Outcome of non-invasive domiciliary ventilation in elderly patients

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Summary

Study objectives: To analyze the short- and long-term effects of domiciliary non-invasive ventilation (NIV) in the elderly.

Methods: From 1990 to 2005 all patients who initiated NIV at age 75 or older were included in the study. The mean follow-up period was 36 (24) months. Data were obtained from a database record.

Results: Forty-three patients, mean age 77 (1.9) years and hypercapnic respiratory failure secondary to restrictive, neuromuscular or hypoventilatory disease were included. The short-term effects included a significant improvement in arterial blood gases and nocturnal desaturations during NIV compared to baseline: $P_{aO_2}$ increased a mean of 19 mmHg ($P < 0.0001$), $P_{aCO_2}$ decreased a mean of 16 mmHg ($P < 0.0001$) and nocturnal time with $S_{aO_2} < 90\%$ decreased a mean of 72\% ($P < 0.0001$). Arterial blood gases while breathing room air also improved significantly at 6 months after NIV initiation. Five patients (11\%) discontinued treatment; this group did not differ from patients who continued NIV. Mean compliance was 8.3 (3.1) h/day. In the long-term effects, we observed that the initial improvement of arterial blood gases breathing room air was maintained throughout the followup period. The number of hospital admissions and days of hospital stay decreased significantly ($P < 0.0001$ and 0.001, respectively) after NIV initiation. The poorest survival was observed in ALS patients (median 10.9 (2.3) months) significantly lower than the survival for the other diagnostic groups (median 58.5 (4.8) months), $P = 0.0013$.

Conclusions: NIV is an effective treatment in the elderly. It improves arterial blood gases and nocturnal desaturations, decreases hospital admissions and is associated with long survival. So advanced age should not be considered as an exclusion criteria to prescribe NIV.

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Introduction

Over the last decade, domiciliary non-invasive ventilation (NIV) has become a widely accepted treatment for chronic respiratory failure due to chest wall disorders and neuromuscular diseases. Numerous uncontrolled studies have been published supporting the efficacy of NIV for these indications, and improvements have been observed in daytime gas exchange, symptoms of hypoventilation, survival, quality of life and length of hospital stays.\(^1\)\(^-\)\(^5\)

The appearance of bilevel pressure ventilators and improvements in nasal masks have increased patient comfort and reduced adverse effects of NIV, but the treatment can still be cumbersome and difficult for some patients to tolerate. Furthermore, the open-circuit design of NIV requires the patient’s cooperation and acceptance to ensure treatment efficacy.\(^6\) For these reasons, and also considering the lower life expectancy in elderly patients (75 years or above) with chronic respiratory insufficiency, NIV is sometimes rejected as a therapeutic option in this group, even though there is no specific mention of age among the criteria for the indication of NIV.\(^7\)

Very few data are available about the outcomes of NIV in the elderly population, and to the best of our knowledge, one short study only has been published, reporting data of six patients.\(^8\)

Treatment with home mechanical ventilation was initiated in our center in 1990, and since then, NIV has been prescribed to more than 500 patients with no age-related restriction in its indications. However, as some patients have abandoned treatment we were interested to know whether we should modify our clinical practice. The aim of this study was to evaluate the outcome—including short- and long-term effects of NIV in our elderly patients, especially concerning tolerance, compliance, efficacy of ventilation and long-term results such as survival.

Methods

Patient selection and database

All patients who initiate NIV in our respiratory department are included in a database which records the following data: (a) assessment prior to the initiation of NIV, (b) efficacy of ventilation at onset, and (c) prospective follow-up.

The present study includes all patients who started NIV at 75 years of age and over who were included in our database from January 1990 to December 2004. Patients were followed up until death or until the end of the study in December 2005. The mean followup was 36 (24) months.

The study was approved by the ethics committee of the Hospital Universitari de Bellvitge and informed written consent was obtained for each subject undergoing domiciliary NIV.

Initial assessment

Patients were evaluated in the outpatient clinic or during hospital admission if NIV was initiated in an acute situation. Data recorded in the database included: demographic data, living arrangements, diagnosis, Charlson comorbidity index,\(^9\) lung function tests (FVC and FEV\(_1\)), arterial blood gas analysis (PaO\(_2\) and PaCO\(_2\)), and nocturnal oximetry while breathing room air. Hospital admissions and number of days spent in hospital in the year prior to the initiation of NIV were also recorded.

Initiation of ventilation

NIV was indicated for patients with restrictive thoracic and neuromuscular disorders or hypoventilatory syndromes with symptoms attributable to chronic hypoventilation (e.g.: poor sleep quality, daytime hypersomnolence and morning headache) or respiratory muscle weakness (orthopnea, ineffective cough) and nocturnal desaturation or daytime hypercapnia (PaCO\(_2\) > 45 mmHg). As mentioned above, no restrictions were made in relation to age. Adaptation to ventilation and adjustment of ventilator settings were always done during an inpatient admission. The type of ventilator and interface were selected based on the patient’s comfort and adaptation, correction of gas-exchange abnormalities and the number of hours of ventilation. Equipment used included volumetric ventilator (PLV-100, Lifecare\(^{10}\), Germany and PV 501, BREATS Medical\(^{10}\), Sweden) or pressure ventilator (O’NYX, Pierre Medical S.A., France; BiPAP, Respironics Inc, Murrysville, PA and Sullivan VPAP ST II, ResMed Ltd., UK). Interfaces included custom-molded and commercial nasal masks with chin-strap to minimize oral leaks.

Data recorded in the database included: type of ventilator and interface, ventilation parameters, arterial blood gases during diurnal ventilation, and oxygen saturation (SaO\(_2\)) during nocturnal ventilation.

Follow-up

Patients were closely followed up after NIV initiation with a home visit during the week after hospital discharge, and an outpatient clinic visit 1 month later. Subsequent visits were made according to the patient’s stability, every 3 or 6 months. Visits were also established at the patient’s request if symptoms worsened or in case of troubles with interfaces or the ventilator.

External companies are responsible for servicing (maintenance, repair and delivery of consumables) the home ventilators. Routine visits were carried out every 1–3 months and the number of hours on the counters on ventilators were recorded.

Data recorded in the database included: arterial blood gases while breathing room air at each outpatient clinic visit, compliance, admissions and days spent in hospital in the year after initiation of NIV, and survival.

Statistical analysis

Changes in arterial blood gases, nocturnal SaO\(_2\) and hospital admissions after NIV were evaluated using the Student’s t-test or Wilcoxon test to compare quantitative variables and \(\chi^2\) test to compare qualitative variables. Data are reported as mean (standard deviation).
Analysis of survival was undertaken using the Kaplan–Meier method, applying the Log rank test for differences between groups.

Results

Patients

In total, 43 patients (23 women, 54%) with chronic hypercapnic respiratory failure started domiciliary ventilation at age 75 or above. Diagnosis included: kyphoscoliosis 11 (25%), post-tuberculosis sequelae 14 (33%), neuromuscular disease 9 (21%) [5 amyotrophic lateral sclerosis ALS], hypoventilatory disorders 8 (19%) [5 related to obesity], and bronchiectasies plus kyphosis 1 (2%). Ventilators used were: a volume ventilator in 9 patients (21%), O’NYX in 4 patients (9%), and bilevel pressure devices in 30 patients (70%). Interfaces used were custom-molded nasal mask in 9 patients (21%) and commercial nasal masks in 34 patients (79%).

The majority of patients (86%) lived with their family, 3 patients (7%) lived in a nursing home and 3 patients (7%) lived alone.

Seven patients (16%) initiated NIV in acute situation and 36 patients (84%) initiated NIV electively. Patients’ characteristics of both groups at onset of ventilation are shown in Table 1. Among patients in acute situation, nocturnal oximetry while breathing room air was not recorded in one case due to severe hypoxemia and forced spirometry was not recorded in 2 patients (5%) because of their clinical severity. The results of forced spirometry were disregarded in 6 patients (14%) of the elective group due to lack of cooperation.

Tolerance, side effects and compliance

Five patients (11%) (4 women, 1 man), with a mean age of 76.4 (1.5) years, discontinued ventilation treatment at between 1 week and 6 months. Their diagnoses were kyphoscoliosis in 3 patients, post-tuberculosis sequelae in 1, and obesity-hypoventilation syndrome in 1. All five presented markedly abnormal arterial blood gases (mean $\text{PaO}_2$ 53.6 (12.7) mmHg, mean $\text{PaCO}_2$ 64.2 (11.3) mmHg, mean percentage of time with $\text{SaO}_2<90\%$ (CT 90) in nocturnal oximetry 74 (37)% when ventilation was started. NIV efficacy was observed during the hospital stay with a significant improvement both in blood gases and nocturnal saturation during ventilation: mean $\text{PaO}_2$ 74.2 (5) mmHg, mean $\text{PCO}_2$ 43 (3.5) mmHg, mean CT 90 0%. Adaptation and tolerance to NIV was considered normal during hospital admission and patients agreed to continue treatment at home. Once home, however, they found it very uncomfortable, reported inability to sleep, and refused to continue the therapy. No significant differences were observed in the baseline characteristics between these five patients and the group that continued with NIV (Table 2). The side effects were rare in the group of patients who abandoned treatment, only one patient presented skin eczema that was easily resolved by changing the nasal mask. Among patient who continued treatment, adverse effects were observed in 22 patients (58%) being nasal skin lesions (26%) and rinitis with nasal dryness (16%) the more frequent. The severity of side effects was minor and in no case forced us to break off the treatment. On the contrary, the incidence and type of side effects observed in the elderly was very similar to that observed in our general population treated with NIV for long term.

The mean compliance of patients who continued NIV was 8.3 (3.1) h/day.

The efficacy of the treatment, and survival in this study refer to patients ($n=38$) that continued with NIV.

Efficacy of ventilation

A significant improvement in diurnal arterial blood gases and nocturnal $\text{SaO}_2$ was observed when the patients were receiving ventilation in comparison with the baseline situation breathing room air. Because of possible effects of the acute situation in the evolution of blood gases, we analyzed separately data for patients that initiated NIV in acute situation and for patients that started treatment electively in stable situation. The magnitude of improvement was similar in the acute and the elective patients, although hypercapnia was not completely normalized during ventilation in the acute group, Table 3.

### Table 1 Patients’ characteristics at baseline.

<table>
<thead>
<tr>
<th></th>
<th>NIV elective ($n=36$)</th>
<th>NIV acute ($n=7$)</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>76.8 (1.8)</td>
<td>77.8 (2.3)</td>
<td>ns</td>
</tr>
<tr>
<td>$\text{PaO}_2$ (mmHg)</td>
<td>56 (13)</td>
<td>45 (6)</td>
<td>0.05</td>
</tr>
<tr>
<td>$\text{PaCO}_2$ (mmHg)</td>
<td>57 (11)</td>
<td>60 (12)</td>
<td>0.01</td>
</tr>
<tr>
<td>CT 90 (%)</td>
<td>74 (37)</td>
<td>100 (0)</td>
<td>0.03</td>
</tr>
<tr>
<td>FVC (% predicted)</td>
<td>47 (16)</td>
<td>53 (21)</td>
<td>ns</td>
</tr>
<tr>
<td>FEV$_1$ (% predicted)</td>
<td>45 (20)</td>
<td>43 (15)</td>
<td>ns</td>
</tr>
<tr>
<td>Comorbidity (Charlson)</td>
<td>2 (1.5)</td>
<td>2.1 (0.6)</td>
<td>ns</td>
</tr>
</tbody>
</table>

### Table 2 Patients’ baseline characteristics according to NIV tolerance.

<table>
<thead>
<tr>
<th></th>
<th>Abandon NIV</th>
<th>Continue NIV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (year)</td>
<td>76 (1.5)</td>
<td>77 (2)</td>
</tr>
<tr>
<td>Sex (men/women)</td>
<td>1/4</td>
<td>19/19</td>
</tr>
<tr>
<td>$\text{PaO}_2$ (mmHg)</td>
<td>53 (12)</td>
<td>54 (13)</td>
</tr>
<tr>
<td>$\text{PaCO}_2$ (mmHg)</td>
<td>64 (11)</td>
<td>59 (12)</td>
</tr>
<tr>
<td>CT 90 (%)</td>
<td>74 (37)</td>
<td>79 (35)</td>
</tr>
<tr>
<td>FVC (% predicted)</td>
<td>56 (18)</td>
<td>47 (16)</td>
</tr>
<tr>
<td>FEV$_1$ (% predicted)</td>
<td>46 (12)</td>
<td>44 (20)</td>
</tr>
<tr>
<td>Comorbidity (Charlson)</td>
<td>2.6 (2.5)</td>
<td>2 (1.3)</td>
</tr>
</tbody>
</table>
Arterial blood gases while breathing room air also improved after initiation of NIV and the improvement remained over the followup period. The improvement, specially for hypercapnia was more rapid in the patients that initiated NIV in elective situation. Figure 1 plots the evolution of the diurnal $P_{aO2}$ and $P_{aCO2}$ while breathing room air for both groups.

Eighteen patients (47%) were on previous long-term oxygen therapy (LTOT). After initiation of NIV, LTOT was withdrawn in 5 patients (28%). Thirteen continued to have additional oxygen during the night because of nocturnal desaturations, related in most cases to oral leaks that could not be avoided in spite of the efforts to improved efficacy of nocturnal ventilation (adjusting parametres of ventilation, changing type of mask, adding chin strap, etc.).

When the number of hospital admissions and the total days spent in hospital in the year prior to NIV was compared with figures for the year after NIV was initiated we observed a significant decrease (paired $T$-test) in both parameters: number of admissions per patient decreased from 2.21(2.4) to 0.45(0.6), $P<0.0001$ and hospital stay decreased from 24.6 (26) to 5.3 (8.9) days, $P<0.001$.

**Survival**

In December 2005, 19 patients (50%) were alive and 19 patients died: 11 (58%) due to progression of respiratory failure, 1 due to empyema and 2 to cardiac insufficiency; 5 patients (26%) died at home and information available was insufficient to determine the cause of death. The poorest survival was observed in the ALS patients, with a median of 10.9 (2.34) months, significantly lower than the other diagnostic groups (log-rank, $P=0.0013$). Median survival for non-ALS patients was 58.5 (4.8) months (Fig. 2).

**Discussion**

NIV proved to be a very effective therapy in our elderly population; it provided a highly significant, long-lasting improvement in arterial blood gases and led to a decrease in hospital admissions and length of hospital stay in the year after treatment initiation. Our results are in accordance with Janssens et al.’s study in 6 patients. Moreover, in spite of the mean age in our study group, the level of hypercapnic respiratory failure and the comorbidity observed at the initiation of NIV, survival was surprisingly long, with a median of almost 5 years, except in ALS patients. A shorter survival in ALS patients is not unexpected, especially when bulbar impairment is present as was the case in two of our patients who died.

Owing to the progressive increase in life expectancy and the lower birth rate in developed countries in recent years, the absolute number of elderly has grown.
disability-free life expectancy is increasing and there is a decrease in the prevalence of severe disability among the elderly.\textsuperscript{14} Taken together, these factors are likely to influence changes in clinical decision-making in the future.\textsuperscript{15}

When considering how far a clinician should go in the treatment of the elderly, side effects should be carefully considered as their incidence and severity are frequently higher the older the patient. In such situations, the risks and benefits must be estimated prior to the initiation of treatment. This is not the case, however, in NIV as it is a safe, well-tolerated treatment and its most frequent adverse effects are minor. These are generally related to the nasal mask (regional pain, skin lesions) or to the ventilator airflow (nasal dryness, conjunctival irritation).\textsuperscript{6}

In our population, as in Janssens et al.’s\textsuperscript{8} study, no significant side effects were reported and their incidence was very similar than the observed in our general population.\textsuperscript{19} So in our experience, the incidence and severity of side effects are not related to age.

Another aspect to consider in the elderly is the difficulty that may be encountered when treatment is complex. Physicians may consider that efficacy of therapy could be limited in this group of patients because of higher intolerance, lower compliance or incorrect application of therapy. As a result, NIV therapy may not be considered an option as first choice treatment and less effective but simpler treatment may be given. This is likely what occurred in almost 50\% of our patients who were treated with home oxygen therapy before they were finally referred to our center for NIV assessment due to their clinical and blood gas deterioration and frequent hospital admissions. After initiation of NIV, a significant improvement in gas-exchange and a decrease in hospital admissions was observed, and home oxygen therapy was successfully discontinued in several patients.

The initial level of tolerance observed in our study was acceptable, although five patients (11\%) finally abandoned domiciliary NIV. This percentage is significantly higher than that observed in the younger population in our center (4\%, unpublished data), but is similar to data from the general population treated with NIV reported in other studies, such as the 10\% in Rey et al.’s\textsuperscript{16} study, and considerably lower than the 35\% in Criner et al.’s\textsuperscript{17} report. However, it should be kept in mind that 71\% of Criner’s population had COPD diagnosis\textsuperscript{17} and NIV is still considered controversial treatment for this entity in the stable situation.\textsuperscript{18} All patients in our study however, had clearly established criteria for NIV according to clinical diagnosis and hypercapnia, as we considered candidates to home NIV only patients with restrictive extrapulmonary disease but not COPD.

Like Rey et al., we found no significant differences between patients who discontinued NIV and patients who continued on NIV, so no predictive factors of tolerance and compliance could be identified prior to treatment.

Compliance was also good in this elderly population; 8.3 (3.1) h/day, comparable to data reported in the large series of domiciliary ventilation which included patients of all ages: 7.88 (2.1) h/day in the Simonds and Elliot’s study\textsuperscript{19} and 9 (2) h/night and 1.5 (2) h/day in the study of Leger et al.\textsuperscript{1}

In conclusion, our results show the efficacy of NIV in the elderly. We observed an improvement in arterial blood gases and nocturnal desaturations, a decrease in hospital admissions and length of hospital stay and a median survival of almost 5 years. Furthermore, compliance and tolerance were comparable to results in the general population. As no predictive factors of continuation of domiciliary therapy were found, we propose a trial period of NIV for all patients fulfilling the indication criteria, irrespective of age.

References


