NON INVASIVE MECHANICAL VENTILATION IN THE 21ST CENTURY: PRESENT AND FUTURE

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ABSTRACT

The number of mechanically ventilated patients for ARF and long-term ventilator assisted patients are increasing. More severe patients are being treated with similar success and Non Invasive Mechanical Ventilation (NIMV) is becoming available in more centres. Choosing the appropriate interface and ventilator for the specific patient will still be a challenge. Training and education are vital for improving the care of patients with Respiratory Failure. NIMV services will increase the demand of specific units where the pulmonologist will have a leading role.

The next few years will certainly see further technological advances, and NIV will have its indications more clearly defined in patients with both acute and chronic respiratory failure.

INTRODUCTION

The first trials of non invasive positive pressure ventilation (NIMV) appeared in 1956 via a mouthpiece[1]. Then in the early 1980s NIMV was employed though a nasal interface[2,3].

Since those times NIMV performed through different interfaces was widely applied from the Hospital to Home and became a real advance in the management of both chronic and acute respiratory failure (ARF)[4,5].

It became the most commonly used home respiratory support and a therapy of choice for many cases of ARF.

EPIDEMIOLOGY OF NIMV

Two differents circunstances mus be considered when talking about the epidemiology on NIMV: acute respiratory failure and chronic respiratory failures.

Acute respiratory failure

In a international survey, Esteban et al.[6] showed a 1 day point-prevalence of NIMV of 1% in 412 medical-surgical Intensive Care Units (ICU) from North America, South America, Spain and Portugal. A similar study performed by the same group two years later reported a 28 day prevalence of NIMV 4.9% in 361 ICU's[7].

In 1997, a 3 week screening survey[8] concluded that in European ICU's, NIMV was used as a first line treatment in 16% of patients, while the same survey in 2002[9] reported a significant increase to 24% of patients, with the same success rate (60% *versus* 56%). Moreover, in another study from France, it was concluded that as soon as NIMV use increases there is a trend for reducing ICU mortality[10]. In the two main conditions precipitating ARF, in 1997 NIMV was used in 14% of Hypoxemic ARF while in 2002 it increased to 25%; concerning hypercapnic ARF in 1997 NIMV was applied in 50% of cases while in 2002 it reached 66% of cases (Fig. 1)[8,9].

In a 2003 survey, 62.8% of respondents from 4 specialities in Ontario used bi-level NIMV in ARF[11] while in a regional survey of acute care hospitals in Massachusetts and Rhode Island the overall utilization rate for NIMV was 20% of ventilator starts[12]. In both surveys[11,12], COPD and congestive heart failure constituted the majority of the diagnosis of patients receiving NIMV and the main reasons

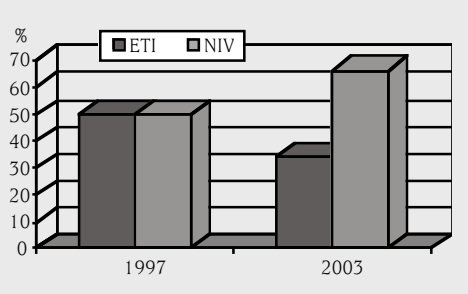

FIGURA 1. NIV *versus* ETI in COPD with ARF (comparison between 1997 and 2003)-ICU.

for lower utilisation rates were a lack of physician knowledge and inadequate equipment.

In another survey of teaching hospitals across Canada, the use of NIMV for the treatment of acute exacerbations of COPD varied enormously from sites that rarely used NIMV to others where it was routine practice[13]. In a National audit in England and Wales mortality in acute COPD was higher in small district general hospital than in teaching hospitals where NIMV was more frequently used[14].

At least in COPD exacerbations there has been a change in practice in recent years with expert centers treating with NIMV patients with increasing levels of acidosis while maintaining the same rate of success[15].

In an epidemiological study performed in North Carolina, the incidence of mechanical ventilation from 1996-2002 increased by 11 % over these 7 years, however for respiratory diseases there was a slight decrease after the year 2000, may be related to the growing use of NIMV[16].

Chronic respiratory failure and home mechanical ventilation (HMV)

Advances in medical care and the acute application of invasive mechanical ventilation have resulted in increased survival of critically ill patients, some of whom may become dependent on long-term mechanical ventilation. Moreover, the indications of elective long-term NIMV have been clearly defined[17] and there seems to be a rapid growth in HMV users[18].

In 1983 it was estimated that there were 6,800 long-term ventilator-assisted patients in the US; by December 1990, estimates had nearly doubled, with the American Association for Respiratory Care (AARC) and the Gallup organization estimating that the number of patients nationwide receiving long-term ventilatory support was 11,419[19].

In a European survey performed in 2001 it was estimated that patients 6.6/100.000 inhabitants are under HMV[20]. This recent Eurovent study showed that there are around 21 500 individuals receiving home ventilation in Europe: about one third have neuromuscular conditions, one third parenchymal lung disease (mainly COPD), and the remainder have chest wall disorders (scoliosis, thoracoplasty, obesity hypoventilation syndrome); 13 % use tracheostomy ventilation and around 10 % are in the paediatric age range (Fig. 2).

In another study from Europe, Janssens et al. 21 including 211 patients from 2 University Hospitals and 1 Rehabilitation centre in Switzerland, reported from 1994 to 1999 a significant increase in HMV users. COPD and OHS became the most frequent indications for NPPV increasing regularly while other indications remained stable.

NEW INTERFACES

The development of various interfaces has made the delivery of NIMV most successful 22 as there is sufficient evidence to support the importance of ventilatory interfaces for the success of NIV[23,24].

In an attempt to improve tolerability and performance, new interfaces have been developed. A prototype mask with an inflated air cushion reduced significantly nasal pressure sores[25] and exhaust ports over the nasal bridge in face masks effect important decreases in dynamic dead space[26].

The use of a "helmet" has been described in hypoxemic ARF, with patients receiving continuous ventilation for many days[27].

The "old" mouth-piece, described back in the 70´s, has been considered the interface of

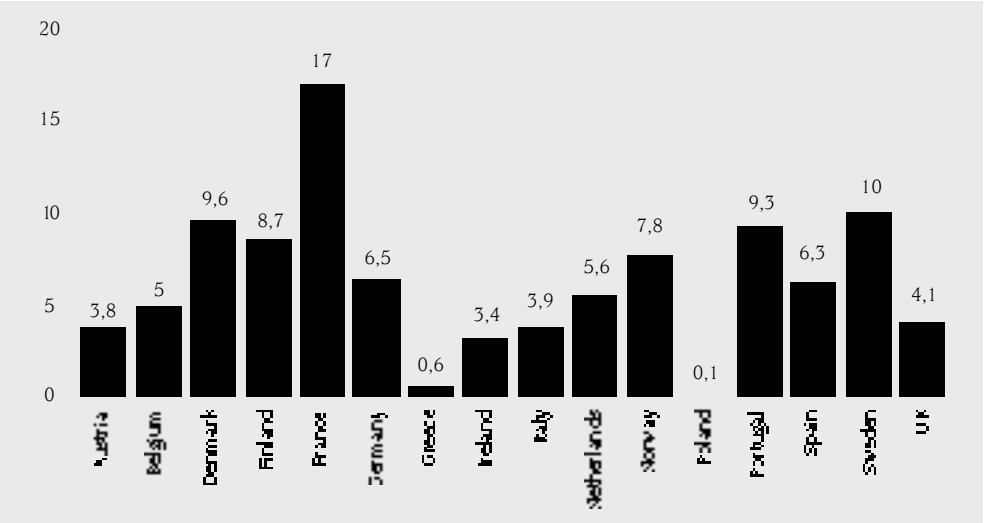

FIGURA 2. Prevalence of HMV in Europe (per 100.000 people).

choice when longterm continuous NIMV is required as an alternative to tracheostomy[28,29]. In fact, this interface avoids skin breakdown, facilitates speech and cough, and is easy to be mounted in a wheelchair even for quadriplegic patients (Fig. 3).

FIGURA 3. Angled Mouth Piece for daytime NIMV.

NEW VENTILATORS AND MODES

Ventilators used for NIMV range from ICU ventilators with full monitoring and alarms to lightweight devices designed for home use. Considerable progress has been made in the design, function and performance of home ventilators, such as these machines can perform as well as some ICU ventilators[30] and new generation ventilators outperform previous generation ventilators[31]. Moreover, recent home mechanical ventilato rs show very good triggering chara cteristics, but pressurization characteristics vary widely suggesting less efficacy in patients with seve re restriction[32].

There are now more than 30 models on the market, each providing seve ral ventilation modes and settings. Sometimes technical developments are really ahead of scientific evidence and user-friendliness of the home mechanical ventilators are questionable[33].

According with the British Thoracic Society, the ideal ventilator suitable for NIMV in the hospital should have pressure capability at least 30 cmH_20, rate capability of at least 40 breaths/min, internal battery, simple control knobs, adjustable triggers, etc.[34]. Built-in heated humidifier as well as monitoring and alarms should also be advisable.

Improvement should also be made to ensure adequate ventilator settings and correct ventilator performance and ventilator alarm operation[35].

Traditionally, pressure support and volume cycled ventilation have been the most used modes for NIMV. In the last two decades, new modes of mechanical ventilation like proportional assist ventilation or neurally adjusted

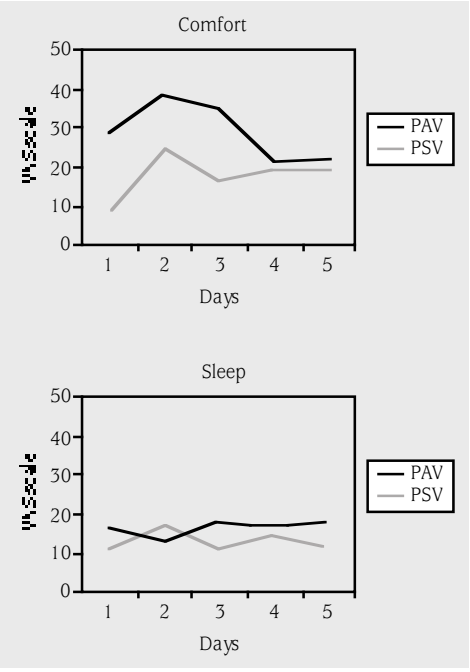

FIGURA 4. Median VAS scores for Comfort and Sleep after 5 days of PSV and PAV (from reference 38).

ventilatory assist, designed to improve patient-ventilator interaction have been investigated by ICU researchers[36].

Proportional assist ventilation has been used for NIMV both in the acute and chronic setting[37,38]. Despite positive results in terms of comfort[37,38] (Fig. 4) PAV seems to be more a research tool rather than a ventilatory mode for the "real world".

WHAT WILL THE FUTURE BRING?

Basic sciences (sleep and ventilation neurobiology) and technology advances (diagnosis and therapy) will certainly improve the quality of life of patients with acute or chronic respiratory failure.

Telemedicine can also have a role in the reduction of costs and improving quality of life of patients under HMV.

Respiratory failure due to chronic pulmonary diseases will still exist and increase. But, with lung transplantation or the genetic or stem cells therapy[39], some lung diseases that evolve to chronic respiratory failure (like pulmonary emphysema, cystic fibrosis or alpha1 anti-trypsin deficiency) may be potentially curable.

In the cases not amenable to these therapies, noninvasive ventilatory support will still be necessary to take patients out of ICU beds and transfer them to home. In fact, in the future it is possible that the indications for NIMV will widen, according with the world wide epidemiologic studies of HMV users.

Moreover, neuromuscular disorders that evolve to respiratory muscle failure, while new stem cell therapies are still under investigation, unavoidably non-invasive respiratory muscle aids will help to improve survival and quality of life of these patients. In this context, so-called neurotechnology (Neuromotor Prostheses) as the one recently described in Nature can be a hope for tetraplegic patients[40].

CONCLUSIONS

Apart from the COPD and Obesity Epidemies (that will certainly increase the figures of longterm ventilator assisted patients), there is a new emerging population of "chronically critically ill" coming from ICU survivors who behave just like neuromuscular patients[41]. More severe patients are being treated with similar success and NIV is becoming available in more centres[9,10,15].

For the clinician, choosing the appropriate interface and ventilator for the specific patient will be a challenge.

Training and education are vital for improving the care of patients with respiratory failure.

A further challenge for the future is that more physicians will have dual accreditation in respiratory medicine and critical care[42]. This may be a driver for the creation of units that provide not only acute 24 hour per day NIV service, but also a rehabilitative approach to weaning and longterm non-invasive ventilation.

Programs like those at the Ventilator Rehabilitation Unit at Temple University Hospital (Philadelphia, USA)[43] or the Respiratory Intermediate Intensive Care Medicine located at a Rehabilitation Centre (Pavia, Italy)[44] have moved in the right direction.

The next few years will certainly see further technological advances and NIMV will have its indications more clearly defined in patients with both acute and chronic respiratory failure. In the meantime NIMV services and advances will certainly drive the future of Pulmonology.

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