual body weight (6.9–9.4 ml/kg) and 5 cmH2O (3–6 cmH2O), respectively. Several invMV patients (172%) (CI: 16.4–18.3%) were ventilated with zero PEEP (ZEEP). These patients exhibited a significantly increased risk-adjusted hospital mortality, compared with patients ventilated with higher PEEP (O/E ratio 1.12 [1.05–1.18]). NIV was used in 4.2% (CI: 3.8–4.5%) of all patients and was associated with an improved risk-adjusted outcome (OR 0.79, [0.69–0.90]). CONCLUSION: Ventilation mode and parameter settings for MV varied significantly across ICUs. Our results provide evidence that some ventilatory modes and settings could still be used against current evidence and recommendations. This includes ventilation with tidal volumes >8ml/kg body weight in patients with a low PaO2/FIO2 ratio and ZEEP in invMV patients. Invasive mechanical ventilation with ZEEP was associated with a worse outcome, even after controlling for severity of disease. Since our study did not document indications for MV, the association between MV settings and outcome must be viewed with caution.


The application of noninvasive ventilation (NIV) to treat acute respiratory failure has increased tremendously both within and outside the intensive care unit. The choice of ventilator is crucial for success of NIV in the acute setting, because poor tolerance and excessive air leaks are significantly correlated with NIV failure. Patient-ventilator asynchrony and discomfort can occur if the physician or respiratory therapist fails to adequately set NIV to respond to the patient’s ventilatory demand, so clinicians need to fully understand the ventilator’s technical peculiarities (e.g., efficiency of trigger and cycle control, systems, speed of pressurization, air-leak compensation, CO2 rebreathing, reliability of fraction of inspired oxygen reading, monitoring accuracy). A wide range of ventilators of different complexity have been introduced into clinical practice to noninvasively support patients in acute respiratory failure, but the numerous commercially available ventilators (i.e., level, intermediate, and intensive care unit ventilators) have substantial differences that can influence patient comfort, patient-ventilator interaction, and, thus, the chance of NIV clinical success. This report examines the most relevant aspects of the historical evolution, the equipment, and the acute-respiratory-failure clinical application of NIV ventilators.


BACKGROUND: Mechanical ventilation during patient transport frequently utilizes compact portable pneumatic ventilators that have limited ventilator-settings options. New advanced transport ventilators should yield quality improvements, but their user-friendliness needs to be tested. OBJECTIVE: To evaluate the ventilator-user interface of 2 new transport ventilators. METHODS: This was a 2-center descriptive study in which the ventilator-user interfaces of the Oxylgo 3000 and Elise 250 were compared by 20 French senior emergency physicians who were initially unfamiliar with these ventilators. Each physician carried out 15 tasks with each ventilator and then assigned each ventilator a satisfaction score. RESULTS: With the Elise 250 the task success rate was significantly higher (89.6% vs 66.6% with the Oxylgo 3000, p < 0.0001), and the total number of errors was lower (46 vs 113). The main errors were related to inspiratory flow settings with the Oxylgo 3000 (31 errors), inspiratory-expiratory ratio settings with the Elise 250 (11 errors), and alarm range setting with the Oxylgo 3000 (10 errors). The mean satisfaction score was significantly better with the Elise 250 (81.2% vs 64.9%–92%) than with the Oxylgo 3000 (86% 10, range 49–87%) (p < 0.0001). CONCLUSIONS: The Elise 250 ventilator-user interface was easier to use than that of the Oxylgo 3000. The applicability of these results to other types of users will require further studies, but the types of errors found in our study might help future users.


Noninvasive mechanical ventilation (NIV) has a long tradition for the treatment of chronic respiratory failure and more recently has also been applied in acute respiratory failure. Based on this experience both critical care ventilators and portable ventilators are used to perform NIV. The individual choice of ventilator type should depend on the patient’s condition and also on the expertise of attending staff, therapeutic requirements and the location of care. The majority of studies have used pressure-targeted ventilation in the assist mode. Positive qualities of pressure support ventilation (PSV) are leak compensation, good patient-ventilator synchrony and the option of integrated positive end-expiratory pressure to counteract the effect of dynamic hyperinflation. In this article, some crucial issues concerning PSV (i.e. triggering into inspiration, pressurisation, cycling into expiration and carbon dioxide re-breathing) and some corrective measures are discussed. The parameters which should be monitored during noninvasive ventilation are presented. The interface between patient and ventilator is a crucial issue of noninvasive ventilation. Advantages and disadvantages of face and nasal masks are discussed. Finally, causes and possible remedies of significant air leaks and some technical accessories for noninvasive ventilation are dealt with.
## 2010 Calendar of events

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