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Long-Term Ventilation in Neuromuscular Patients: Review of Concerns, Beliefs, and Ethical Dilemmas

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Keywords

Neuromuscular disorders · Noninvasive ventilation · Tracheostomy · Home care · Amyotrophic lateral sclerosis · Duchenne muscular dystrophy

Abstract

Background: Noninvasive mechanical ventilation (NIV) is an effective treatment in patients with neuromuscular diseases (NMD) to improve symptoms, quality of life, and survival. ***Summary:*** NIV should be used early in the course of respiratory muscle involvement in NMD patients and its requirements may increase over time. Therefore, training on technical equipment at home and advice on problem solving are warranted. Remote monitoring of ventilator parameters using built-in ventilator software is recommended. Telemedicine may be helpful in reducing hospital admissions. Anticipatory planning and palliative care should be carried out to lessen the burden of care, to maintain or withdraw from NIV, and to guarantee the most respectful management in the last days of NMD patients' life. ***Key Message:*** Long-term NIV is effective but challenging in NMD patients. Efforts should be made by health care providers in arranging a planned transition to home and end-of-life discussions for ventilator-assisted individuals and their families.

Introduction

Over the last three decades, noninvasive ventilation (NIV) [1–3] has become a widely accepted respiratory support for patients with neuromuscular disorders (NMD) [4, 5], accounting for around 10–51% of the overall indications for home mechanical ventilation (HMV) [6–8].

The aims of NIV in this patient population are to normalize arterial blood gases, ameliorate symptoms, decrease hospital admission, and improve their health-related quality of life (HRQOL) [9]. The approach to the use of NIV in NMD has greatly changed over time, and this review aims to detail the latest updates focusing on the most important topics.

Previous articles in this series: 1. Randerath WJ, Bloch KE: Noninvasive ventilation for chronic hypercapnic respiratory failure. Respiration 2019;97:1–2. 2. Vitacca M, Ambrosino N: Non-invasive ventilation as an adjunct to exercise training in chronic ventilatory failure: a narrative review. Respiration 2019;97:3–11. 3. Adler D, Janssens J-P: The pathophysiology of respiratory failure: control of breathing, respiratory load, and muscle capacity. Respiration 2019;97:93–104.

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Rationale and Timing for NIV Application

Over the last few years, the great benefits related to the use of NIV in NMD supported the anticipation in timing and setting for NIV to be started.

In rapidly progressive NMD, monitoring pulmonary function tests (PFTs) every 3–4 months is crucial for assessing respiratory muscle impairment progression, i.e., amyotrophic lateral sclerosis (ALS) [10]. The most recent guidelines [10–12] proposed to consider sitting forced vital capacity (FVC) as the most important parameter to start NIV in ALS patients and suggested to initiate NIV with an FVC <80% of predicted values in the presence of symptoms of respiratory impairment such as: dyspnea, tachypnea, orthopnea, disturbed sleep due to nocturnal desaturation/arousals, morning headache, use of auxiliary respiratory muscles at rest, paradoxical respiration, daytime fatigue, excessive daytime sleepiness (Epworth Sleepiness Scale score >9), and/or a rate of decrease in sniff nasal inspiratory pressure or maximum inspiratory pressure (MIP) of more than 10 cm H_2O per 3 months at repeated regular tests. Sniff nasal inspiratory pressure <40 cm H_2O and MIP <60 mm H_2O are also used as an indication to initiate NIV in NMD patients. However, using absolute values only, although useful, may be debatable because of age influence. More than absolute cutoffs, the PFT deterioration over 3 months, and its integration with the presence of symptoms might be more useful in assessing respiratory impairment in these patients.

Moreover, recommendations [13] suggested that one of the following physiological parameter should be considered: nocturnal overnight oximetry showing oxygen saturation at ≤88% for 5 consecutive minutes or morning pCO_2 >45 mm Hg. However, Boentert et al. [14] recently showed that oximetry alone and even polygraphy are not sufficient to reveal the presence of nocturnal hypoventilation. However, the combination of early morning base excess, bicarbonate, and desaturation time (t < 90%) were independent predictors of nocturnal hypoventilation and transcutaneous capnography is strongly recommended for a reliable detection of nocturnal hypoventilation in patients with ALS. Furthermore, residual hypoventilation is significantly associated with negative outcomes in adult ventilated NMD patients; therefore, nocturnal transcutaneous capnography may play a key role in the initial assessment of hypoventilation in NMD [14].

Guidelines suggest that "patient's advance directives and a plan for management of respiratory insufficiency should be established before respiratory complications occur" [11, 15].

Beyond what is suggested by guidelines, preventive NIV has been successfully accomplished in ALS patients. A recent retrospective study demonstrated that in a group of ALS patients initiated on NIV very early (i.e., with FVC ≥80%) and for at least 4 h/day or 120 h/month, the survival from symptom onset was significantly longer and the crude death rate was significantly lower compared to those patients initiated to NIV later (i.e., with FVC <80%) [16, 17].

Similarly, the guidelines on the management of patients with Duchenne muscular dystrophy (DMD) encouraged earlier onset of NIV compared to previous standards. Firstly, they underline the importance of frequent regular PFT checks. Secondly, they suggest some cutoffs to start nocturnal assisted NIV with a backup rate when there are early signs or symptoms of sleep hypoventilation or other sleep-disordered breathing such as abnormal sleep study, FVC <50% predicted, MIP <60 cm H_2O, or awake baseline SpO_2 <95% or pCO_2 >45 mm Hg; however, integrating all elements of PFT assessment rather than relying on a single limit value is advisable. Furthermore, daytime NIV should be added when, despite nocturnal ventilation, daytime SpO_2 is <95%, pCO_2 >45 mm Hg, or symptoms of awake dyspnea are present [18, 19]. However, real-life studies showed that despite great FVC reduction, many ALS and DMD patients still do not receive NIV at the time suggested by guidelines [20–22].

This may be explained as many other elements from the patients' side may also concur to determine whether or not to initiate NIV (i.e., cultural background, religiousness, personal values, HRQOL, depressiveness) [20, 23].

Modes and Monitoring

Technological improvements in ventilators, ventilator modes, interface design, and secretion removal techniques have simplified NIV use, increasing patients' comfort and HRQL [24–29].

In patients affected by DMD, nighttime NIV has shown to delay daytime hypercapnia and to improve survival [30, 31]. In addition, daytime NIV further reduces breathlessness and enhances endurance capacity compared to nighttime NIV alone [31, 32]. NIV has also been found to increase HRQOL and survival in ALS [33], even in those with bulbar dysfunction [34]; however, the presence of bulbar involvement favors intolerance to NIV and it shortens survival expectancy [33–35]. Moreover, ALS patients may be very sensitive to pressure variations [36], which can lead to glottis closure [37, 38] and, as a consequence, to severe oxygen desaturation [39].

Modes

There is no consensus for the use of volume- or pressure-controlled modes [40, 41]. Nevertheless, a crossover trial carried out during sleep in patients with restrictive thoracic disorders confirmed that volume- or pressure-controlled modes were not significantly different in improving alveolar ventilation [42]. Interestingly, when NIV is set to unload respiratory muscles and to improve daytime arterial blood gases on the basis of patient's respiratory mechanics, it is as effective as the setting based on the patient's comfort [43].

Pressure-Controlled Ventilation

During pressure-controlled ventilation (PCV), volume does not remain constant when increased impedance occurs [1]. However, constant peak inspiratory pressures and the presence of nonintentional leaks, which are best handled compared to volume-controlled ventilation (VCV) [41, 44], has made PCV the first choice in the majority of patients [45]. Nevertheless, in a study collecting data from 209 individuals with NMD, 82 (39%) patients were using the pressure-controlled mode, while 122 (59%) were on a volume-controlled mode [46]. Although pressure-controlled modes better compensate with nonintentional leaks [41], the best results have been found when pressure-controlled modes are coupled with a bilevel ventilator in vented configuration [27, 28, 47, 48].

Most of the bilevel ventilators for chronic care can be time- and flow-cycled. Overall, in NMD patients, timed modes are usually preferred over flow-cycled modes because they have a backup rate for definitions (e.g., assist PCV mode). If a flow-cycled mode is used, it should be combined with a timed mode (e.g., ST mode). In particular, a minimum and maximum inspiratory time during the flow-cycled breath should be set. The latter one could also prevent a prolonged inspiratory phase, which can worsen patient-ventilator synchrony [49].

Volume-Controlled Ventilation

During VCV, the volume remains constant despite the increase in respiratory impedance until the maximal safety limit (set in the alarm configuration) is reached [1]. Assist volume-controlled ventilation (ACV) has been used in the USA for many years [50] and according to the Eurovent study [8, 45], ACV was still used in 42% of patients with NMD in the 90s, but the use of pressure-cycled ventilators has progressively replaced volume-cycled ventilators [45].

Nevertheless, patients with increased respiratory impedance (i.e., chest wall deformities, scoliosis) may still require VCV [26, 51]. Interestingly, in a retrospective study of 144 patients with ALS, although survival was not significantly different between patients using volume-controlled or pressure-controlled NIV, the former one resulted in better symptom relief and gas exchange [36].

ACV has also the advantage to provide air "stacking" [52] either via the nasal, oral-nasal interface or via a mouthpiece.

Volume-Targeted Pressure-Controlled Ventilation

Tidal volume (VT) or alveolar volume-targeted pressure-controlled ventilation (VTPCV) are hybrid ventilation modes aimed to combine the advantages of conventional modes, while preventing their possible drawbacks [53]. The intrinsic feature of these modes should allow the ventilator to maintain adequate ventilation when respiratory impedance increases thus avoiding unnecessarily high preset inspiratory pressures [53]. VTPCV was initially used for invasive mechanical ventilation [54, 55] and later introduced in the noninvasive mode [55–59].

However, according to recent data collected in France and in Belgium, only 2% of patients were using a volume-targeted pressure-controlled mode [46]. As a consequence, there is no clear evidence for the superiority of any of these modes over conventional ones [60].

In conclusion, robust evidence is not yet available for VTPCV modes to show its superiority over the traditional modes. However, some clinical evidence suggests that patients might benefit from the VTPCV mode in selected cases [53].

Technical Issues during VTPCV

Unintentional leaks are common during NIV and may cause patient-ventilator dyssynchrony, sleep disturbances, and eventually hypoventilation [44, 61–63].

In this regard, it has been shown that intentional leak vented circuit configuration was able to maintain the set VT in the presence of nonintentional leaks in normal, obstructive, and restrictive lung parenchyma. On the other hand, the nonvented circuit configuration undercompensated in order to maintain the preset VT [47, 48].

Mouthpiece Ventilation

Open circuit ventilation is a noninvasive ventilatory support delivered via a mouthpiece circuit which can be used in respiratory-dependent patients with standard ventilator modes or other dedicated modalities [51, 64].

It was first introduced in the mid-fifties [65] but its use has significantly increased, mainly in patients with NMD or spinal cord injuries [32, 66–68]. Mouthpiece ventila-

tion (MPV) can be used with single-limb intentional leak circuit ventilators both in PCV and in VCV to allow air stacking [52, 64, 68]. The user grasps the mouthpiece and based on the possibility of head movements, he/she may continuously use the device or grasp it on demand. The patient can get passive volume-controlled breaths at a given rate or can trigger a volume-controlled breath, keeping a part or the entire volume. Alternatively, a pressure-controlled breath can be delivered according to the patient's need and comfort. The setting of the ventilator is crucial to avoid nuisance alarm [48, 64].

Some home care ventilators now provide a dedicated "mouthpiece," which makes setting it up easier [64].

Positive End-Expiratory Pressure

Although positive end-expiratory pressure (PEEP) is primarily used to improve oxygenation in patients with reduced functional residual capacity, whether or not associated with hypoxemia, patients with NMD usually have normal lungs and PEEP is rarely required [51]. However, the presence of an associated obstructive sleep apnea may be an indication for using it [39]. Nevertheless, high levels of PEEP may reduce cardiac output in NMD patients with cardiomyopathies as well as may cause abdominal bloating [51].

Monitoring

Monitoring the efficacy of nocturnal NIV represents a crucial aspect in the management of NMD with the aim of titrating the best ventilator setting in order to achieve an effective patient ventilation.

At the present time, no scientific evidence supports one strategy as the best assessment of home NIV efficiency in NMD. The European SomnoNIV Group suggested an algorithm for monitoring home NIV in chronic respiratory failure, which included oximetry as the first screening step to identify patients who require further nocturnal investigations. In particular, patients with no residual daytime symptoms may be considered well ventilated if an improvement of daytime hypercapnia and a mean nocturnal SpO_2 over 90% for at least 90% of the total recording time is achieved [69]. Later on, Ogna et al. [70] showed a lack of sensitivity of SpO_2 to identify nocturnal hypoventilation. In fact, in an unselected population with NMD diseases, the authors showed that residual hypoventilation during nocturnal NIV detected by nocturnal capnometry is significantly associated with negative outcomes in adult ventilated NMD patients, while oximetry is not. NMD patients, in fact, suffer mainly from restrictive respiratory failure without lung disease. As a consequence, they are on the flat portion of the oxyhemoglobin dissociation curve, so that the small decrease in PaO_2 occurring during nocturnal alveolar hypoventilation is poorly reflected by changes in the SpO_2.

In a recent observational study performed in ALS patients treated with nocturnal NIV, enrolled patients were divided into well and poorly ventilated groups according to the time spent with SpO_2 above or below 5% of the total sleep time, respectively [71]. The authors found that almost 50% of patients were poorly ventilated and this correlated with a lower survival rate. The main reason for bad ventilation was the presence of leaks in half of them, and the presence of upper airway obstruction in a quarter of them. Although the American Academy of Sleep Medicine recommends using polysomnography (PSG) to monitor NIV [72], in practice, this is not possible in many countries because of costs and availability. Nowadays, the majority of home NIV ventilators are equipped with a built-in software (BIS) that provides data about adherence to the therapy (usage/night), leaks, estimation of the apnea/hypopnea index (AHI), and trends of some ventilator parameters. In some advanced ventilators, it is also possible to have remote access to the flow and pressure waveforms. Moreover, some of these ventilators may be equipped with an internal oximeter so that data almost similar to PSG may be collected.

Remote monitoring is increasingly used in patients who receive home NIV. In a study on stable subjects with obesity-hypoventilation syndrome, the BIS tested by the authors provided a reliable AHI compared to the PSG [73].

In a similar recent study on patients affected by obesity-hypoventilation syndrome [74], the authors showed that manual scoring of raw data provided by the BIS of a home NIV device showed a very good correlation with PSG-based scoring, and significantly better reliability than scoring provided by the software automated analysis. No comparative data are available for patients affected by chronic respiratory failure in NMD. However, these data indicated that unattended home-based monitoring using ventilator BIS may be used, with good accuracy, as a first step to estimate the effectiveness of home NIV, hence, limiting the PSG and capnometry to selected complex cases.

The current technology enables bilevel monitoring through a cloud-based system, thus, leading to fast access to patient therapy. This telemonitoring system is able to provide data on air leaks, AHI, and usage time for every single night of therapy but, at the present time, no data

about the feasibility and usefulness of NIV telemonitoring in NMD are available in the literature. However, considering the prognostic value of data provided by these new technologies, a promising prospective may arise from this field.

Home Care Management of Long-Term Noninvasive Ventilation

Patient and Caregiver Training/Education before Hospital Discharge

Clinicians are well aware of the powerful long-term effects of NIV in patients with NMD [5, 75–79]. However, very often they underestimate the potential burden and consequences of technological dependency for both patients and caregivers [80–82] and the importance of integrating patient and family into the treatment process from the very beginning [83].

To establish a therapeutic alliance between patient, family/caregivers and health care providers is a key strategy when deciding to start HMV; this is even more important in patients with NMD, where the patient's family and caregivers have a central role in providing care [84]. Few studies explored the caregiver burden associated with caring for HMV in NMD patients [9, 85–87]. Findeis et al. [88] observed that caregivers perceive their lack of training and preparation on ventilator-specific issues, and this limits their ability to manage potential problems promptly and adequately and that they deem necessary discharge plans with problem-solving strategies. Dale et al. [89] explored the perspective of Canadian ventilator-assisted individuals and their family caregivers and identified barriers (conflict with health professionals, limited access to information, and lack of skilled personal support workers), and facilitators (health status, knowledge of and self-efficacy in HMV management, social support, and advanced preparation of the home environment) for transition to home. Hence, it is essential that clinicians provide adequate education to patients and their family not only about disease progression and prognosis but also about preventing strategies in airway clearance, training in the use of equipment for HMV, and information on preparing the home environment. Moreover, patients and caregivers also need assistance on bureaucracy for obtaining service and support to anticipate the impact of the disease on their daily lives, lifestyle changes, and evolving needs over time. Last but not least, they need to be acknowledged on the burden of living with disability, caregiving and dealing with technological dependency [12, 90]. Therefore, an extra effort should be made by health care providers in arranging planned transition for ventilator-assisted individuals in order to enable independent management of HMV, to prevent hospital readmission, and to reduce costs of health care services [91].

Medical Emergencies and Ventilator Failure at Home

Emergencies related to ventilator malfunction at home are rare, but possible [91]. In a US study exploring frequency, causes, and outcome of home ventilator failure over 1 year, equipment failure was not a frequent event [92]. Minor problems in the management of mechanical ventilation are instead relatively frequent. Chatwin et al. [93] demonstrated that ventilator failure accounted for 28% of visits to the home over 6 months.

Farre et al. [94] observed a mismatch between prescribed and actual delivered pressure or volume of approximately 10% but no link between ventilator performance or alarm problems and the number of hospital admissions in the year before the study was established.

Therefore, a risk management evaluation including training on technical, medical, and social aspects should be done in each home-ventilated patient [91].

Discharging Plan, Costs, and Home Care Programs

Although mechanical ventilator malfunction is a rare event, unwise interaction between users/caregivers and the ventilator may cause unpredictable problems. Therefore, a structured discharge plan and training on the equipment, illustrating potential problems and identifying possible solutions, is essential for NMD patients treated with HMV [91]. It should be considered that home is always the preferred location for these patients because it is less expensive than hospital or long-term facilities, and it maximizes their quality of life [95]. Nevertheless, very few publications have addressed this aspect in recent years [91, 96]. Limited data are available on health care costs for HMV patients; higher costs are associated with more severe disease [97] and with the use of HMV in patients with ALS [33]. Indeed, a recent Canadian study found that 39% of the monthly health care costs was due to caregiving time provided by family members [98]. In this regard, home care programs meeting patient's specific needs would be desirable to avoid the cost of respiratory assistance and of chronic care. However, in most countries, budget restrictions, and lack of resources in health care services very often do not allow patients and their family to get "extra help" [99]. In France, though, an integrated health system for chronic disease management

has been successfully created and it should be used as a model for creating focused interventions in other countries [100].

Telemonitoring

Recent advantages in telecommunications technology allowed the development of telemedicine modalities in an effort to promote patient care, increase safety, decrease health care costs, and burden of patients' travel [101].

Initiating and monitoring long-term HMV in an outpatient setting has been shown to be safe and feasible [102]. In particular, the use of telemonitoring to adapt patients to HMV showed a reduction in health care resources with results in clinical and adherence comparable to in-hospital settings [103–105]. Another study explored the possibility of telemonitoring HMV patients using a nurse-led teleassistance program. Telemonitoring was effective in preventing hospitalizations, home acute exacerbations, and urgent calls, and was cost-effective [106]. Interestingly, a survey of home ventilator users showed that the possibility of being remotely monitored by health care professionals was appreciated by nearly 50% of the interviewed patients [107]. Moreover, a recent pilot study assessed that the combination of telemonitoring and chest physiotherapy at home for patients with NMD may reduce hospitalizations and emergency room admissions related to respiratory complications [108].

Thus, ideally, telehealth could be a key strategy in the management of HMV patients, representing a way for increasing health care access to these patients with special needs who are usually highly unfavorable to hospitalization, in an effort of providing more personalized care [101]. However, in a recent study published by Chatwin et al. [102], the addition of telemonitoring to standard care did not lengthen the time to the next acute hospital admission and did not improve HRQOL of chronic respiratory patients.

Although telemedicine is a promising strategy, it did not show to be sufficient to yield better outcomes, but it is more of a useful tool to be integrated into the home care program package. Further improvement and research is needed before considering telemonitoring a real advancement at the service of patients with NMD on HMV [101, 109].

In conclusion, continuity of care is crucial for transitions of patients with complex care needs and advanced medical technology dependency from hospital settings to home, but it is not easy to achieve. Moreover, the transition to home shifts totally or in part the responsibility for ventilator-dependent patient care to family caregivers; nevertheless, families and patients see the benefits of care in a home setting. Therefore, professional problem-solving assistance, home care program, and caregiver educational and psychological support are key aspects to guarantee patients' safety and quality of life.

Ethical Dilemmas

HRQOL: Improving Symptoms or Prolonging Suffering?

Several studies have clearly shown that NIV treatment can prolong survival of NMD patients who accept and tolerate NIV compared to those who do not accept, tolerate or use it [17, 33, 110–115].

However, HRQOL may improve at a different rate in NMD patients on long-term NIV. Specifically, patients without ALS showed a more evident HRQOL improvement after 6 months from NIV initiation compared to the ALS group in whom only few of the considered domains have ameliorated [116].

Conversely, initiation of NIV in DMD patients is not perceived as adversely affecting their HRQOL [117]. In addition, despite various strategies adopted for optimizing patient comfort and prolonging NIV use, almost 30% of ALS patients can be intolerant to NIV utilization after only 1 month because of anxiety, emotional lability from pseudobulbar palsy, claustrophobia, nasal bridge soreness, and most importantly, excessive salivation [118, 119]. Other key factors that may influence overall compliance to NIV are presence of cognitive impairment [120] or severe bulbar dysfunction [121]; the latter is six times more likely to cause intolerance to NIV [33].

Another element affecting NMD patients' HRQOL is food intake. In a case series of DMD patients, continuous NIV via an angled mouthpiece was effective in providing more time to swallow food via oral intake and relieve tachypnoea, reversing their weight loss [122]. Moreover, advanced dysphagia is common in ALS patients with bulbar involvement and percutaneous endoscopic gastrostomy is frequently offered to guarantee adequate food intake and weight stabilization and it has been shown to moderately improve survival in dysphagic ALS patients [123].

Tracheotomy or Not?

One of the key determinants for longer NIV use in NMD patients is the combination of NIV and assisted mechanical cough [30]. Indeed, the synergic use of both techniques can prolong the successful use of NIV in pa-

tients with NMD [124–126]. Full-time NIV and cough assist combination is another option for selected motivated patients with neuromuscular respiratory failure and intact glottic function [127]. The use of full-time NIV is suggested as a safe and well-tolerated option for both ALS [128] and DMD [129, 130] requiring more than nocturnal ventilation alone, with assisted ventilation during the day using MPV as a valuable option in ALS [131] and a feasible but poorly used solution in DMD [32].

However, when desaturation occurs, despite the use of both techniques, or bulbar muscular impairment is too advanced and the patient is unable to protect the airways, tracheostomy and invasive mechanical ventilation (IMV) should be considered in both ALS and DMD [132, 133]. The capability to initiate and to monitor NIV 24 h/day is often a prerogative of tertiary centers where expert teams of physicians are involved in the care of NMD patients with often remarkable results [134]. Tracheostomy could be safely employed for prolonged mechanical ventilation in patients with chronic NMD but involves consideration of several factors including complications, resources, quality of life, cosmetic issues, cost and patient desire [135].

When evaluating the option of undergoing tracheotomy, physicians do not often consider patient's propensity towards it. Indeed, it is not always a voluntary decision carried by ALS patients. In fact, on the one hand, some patients are satisfied with their choice [136], and on the other hand, only a minority of patients voluntary opt for tracheotomy. The advising process as well as timing and the content of decisions is not always a shared decision-making process, this considering that at the present time no guidelines have addressed this delicate topic [137]. Another not negligible fact is that HRQOL of patients undergoing tracheotomy is often worse than before tracheotomy, and in some studies, >50% of patients declared they did not want to be tracheotomized before the procedure [85]. Over the last few months of life, ALS patients and carers usually elicited several indicators of disease worsening. This phase should trigger palliative care interventions in time so as to discuss options to relieve these patients in their last and heaviest stage of the disease [138].

In a Japanese long-term retrospective study, the authors analyzed the long-term use of NIV in a group of patients with ALS, and their transition to IMV. They found that major factors related to IMV avoidance were female gender, NIV use longer than 6 months, bulbar onset, and absence of spouse/partner [139]. It is also important to consider that these patients get used to NIV, and over time they become dependent on it, so it becomes difficult to opt for IMV [140]. Moreover, ALS patients during NIV show a decreased pain threshold leading to avoidance of further invasive procedures, increased social restrictions, and raised psychological barriers against transition from NIV to IMV [141]. In case of patient compliance, there are strong recommendations for continuation of NIV up to 24 h according to patient interface preferences [18].

Tracheotomy in DMD patients may be considered in the following circumstances: patient preference, inability to use noninvasive ventilation, three failed extubation attempts during a critical illness despite optimum use of noninvasive ventilation and mechanically assisted coughing, or failure of noninvasive methods of cough assistance to prevent aspiration of secretions into the lungs due to weak bulbar muscles [18]. Similarly, in ALS patients, when deteriorating respiratory functions start to appear during full-time NIV, there are alternatives to tracheotomy that should be considered [142]. In fact, for those patients who would not opt for IMV in the long term, a daytime mouthpiece option may be considered. A recent Canadian study described MPV use during daytime in selected patients with ALS being an effective alternative to IMV because it optimizes convenience and communication [143].

Dying with NIV

Facing end-of-life discussion is difficult, especially in young patients. Only recently has the literature been gaining information regarding end-of-life discussion and care for NMD patients [144], and palliative care is often not mentioned to any family of patients with DMD [145]. In one study, older interviewed DMD patients emphasized that it is important to face end-of-life issues "within a positive frame of reference, focusing first, on living with DMD and having a good life with it and then, as a natural part of it, about death and dying." These patients underlined the importance to die at home, surrounded by family and not in hospital [146]. This emphasizes the need of home care-based palliative care training to deal with NIV-dependent patients.

One study reported that the last days of life for ALS patients who did not choose IMV are usually characterized by dyspnea, pain, and fatigue and that more than one third of patients decide to continue NIV to relieve symptoms up until the last 24 h rather than oxygen alone [138, 147].

However, the use of NIV in the palliative care setting of patients with ALS is controversial and only few studies have explored this topic. The burden of becoming dependent on NIV is very distressful and it sums up to the other discouraging experiences that this fatal disease carries

with itself [138, 140, 148]. Withdrawing from long-term NIV has not fully been explored. One study has described withdrawing from NIV and IMV of long-term users and their last hours/days of life, highlighting that physicians should offer a palliative approach for patients who decide to withdraw from long-term ventilation and share decisions with their families [147].

This once again highlights the importance of discussing end-of-life issues with NMD patients on HMV and their family in the early course of the disease.

Conclusions

NIV plays a key role in the projection of progressive NMD improving HRQOL and survival. Monitoring NIV settings through the new built-in ventilator software is recommended. Patient and caregiver education is pivotal for the transition to home since home care programs are rarely available and telemonitoring is a promising resource but still not widespread yet. Although NIV provides a good HRQOL and longer survival, life on NIV might be challenging for NMD patients and early end-of-life discussion is mandatory as to put in place proper advanced directives.

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