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Daytime alternatives for non-invasive mechanical ventilation in neuromuscular disorders

Anna Annunziata, Antonietta Coppola, Giorgio Emanuele Polistina, Pasquale Imitazione, Francesca Simioli, Maurizia Lanza, Rosa Cauteruccio, Giuseppe Fiorentino

Unit of Respiratory Pathophysiology, Monaldi-Cotugno Hospital, Naples, Italy

Mechanical ventilation in recent years has benefited from the development of new techniques and interfaces. These developments allowed clinicians to offer increasingly personalised therapies with the combination of different complementary techniques for treating respiratory insufficiency in patients with neuromuscular diseases. The mouthpiece ventilation, intermittent abdominal pressure ventilator and the negative pressure ventilation can offer many patients alternative therapy options when ventilation is required for many hours a day. In this non-systematic review, we will highlight the use of alternative methods to non-invasive mechanical ventilation at positive pressure in neuromuscular patients, to ensure the optimal interface for each patient.

Key words: mouth-piece ventilation, negative pressure ventilation, daytime non-invasive ventilatory support

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Correspondence
Anna Annunziata
UOC Pathophysiology and Respiratory Rehabilitation, Intensive Care Department, Azienda Ospedaliera dei Colli, via L. Bianchi, 80131 Naples, Italy
E-mail: anna.annunziata@gmail.com

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Introduction

The birth of non-invasive mechanical ventilation (NIV) occurred in the late 1920s, following the poliomyelitis epidemic that was notable for respiratory muscle paralysis and subsequent death in many children. Mechanical ventilation was in the form of the iron lung, a non-invasive negative-pressure respirator developed by Philip Drinker and Charles McKhann [1]. Motley et al. investigated the use of intermittent positive pressure ventilation in the form of expiratory positive airway pressure (EPAP) and continuous positive airway pressure (CPAP) via a rubber mask for the treatment of acute pulmonary edema, pneumonia, Guillain-Barre syndrome, near-drowning, drug overdose, and acute asthma [2,3]. In 1980, Sullivan et al. described the successful use of CPAP via nasal mask in the management of obstructive sleep apnea [4]. Subsequently, its use was extended to the chronic respiratory failure from neuromuscular disease (NMD) and symptomatic worsening nocturnal hypoventilation [5]. During the 1990s, the Consensus Conference recognized non-invasive ventilation as a valuable and essential strategy in the managing of subjects with acute respiratory failure [6-8].

Acute respiratory failure is a frequent life-threatening problem of acute onset NMD and may exacerbate chronic hypoventilation in patients with NMD or chest wall disorders [9,10].

Respiratory care is of high importance because it is a main determinant of quality of life and survival [11]. NIV is one of the limited modali-

ties that has shown a survival benefit in the NMD patient population. Newer modes with smart technologies are being developed to assist in better ventilation [12]. These developments allowed clinicians to offer increasingly personalised therapies, with the combination of different complementary techniques for treating respiratory insufficiency in these patients, who often require 24 hours non-invasive mechanical ventilation or tracheostomy [9-10].

MouthPiece Ventilation (MPV) [13], Intermittent Abdominal Pressure Ventilator (IAPV) [14] and Negative Pressure Ventilation (NPV) [15] can offer many patients the option of an alternative therapy when ventilation is required for many hours a day. The ability to alternate complementary techniques to NIV, may be a viable alternative to tracheotomy.

Various conditions such as claustrophobia, skin lesions induced by the mask, rhinitis, or no tolerance to the face's pressure may be responsible for the failure of NIV, therefore alternative NIV techniques should be considered in highly dependent ventilator patients, besides the traditional ventilation with a mask.

The aim of this non-systematic review is to highlight the use of alternative methods of non-invasive respiratory support to positive pressure NIV in neuro-muscular patients.

Mouthpiece ventilation

MPV is a type of non-invasive ventilation delivered – as the name implies – via a mouthpiece. It is used for many years, and there is already evidence in literature documenting the effectiveness of the treatment and greater patient compliance [13].

The use of the mouthpiece was first described in 1953 in patients with polio, and to date many cases have been documented in the literature of successful treatment. However only one center has documented 500 cases of long-term survival for daytime use in patients requiring 24-hour ventilator support up to 1993 [16,17]. Surprisingly, this technology is still not commonly used. There were no evidence-based guidelines for this technique, that is applied on the basis of the experience of few centers until 2020, when the European Neuromuscular Centre (ENMC) Respiratory Therapy Consortium, during the 252nd ENMC International Workshop developed the "best practice guidelines for management of mouthpiece ventilation in neuromuscular disorders" [18].

The mouthpiece ventilation is used with single non-vented circuit ventilators in pressure-controlled or, more frequently, in volume-controlled mode to allow air stacking [19]. The patient can achieve mouthpiece ventilation, breathe passively using the backup rate set on the ventilator, or actively trigger the breath, retain a part or all, of the delivered volume. Different types of triggers are available. In addition to the traditional flow or pressure trigger, normally used for NIV, the "Kiss trigger" is available on a portable ventilator (Trilogy, Philips Respironics, Murrysville, PA, USA). Such a dedicated MPV trigger allows for activation of inspiration when the patient's lips touch the mouthpiece. It is possible to use a simple single-tube circuit or a circuit with a valve [20]. The valve is preferred for patients who cannot disconnect to exhale outside the circuit and in this way can remain connected for a long time in succession, avoiding the rebreathing of carbon dioxide. Dedicated MPV mode has been introduced on many portable devices; it is possible to set the type of circuit selected and then select the pressure or volume mode, and the parameters chosen for the patient. In this way, the patient is able to independently remove the mouthpiece to speak, eat, cough, or call a family member. Its use presents no risk of skin breakdown, conjunctivitis, does not induce claustrophobia while causing a lower probability of gastric distension [21].

Despite these obvious advantages, this modality of ventilation is not commonly used. Mouthpieces for daytime use may cause salivation and more rarely vomiting while prolonged use can cause orthodontic deformities after 20 years [22].

However, the same problem was found with the traditional interface in pediatric patients. Nasal pledges or nose clips can prevent air leak through the nares for patients using lip cover interfaces for the NIV mouthpiece while sleeping [13]. During the nighttime sleep, most patients use a mask because the mouthpiece requires collaboration and is uncomfortable. Moreover, though rarely, the air can also be ingested causing gastric distension [19].

Different angled replacement mouthpiece 22 and 15 mm, and MPV straw kit are available [20]. Mouthpiece and nasal NIV are open systems of ventilator support; the low-pressure alarms of ventilators not having mouthpiece NIV modes can often be inactivate. Backpressure from a 15 mm angled mouthpiece is sufficient to prevent a low-pressure alarm set at 2 cmH2O.

Carlucci et al. studied how to set different types of the ventilator when using the mouthpiece [12]. They found that a proper alarm setting, and a combination of VT and TI would allow most ventilators to be used for mouthpiece ventilation without the alarm activation [21].

The patient triggers the breath by placing lip on the mouthpiece and generating a small negative pressure in the circuit, by tasting or inspiring. The mouthpieces are very useful as additional daytime ventilation in patients with neuromuscular diseases, who do not have the capacity to preserve acceptable diurnal blood gas without frequent intermittent periods of care [16-18,22-24].

Some authors report that patients that used MPV were satisfied and preferred the mouthpiece to the nasal

mask [22]. Though this aspect can favour NIV adherence, however, it exposes the patient to the risk of underventilation because of frequent disconnection from the mouthpiece [14]. Underventilation with hypoxemia and hypercapnia can be tolerated by the patient for a short time, for which he himself feels the need to reconnect. The mouthpiece allows support ventilation with the possibility of consecutive detachments, for speaking or eating. Desaturations during MPV are possible, as well as for mechanical mask ventilations, due to increased resistance (secretions) and excessive system leaks. For example, MPV-dedicated mode without backup respiratory rate may be beneficial in less-dependent patients (frequent disconnections), while severe ventilator-dependent patients may take greater advantage of a more reactive ventilator, with greater rapidity in adjusting tidal volume and setting back up rate [25].

Just like masked NIV, the patient should be monitored periodically to identify any progression of the disease and the need for therapeutic changes. The time of interruption is probably the major limitation of this approach to NIV. It has been documented that the periods of disconnection are associated with > 5 mmHg paCO2 increase and > 2% spO2 decrease, but no medical complication occurred before or after the monitoring time. Few patients accepted prolonged disconnections without developing hypercapnia [23].

The most common type of asynchrony was an ineffective effort, suggesting a need to improve trigger sensitivity. The newly introduced MPV software that allows the insufflation to be triggered only by positioning the patient's lips appears to be a useful option for patients with severe muscle weakness [23]. The most commonly used ventilation mode is assisted volume- and pressure-controlled with no expiratory positive airway pressure, with the low-pressure alarm set to apnea minimum and maximum duration [23-25].

The MPV characteristics, such as the intermittent disconnection of the patient and the presence of continuous leaks, may represent a challenge for turbine-based home ventilators. There are considerable differences in the ability of the different life-support ventilators to cope with the rapidly evolving respiratory load features that characterise MPV, which can be further accentuated by choice of ventilator settings. It is always needed to carefully monitor the patient during the adaption phase as MPV requires a real patient's collaboration. Not all ventilators guarantee a rapid adaption to the patient's breaths [25].

The physician should also evaluate the patient's ability to synchronise with the mouthpiece held in the mouth, and whether or not to exhale outside the mouthpiece. Depending on the ability to turn the neck, the subject can uninterruptedly keep the mouthpiece between lips or leave it for a variable time [18]. Patient's limiting factors include inability to close one's mouth to seal the interface, inability to move the neck, impaired bulbar function, non-acceptance to try MPV, lack of available interfaces / equipment, absence of caregivers who can guarantee the change with NIV if necessary (Tab. I). For these reasons, and because of its specific features and drawbacks such as air leaks, MPV must be managed by expert hands, and well-monitored (Tab. II).

Table I. Indication and contraindication of MPV use.

Indication	Contraindication
Diurnal respiratory support needed	Inability to close mouth to seal the interface
Dyspnoea persistent	Inability to move the neck
Weight loss	Impaired bulbar function
Adaptation to any NIV	Non-acceptance to try MPV
Daytime fatigue or hypercapnia	Poor compliance
Weaning from invasive mechanical ventilation	Lack of available interfaces/equipment
Request for autonomy by the patient	absence of caregivers who can change with NIV

Table II. Mode and setting of MPV.

Pressure mode	Volume mode
ST, PSV	ACV
With dedicated mode	With or without dedicated mode
Pressure 10-14 cmH2O	VC 700-1500 ml
EPAP 0	EPAP 0
Back up frequency (as needed)	Back up frequency (as needed)
Inspiratory time 0.8-1.3 sec	Inspiratory time 0.8-1.3 sec

Some authors described the use of mouthpiece in a cohort of patients affected by kyphoscoliosis and acute respiratory failure. They showed an improvement in clinical symptoms, blood gases and nocturnal ventilation, sleep related parameters, and HRQL scores. These improvements were accompanied by a significant increase in lung volumes and respiratory muscle function following diurnal ventilation via angled mouthpiece, alternated with nocturnal ventilation via mask [26].

Applications in clinical practice

Amyotrophic lateral sclerosis (ALS)

ALS is a progressive neuromuscular disease characterised by lower motor neuron and upper motor neuron dysfunction. Although clinical presentations can differ, there is no therapy for ALS, and the disease is generally terminal, with most patients dying of respiratory problems. Patients die within 3 to 5 years of diagnosis, unless they choose to undergo tracheostomy, in which case, they may live, on average, 2 additional years [27,28].

Data in literature confirmed the useful of MPV in ALS [29]. Bach et al. [30] reported that mouthpiece ventilation was an effective alternative to tracheostomy in patients with adequate bulbar muscle function. In patients using NIV many hours a day or showing low NIV tolerance with oronasal and nasal masks, or skin lesions, eye irritation, or gastric distention, mouthpiece ventilation should be taken into account [31]. Patients using ventilation even during the night can alternate between daytime MPV and a sleeping interface. Use of mouthpiece in ALS patients may be limited by the involvement of bulbar muscles, or by deterioration of cognitive status; furthermore, disease progression may render MPV ineffective [32]. However it has been reported that MPV, while having no impact on survival, improves the quality of life of the patient with ALS [33].

Duchenne muscular dystrophy

Duchenne muscular dystrophy is a rare genetic neuromuscular disorder, due to mutations in the *DMD* gene, that affects skeletal and heart muscles causing muscle wasting and cardiomyopathy. Chronic respiratory failure is a constant feature in patients with DMD [34], who often require continuous ventilation and need respiratory support 24h a day. McKim et al. [35] argue that 24h NIV should be considered a safe alternative to tracheostomy in these patients, especially in those presenting skin lesions, gastric distension, or eye irritation. They examined the impact of diurnal mouthpiece intermittent positive pressure ventilation and concluded that it is safe, stabilises vital capacity and improves survival. The mouthpiece can be very valuable, in patients who use NIV many hours a day, alternating between nasal masks and full-face masks. It is also useful to promote adherence to NIV. [24]

Myotonic dystrophy type 1

Myotonic dystrophy type 1 (DM1) or Steinert disease is the most common type of muscular dystrophy in adults, and presents multiple organ symptoms, including respiratory dysfunction. As a cause of respiratory dysfunction in DM1, a restrictive ventilatory pattern due to respiratory muscle weakness and central nervous system's involvement has been reported, requiring non-invasive mechanical ventilation [36].

There are few data on the use of MPV in patients with Steinert disease. It could be useful for patients who previously refused NIV for tightness, claustrophobia, and poor compliance interface. MPV was successfully used in our practice in patients who yet refused nasal, oral or oro-nasal interface [37].

Other neuromuscular diseases

Bach et al. reported a large number of patients with neuromuscular diseases, long managed with 24hours NIV [30]. They describe non-invasive acute and long-term management of patients with quadriplegia due to high spinal cord lesions. This includes full-setting, continuous ventilatory support by non-invasive intermittent positive pressure ventilation to sustenance inspiratory muscles and mechanically assisted coughing to support inspiratory and expiratory muscles. Even patients previously ventilated 24h/24h via tracheostomy were converted to non-invasive mechanical ventilation with MPV [30,35]. Bilateral diaphragmatic paralysis (BDP) is usually associated with dyspnoea that worsens when the patient is recumbent, increasing breathing and exercise intolerance. With the BDP progression, there is an increase in ventilatory failure with hypoxaemia and hypercapnia, which can further worsen due to atelectasis and ventilation-perfusion mismatch. Reports are showing that MPV is a clinically beneficial treatment to improve exercise tolerance and exercise-induced dyspnoea in patients with BDP [38]. MPV may also be useful for weaning from orotracheal tube or tracheostomy (Fig. 1).

Intermittent abdominal pressure ventilator (IAPV)

Intermittent abdominal pressure ventilator was first described in 1935 by R.W. Paul for adults and young patients who require continuous respiratory support [39]. In 1938 it was described for the treatment of post-diphtheritic respiratory paralysis or respiratory paralysis due to anterior poliomyelitis [40]. Over the years, an alternative approach to NIV with IAPV was described in patients with spinal cord injury [41]. Later Bach, in 1991, described the

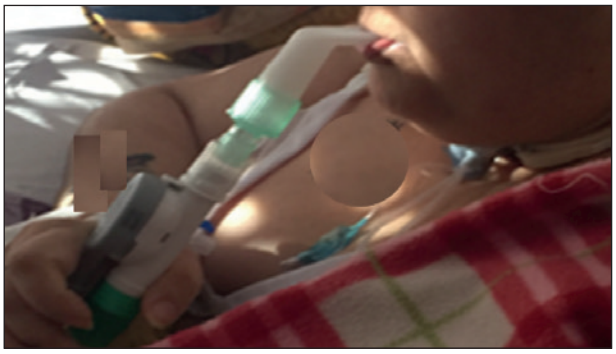

Figure 1. MPV for weaning from tracheostomy.

long-term use of IAPV in 209 patients diagnosed with myopathy, Duchenne dystrophy and spinal cord injury [14].

This approach was used in several types of neuromuscular patients: ventilator-dependent traumatic quadriplegic patients, spinal cord injured, non-Duchenne myopathy, Duchenne muscular dystrophy, myelopathy, polymyositis and Friedreich's ataxia for long-term respiratory support [14,42-45]. The Authors conclude that, in general, patients with traumatic high level spinal cord injury are the best candidates to benefit from these techniques because of their youth, intact mental status and bulbar musculature, absence of obstructive lung disease.

The new IAPV (LunaBelt, Dima, Italia) consists of a corset with an elastic inflatable bladder that fits over the abdomen. A hose attaches the bladder to a ventilator that gives up to 2.5 liter of air to the bladder and the abdominal wall (Fig. 2). This raises the diaphragm to cause expiration below the functional residual capacity. The new models that prevent clothing taking on the corset buckles, are more comfortable, lightweight, suitable, easy to make and put on and use Velcro for fastening [42]. The following IAPV parameters can be set: Pressure inside the bladder, Tinsp (real inspiratory time when the diaphragm moves down), Frequency (respiratory rate), and Rise Time (time to inflate the bladder). The IAPV only works efficiently when patients are in sitting position, at an angle of 30° or greater with the optimum at 75°. No guidelines are available on the use of IAPV and on the parameters to be set, the indications usually derive from case reports and experience (Tab. III).

Figure 2. Patient during IAPV.

Applications in clinical practice

The use of IAPV is reported with success in patients with a post-ischemic cervical myelopathy [42] and in ALS patients with tracheostomy by De Mattia et al. [44] IPAV permitted optimal speech, efficient diurnal ventilatory pattern, good pulmonary gas exchange without dyspnoea, and a significant improvement in the management of salivary secretions, with a reduction in the number of tracheal aspirations. Furthermore, the Authors reported the resumption of the spontaneous respiratory activity, which demonstrates an improvement in the patient's respiratory condition [42-44]. IAPV facilitates diaphragmatic

Table III. IAPV indications and contraindications.

Indications	Contraindications
Daytime respiratory support needed	Inability to posture trunk of at least 30°
Adaptation to any NIV Diaphragmatic weakness	Intolerance of corset Severe sacral decubitus
Weaning from invasive mechanical ventilation Request of autonomy by patient	Hiatal hernia with regurgitation during meals Recent abdominal surgery

Table IV. NPV indications and contraindications.

Indications	Contraindications
Severe facial decubitus	Sleep-apnoea syndrome
Mask intolerance	Severe obesity
Facial deformity	Severe kyphoscoliosis
Inability to fit mask	Rib fractures
Severe hypercapnic encephalopathy	Recent abdominal surgery
Severe respiratory acidosis	Claustrophobia or poor compliance

motion and may be particularly useful in patients with bilateral diaphragmatic weakness or paralysis, and allows for plugging of the tracheostomy tube with the cuff deflating for several hours during the day, thus preventing tracheal damage.

Pierucci et al. described the case of a young patient with late onset Pompe disease who was successfully treated with nocturnal NIV and daytime IAPV [45].

IAPV can also be used in patients who require NIV many hours a day. Patients with gastric distension may benefit from the abdominal compression exerted by the device during the exhalation phase [42]. Disadvantages can be food regurgitation during meals (rarely), locking of clothing on straps and Velcro fasteners, redness of bony prominences, and inability to shower or bathe while using it [46,47]. Indications and contraindications are described in Table IV. Furthermore, regular follow-up is required as it can become less effective over time [42,47].

IAVP can be less effective for the appearance of gastric complications, the worsening of respiratory function due to the evolution of the disease, and the need for invasive support.

Negative pressure ventilation

Negative pressure ventilation (NPV) has played a crucial role in the history of ventilatory support for patients with neuromuscular diseases and respiratory failure. A full-body type ventilator was the first description of a negative-pressure ventilator. The first "tank ventilator" was described by Dalziel in 1838. It was an airtight box, where the patient remained in a sitting position [48].

A pinnacle of negative-pressure ventilation appears with the development of the iron lung, originally designed and built by Drinker and Shaw [49], but manufactured and sold by Emerson during polio epidemics around the world, from 1930 to 1960. Numerous other types were developed over time, such as the "raincoat" and the "chest cuirass". However, due to several factors, in the 1960s, there was a movement away from negative-pressure ventilation (excessive leaks; difficult time to maintain effective ventilation, inability to sustain high airway pressure or establish EPAP, limited access to the patients) [50].

This technique has some strengths as it is able to guarantee a breathing completely analogous to the natural one, consisting of an inspiratory phase followed by the expiratory phase. Both phases are applied by means of a negative pressure ventilator and some accessories connected to it, such as a cuirass or a poncho. The ventilator first applies a negative pressure forcing the movement of the diaphragm downwards while the rib muscles tend to enlarge the thorax: this process generates lung expansion by generating a lower intrathoracic pressure than the external one; subsequently, the ventilator exerts positive pressure forcing the air inside the chamber, to compress the chest and empty the lungs [51]. The cuirass negative pressure ventilators were primarily beneficial in children with neuromuscular disorders. Children had their own cuirass built from a plaster prototype of the chest and abdomen. This was important when there was a severe thoracic scoliosis. The cuirass is a plastic model of the front and sides of the trunk, the edges are padded with airtight material and the cuirass attached to the patient with a back strap. Cuirass pressure injuries are also possible. Cuirass ventilators are easy to put on and suitable for home use (Fig. 3).

The last new soft cuirass (Dima Italia, Negavent - Pegaso Vent) is an accessory for negative ventilation, designed to ensure a good quality of life and normal daily activities. It is a structure that creates a ventilation chamber on the chest. On the edges, it is covered with a soft gasket to ensure patient comfort and low pressure losses. It is available in various sizes and the choice of size depends on the size of the chest, body structure, weight, and height of the patient, and of any deformities of the chest such as scoliosis. Generally new cuirasses are necessary as the patient grows [52].

Kavanagh et al. hypothesized that, compared with positive pressure ventilation, negative pressure translates in a greater functional residual capacity at the same transpulmonary pressure, and results in a greater oxygenation with the same residual capacity. NPV may distend lungs fundamentally differently to positive pressure, resulting in more homogeneous ventilation, less injury, and superior oxygenation [51,53].

The data showed that negative-pressure ventilation produces superior oxygenation unrelated to lung perfusion which may be explained by more effective lung volume inflation during both inspiration and expiration [53].

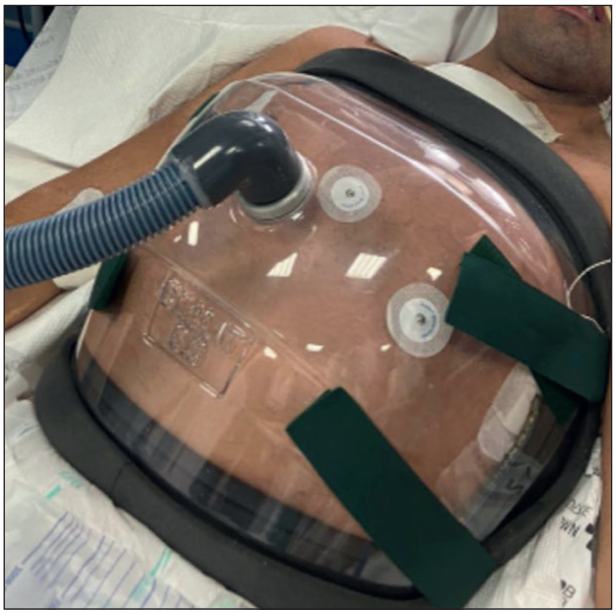

Figure 3. Negative pressure ventilation.

NPV may preserve physiological functions, such as speech, cough, swallowing and feeding and its major advantage is the prevention of endotracheal intubation and its related problems.

A limitation is the lack of upper airway protection, particularly in comatose and/or neurological patients, which may result in aspiration, considering the described impact of NPV on the lower esophageal sphincter [50,54]. Upper airway obstruction can occur in unconscious patients, in patients with neurologic disorders with bulbar dysfunction, and in those with sleep apnea syndrome. This event can be prevented by using concomitant nasal continuous positive airway pressure, although switching to non-invasive positive pressure ventilation may be more helpful in this situation.

Those who cannot tolerate a facial mask due to facial deformity, claustrophobia or excessive airway secretion, or young children, and in particular in children undergoing complex cardiac reconstructive surgery considering the beneficial effects on the cardiopulmonary circulation, and patients in whom excessive airway secretion or difficulty in wearing a mask limits the application of NIV are the best candidates for this type of ventilatory support [54].

The choice of the best negative pressure mechanical ventilation device depends on the indications and contraindications and varies among subjects. The main indications and contraindications are listed in Table V. There are no guidelines on the use of NPV nor on the parameters to be set (Tab. VI).

Conclusions

The use of MPV, IAPV and NPV is limited to a few centres, likely for the long time required to adapt and monitor the patients. The different possibilities of non-invasive mechanical ventilation to ensure the optimal interface for different patients should be known and applied.

Our goal must be to ensure the best possible quality of life for our patients. However, lack of local resources can also interfere with the diffusion of innovative technologies. MPV and IAPV are comfortable alternative to NIV, but more active participation than traditional masks is required when using MPV. For subjects with chronic disease who need to initiate NIV, both systems should be considered. In fact, they are useful for promoting a positive approach to NIV or for alternating the interface in patients who require 24-hour ventilatory support [24,31,37,43,45].

Table V. IAPV parameters; we suggest starting: Pbelt 0-70 Hpa (at the beginning 30-40 Hpa); select desired Ti (during the Ti setted, the PBAir will be deflated, while the patient will be able to inhale); back up rate as desidered; rise time usually 1.0s; Expiratory time (abdominal compression) will be linked to the back up rate and inspiratory time setted. For example: setted inspiratory time 1.5 sec, Fr 15 bpm, derivative expiratory time will be 2.5 sec.

Intermittent abdominal pressure ventilator (LunaBelt)		
Mode	**Timed**	**Spontaneous/timed**
Pression belt	0-70 hPa	0-70 hPa
Time inspiratory	0.3-5.0 sec	na
Time inspiratory minimum	na	0.3-3.0 sec
Time inspiratory maximum	[(60/Freq) - 0.6 sec]	[(60/Freq - 0.6 sec)]
Time espiratory minimum	na	0-1.5 sec
Back-up Frequency	1-60 bpm	1-60 bpm
Frequency maximum	[60/(Tinsp + 0.6 sec)]	[60/(Tinsp + 0,6 sec)
Rise time	0.1-1.0 sec	0.1-1.0 sec
Trigger inspiratory (nasal cannula)	na	Auto
Trigger espiratory (nasal cannula)	na	Auto

Table VI. NPV parameters; we suggest start: Inspiratory pressure of -20, Expiratory pressure from 0 to 5, I:E Ratio from 1:1 to 1:2, back up frequency: set frequency at 2-4 breaths above patient's own spontaneous rate.

Negative pressure ventilation (Negavent)			
Mode	**T (timed)**	**ST (spontaneous/timed)**	**Syncro (syncrhronized)**
Inspiratory pressure	Da -5 a -90 hPa	Da -5 a -90 hPa	Da -5 a -90 hPa
Expiratory pressure	Da +25 a -25 hPa	Da +25 a -25 hPa	Da +25 a -25 hPa
Back-up frequency	5-60 bpm	5-60 bpm	5-60 bpm
I/E ratio	1.0:9.9 - 9.9:1.0	1.0:9.9 - 9.9:1.0	1.0:9.9 - 9.9:1.0
Trigger inspiratory (nasal cannula)	na	1;9	1;9
Trigger espiratory (nasal cannula)	na	1;9	na

NPV, alternating with other techniques or in addition in case of patients with congenital or acquired facial deformities or not tolerating positive pressure, may have still a role in the treatment of patients with neuromuscular disorders [52-54].

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