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Non-invasive negative and positive pressure ventilation in the treatment of acute on chronic respiratory failure

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Abstract *Objective:* To investigate in clinical practice the role of non-invasive mechanical ventilation in the treatment of acute respiratory failure on chronic respiratory disorders. *Design:* An 18 months prospective cohort study. *Setting:* A specialised respiratory intensive care unit in a university-affiliated hospital. *Patients:* A total of 258 consecutive patients with acute respiratory failure on chronic respiratory disorders. *Interventions:* Criteria for starting non-invasive mechanical ventilation and for endotracheal intubation were predefined. Non-invasive mechanical ventilation was provided by positive pressure (NPPV) ventilators or iron lung (NPV). *Results:* The main characteristics of patients (70% with chronic obstructive pulmonary disease) on admission were (mean, SD or median, 25th–75th centiles): pH 7.29 (0.07), $PaCO_2$ 83 mm Hg (19), PaO_2/FiO_2 198 (77), APACHE II score 19 (15–24). Among the 258 patients, 200 (77%) were treated exclusively with non-invasive mechanical ventilation (40% with NPV, 23% with NPPV, and 14% with the sequential use of both), and 35 (14%) with invasive mechanical ventilation. In patients in whom NPV or NPPV failed, the sequential use of the alternative non-invasive ventilatory technique allowed a significant reduction in the failure of non-invasive mechanical ventilation (from 23.4 to 8.8%, p=0.002, and from 25.3 to 5%, p=0.0001, respectively). In patients as a whole, the hospital mortality (21%) was lower than that estimated by APACHE II score (28%). *Conclusions:* Using NPV and NPPV it was possible in clinical practice to avoid endotracheal intubation in the large majority of unselected patients with acute respiratory failure on chronic respiratory disorders needing ventilatory support. The sequential use of both modalities may increase further the effectiveness of non-invasive mechanical ventilation.

Keywords Non-invasive mechanical ventilation · Acute respiratory failure · Chronic obstructive pulmonary disease · Non-invasive positive pressure ventilation · Negative pressure ventilation

Introduction

Prospective controlled trials have shown that compared to standard medical treatment, non-invasive positive pressure ventilation (NPPV) reduces the need of endotracheal intubation [1, 2, 3] and hospital mortality [1, 2, 3, 4] in selected patients with acute exacerbation of chronic obstructive pulmonary disease (COPD). A recent randomised study comparing NPPV with conventional mechanical ventilation in patients with exacerbation of COPD who failed medical treatment, has shown that NPPV avoided endotracheal intubation in 48% of cases [5]. Non-invasive positive pressure ventilation, however, is not without its problems and failure rates of 7–50%

have been reported [6]. Severe respiratory acidosis [7, 8] and illness at presentation [7, 9], excessive airway secretions [9], and inability to minimise the amount of air leakage [9] are major factors associated with failure of NPPV.

Recent studies have shown that negative pressure ventilation (NPV) provided by an iron lung is able to improve arterial blood gases, and to unload inspiratory muscles in patients with exacerbation of COPD [10, 11]. In clinical studies NPV has been used successfully in patients with severe respiratory acidosis or impaired level of consciousness [12, 13, 14].

The field of application of both NPPV and NPV in clinical practice however, is not clearly defined [15, 16]. Interventional trials often did not keep comprehensive logs of excluded patients [2, 3, 12]; in the study of Brochard et al. [1] only 85 (31%) of the 275 screened patients with COPD were qualified for the NPPV. Furthermore, two recent surveys on mechanical ventilation in ICU showed that NPPV was used only in 5–16% of cases and in 17–50% of cases with acute on chronic respiratory failure [17, 18].

Thus, the present prospective cohort study was undertaken to investigate in clinical practice the role of non-invasive mechanical ventilation in the treatment of acute respiratory failure on chronic respiratory disorders (ACRF).

Methods

Setting

Careggi Hospital is a university-affiliated hospital. Critical care services include an 8-bed specialised respiratory intensive care unit admitting mainly critically ill patients with chronic respiratory disorders. The respiratory intensive care unit is staffed by chest physicians and nurses with expertise in NPPV, NPV and invasive ventilation.

Study design

The study was a prospective, observational cohort study over 18 months (from 1 July 1999 to 31 December 2000).

Study population

The study population consisted of consecutive patients with chronic respiratory diseases admitted to the respiratory intensive care unit for acute respiratory failure. Chronic respiratory diseases included COPD, chest wall deformity, neuromuscular disorders, tuberculosis sequelae, sleep apnea-hypopnea syndrome, hypoventilation-obesity syndrome, and pulmonary fibrosis. The diagnosis of chronic respiratory disease was made either from existing pulmonary function studies or from a clinical history, physical examination and chest X-ray compatible with the diagnosis. Acute respiratory failure was defined as respiratory acidosis ($pH<7.35$ with $PaCO_2>60$ mm Hg) or hypoxemia (ratio of PaO_2 to $FiO_2 \leq 150$). Exclusion criteria were: neoplasia, central nervous system alterations unrelated to hypercapnic encephalopathy, and acute respiratory failure without chronic respiratory diseases. Criteria for starting non-invasive mechanical ventilation and for endotracheal intubation were those applied in clinical practice for all patients with ACRF admitted to the respiratory intensive care unit. The study was conducted according to the 1964 Helsinki Declaration concerning human research, and was approved by the institutional ethics committee; patients or their relatives gave written informed consent.

Treatment and data collection

All patients received oxygen through a Venturi Mask or nasal prongs to achieve a oxygen saturation (SaO_2) of 92–94%, and usual medical care for their condition.

Non-invasive mechanical ventilation was started when, despite optimised medical care and oxygen administration, patients met at least one of the following criteria: $pH<7.32$ with $PaCO_2>60$ mm Hg (hypercapnic respiratory failure), or $PaO_2<60$ mm Hg with $FiO_2=50\%$ (hypoxemic respiratory failure), plus one of the following: dyspnoea, accessory muscle recruitment, and respiratory rate >30 breaths/min. The duration of the standard medical treatment and the choice of the first-line non-invasive mechanical ventilation technique (NPV or NPPV) were determined by the physician in charge: NPV was preferentially used in patients with severe hypercapnic encephalopathy, copious airway secretions, facial deformity, or severe respiratory acidosis ($pH<7.25$), and NPPV in patients with consciousness preserved, sleep apnea-hypopnea syndrome, scoliosis or obesity. When the first-line non-invasive mechanical ventilation technique was not tolerated, or failed to maintain $SaO_2>90\%$ or to improve respiratory acidosis ($pH<7.30$ and below the baseline value) after 4 h of application, and major criteria for endotracheal intubation were not present, patients were shifted to the alternative non-invasive mechanical ventilation technique. Failure of first-line non-invasive mechanical ventilation was defined as the presence of criteria for shifting to the alternative non-invasive mechanical ventilation technique or for immediate endotracheal intubation.

Endotracheal intubation and conventional mechanical ventilation were immediately performed in patients who met any of the following major criteria [1]: respiratory arrest, or respiratory pauses with loss of consciousness, or psychomotor agitation requiring sedation, or severe haemodynamic instability (systolic arterial blood pressure below 80 mm Hg), or heart rate below 50 beats/min with loss of alertness. Furthermore, endotracheal intubation was performed when both NPPV and NPV were not tolerated by the patients, or failed to maintain $SaO_2>90\%$ or to improve respiratory acidosis ($pH<7.30$ and below the baseline value).

Negative pressure ventilation was provided by a microprocessor-based iron lung (Coppa, Biella, Italy) as previously described [11, 19]. Non-invasive positive pressure ventilation was delivered through a full-face mask (Mirage, ResMed, North Ride, Australia, or Respironics Inc, Pittsburg, PA), by BiPAP Vision (Respironics Inc, Pittsburg, PA) or 840 (Nellcor Puritan Bennett Inc, Pleasanton, CA) ventilators set in the pressure support mode. The pressure controlled mode with the 840 ventilator was used in the case of patient-ventilator asynchrony due to air leaks [20]. Positive end-expiratory pressure (PEEP) was set at 4–5 cm H_2O, and the level of pressure support was titrated to minimise clinical signs of respiratory distress and to obtain a respiratory rate of 15–30 cycles/min. In patients with hypoxemic respiratory failure the level of PEEP was increased up to 8 cm H_2O until FiO_2 requirement was 60% or less. Both during NPV or NPPV ventilator settings were adjusted on the basis of monitoring of SpO_2, clinical data, and measurements of arterial blood gases (ABG). The FiO_2 was adjusted to maintain a SaO_2 of 92–94%. Non-invasive mechanical ventilation was provided continuously for at least 4 h. The period

could be lengthened depending on the clinical response and tolerance of patients. Ventilatory treatment was then provided intermittently, and the overall duration of non-invasive mechanical ventilation was determined on the basis of clinical criteria and ABG levels.

Diagnostic criteria of nosocomial pneumonia were those used in previous studies with non-invasive mechanical ventilation [17].

Outcome variables

Outcome variables included the effects of both NPV and NPPV on arterial blood gases, the need for endotracheal intubation in the respiratory intensive care unit, mortality rate in the respiratory intensive care unit and hospital, and complications related to NPV and NPPV.

Data analysis

Results are given as means (SD) for normally distributed data and as medians (25th–75th centiles) for non-normally distributed variables. Continuous variables were analysed using analysis of variance and Scheffè test of multiple comparisons, or Kruskal-Wallis H test and Mann Whitney U test if the distribution of the variables was not normal. Nominal variables were compared by using the Pearson χ^2-test. A p-value of ≤ 0.05 was considered statistically significant.

Results

A total of 332 patients were admitted to the respiratory intensive care unit over the period of the study; 258 (83%) patients met the inclusion criteria and were enrolled (Table 1). The other 74 patients (17%) were excluded: 37 were admitted for difficulty in weaning from mechanical ventilation, 17 did not have chronic respiratory diseases, and 20 had the inclusion criteria but were included in other clinical trials. Of patients included in the study, 70% had COPD, whereas the others had non COPD-related chronic respiratory diseases: tuberculosis sequelae (8%), neuromuscular disorders (7%), sleep apnea-hypopnea syndrome or hypoventilation-obesity syndrome (10%), and chest wall deformity (5%). The most frequent conditions precipitating acute respiratory failure were exacerbation of COPD (40% of cases), pneumonia (37%), and heart failure (19%). Of the 258 patients, 55% presented with at least 1 comorbid condition (left heart disease, diabetes, chronic renal failure, rheumatic disease, or cirrhosis), and 25% were >79 years of age.

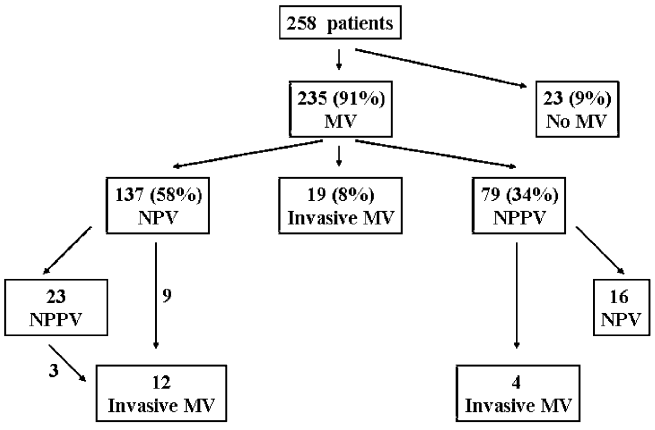

Fig. 1 Profile of the study (*MV* mechanical ventilation; *NPV* negative pressure ventilation; *NPPV* noninvasive positive pressure ventilation, see text for explanation)

As shown in Fig. 1, 23 of the 258 patients (9%) required only medical care and oxygen administration. Among the 235 patients needing mechanical ventilation after a median of 4 h (range: 1–24 h) of medical therapy,

Table 1 Characteristics of patients on admission to RICU

Characteristics	Total	COPD	Non-COPD-related diseases
Number of patients	258	180	78
Age in years	72 (9.8)	74 (7.3)	69 (13.4)*
Origin of patients			
Emergency room	59%	58%	62%
Medical ward	27%	25%	32%
Surgical ward	2%	2%	1%
Other hospital	12%	15%	5%
Body mass index	25 (5.9)	25 (5.8)	24 (6.1)
PaO_2/FiO_2, mm Hg	198 (77)	188 (62)	220 (90)*
$PaCO_2$, mm Hg	83 (19)	86 (18)	78 (21)**
pH	7.29 (0.07)	7.28 (0.07)	7.30 (0.07)*
Glasgow coma scale	14 (13–15)	14 (13–15)	15 (13–15)
APACHE II	19 (15–24)	20 (16–24)	17 (14–24)*

Total All patients included in the study.
COPD Patients with COPD.
Non-COPD-related diseases Patients with non COPD-related chronic respiratory diseases.
RICU Respiratory intensive care unit
APACHE II Acute physiology and chronic health evaluation II.
Mean (SD) or Median (25th-75 th centiles) are shown.
COPD vs non-COPD-related diseases *$p<0.02$, **$p<0.01$.
Arterial blood gas analysis was done during oxygen administration in 91% of patients.

Table 2 Characteristics of patients treated at first with invasive mechanical ventilation, negative pressure ventilation, and non-invasive positive pressure ventilation

Characteristics	InvMV (19 patients)	NPV (137 patients)	NPPV (79 patients)
Age in years	71 (8.2)	75 (7.3)	69 (11.2)**
Body mass index	24 (6.8)	24 (4.8)	27 (7.2)*
PaO_2/FiO_2, mm Hg*	173 (81)	194 (73)	198 (58)
$PaCO_2$, mm Hg*	85 (36)	90 (14)	85 (15)*
pH*	7.27 (0.1)°	7.25 (0.05)	7.29 (0.05)**
Glasgow coma scale	9 (3–15)^	14 (12–15)^^	15 (14–15)**
APACHE II	24 (22–30)^	20 (18–25)^^	16 (14–19)**

Mean (SD) or median (25th–75th centiles) are shown.
InvMV Invasive mechanical ventilation.
* Data obtained immediately before the start of ventilatory support.
NPV vs. NPPV *$p<0.05$, **$p<0.001$.
InvMV vs. NPPV °$p<0.05$, ^$p<0.001$.
InvMV vs. NPV ^^$p<0.01$.

Table 3 Arterial blood gas values in patients treated at first with negative pressure ventilation (NPV) and non-invasive positive pressure ventilation (NPPV), and in two subgroups of patients treated sequentially with NPV and NPPV (NPV-NPPV) or NPPV and NPV (NPPV-NPV)

Blood gas values	NPV	NPPV	Blood gas values	NPV-NPPV	NPPV-NPV
Baseline	(*n*=137)	(*n*=79)	Baseline	(*n*=23)	(*n*=16)
PaO_2/FiO_2	194 (73)	198 (58)	PaO_2/FiO_2	181 (60)	193 (58)
$PaCO_2$, mm Hg	90 (14)	85 (15)	$PaCO_2$, mm Hg	88 (12)	88 (9)
pH	7.25 (0.05)	7.29 (0.05)	pH	7.26 (0.05)	7.29 (0.04)
1 h	(*n*=137)	(*n*=79)	4 h first-line nMV	(*n*=23)	(*n*=16)
PaO_2/FiO_2	216 (62)^	244 (82)^^	PaO_2/FiO_2	208 (48)	244 (78)°
$PaCO_2$, mm Hg	79 (17)^^	80 (17)^	$PaCO_2$, mm Hg	89 (11)	96 (12)°
pH	7.31 (0.07)^^	7.31 (0.06)^^	pH	7.26 (0.04)	7.25 (0.03)°
4 h	(*n*=133)	(*n*=75)	4 h alternative nMV	(*n*=20)	(*n*=16)
PaO_2/FiO_2	223 (47)^^	230 (40)^	PaO_2/FiO_2	226 (46)*	225 (29)
$PaCO_2$, mm Hg	74 (16)^^	76 (16)^^	$PaCO_2$, mm Hg	79 (11)**	79 (6)*
pH	7.33 (0.07)^^	7.32 (0.06)^^	pH	7.31 (0.04)**	7.33 (0.03)*

Mean (SD) are shown.
1 h After 1 h of ventilatory treatment.
4 h After 4 hours of ventilatory treatment.
° $p<0.05$, ^$p<0.01$, ^^$p<0.001$ compared to baseline, *$p<0.05$, **$p<0.01$ compared to 4 h first-line non-invasive mechanical ventilation.

NPV was used as first line treatment in 137/235 patients (58%), NPPV in 79/235 (34%), and invasive mechanical ventilation in 19/235 (8%). Of the 19 patients treated with invasive mechanical ventilation 10 were intubated in the emergency room. The physiologic characteristics of patients at the start of mechanical ventilation are summarised in Table 2. Compared to values on admission, PaO_2/FiO_2 did not change and pH worsened before the start of mechanical ventilation (198±77 vs. 195±61, and 7.28±0.07 vs. 7.26±0.06, $p<0.001$, respectively) in the 216 patients treated with non-invasive mechanical ventilation (NPV or NPPV). Among these patients, 192/216 (89%) met the criteria for hypercapnic respiratory failure, 9/216 (4%) for hypoxemic respiratory failure, and 15/216 (7%) for both. Mean arterial blood gas values improved significantly during the first 4 h in patients treated with both NPV and NPPV (Table 3).

In the 137 patients treated with NPV as first-line treatment the median value of intermittent negative pressure was −30 cm H_2O (range −25 to −35 cm H_2O). The median duration of NPV was 5 days (range 2–9 days). NPV failed in 32/137 patients (23.4%): 9 of them met major criteria for endotracheal intubation and 23 were initially shifted to NPPV (Fig. 1). The causes for shifting to NPPV were intolerance to iron lung in 5 patients and inefficacy of NPV in 18 (failure to maintain $SaO_2>90\%$ in 8 patients and failure to improve respiratory acidosis in 10 patients), ABG improved with NPPV in all but 3 patients which required endotracheal intubation (Table 3). With the shifting to NPPV the failure of non-invasive mechanical ventilation in the 137 patients initially treated with NPV was significantly reduced from 23.4 to 8.8% ($p=0.002$).

In the 79 patients treated with NPPV as first-line treatment, the median values for levels of pressure support and PEEP were 18 cm H_2O (range 14–22), and 5 cm H_2O (4–5 cm H_2O), respectively. The median duration of NPPV was 5 days (2–8 days). NPPV failed in 20/79 patients (25.3%): 4 of them met major criteria for endotracheal intubation and 16 were shifted to NPV

Table 4 Length of RICU stay and mortality rate in different subgroups of patients

Characteristics	InvMv	NPV	NPPV	Total
Number of patients	19	137	79	258
Length of RICU stay in days	14 (10–20)	10 (7–15)*	10 (7–13)**	10 (6–14)
RICU mortality (%)	26	17	10	14
Hospital mortality (%)	32	22	16	21
Predicted mortality (%)	45	32	20	28

RICU Respiratory intensive care unit.
InvMV Patients treated with invasive mechanical ventilation as first line treatment.
NPV Patients treated with negative pressure ventilation as first line treatment.
NPPV Patients treated with non-invasive positive pressure ventilation as first line treatment.
InvMV vs NPV and InvMV vs NPPV *$p<0.05$, **$p<0.01$.

(Fig. 1). The causes for shifting to NPV were intolerance of mask ventilation in 2 patients and inefficacy of NPPV in 14 (failure to maintain SaO_2>90% in 1 patient, and failure to improve respiratory acidosis in 13 patients). ABG improved with NPV in all patients (Table 3). With the shifting to NPV the failure of non-invasive mechanical ventilation in the 79 patients initially treated with NPPV was significantly reduced from 25.3 to 5% (p=0.0001).

As a whole, endotracheal intubation was required in 16 (7.4%) of the 216 patients who initially received non-invasive mechanical ventilation. The rate of endotracheal intubation tended to be higher in the 9 patients with hypoxemic respiratory failure than in the others (22% vs. 6.8%, p=0.279). Within 24 h of admission, 11 patients were intubated in the respiratory intensive care unit: 5 due to severe haemodynamic instability, 4 due to severe psychomotor agitation, 1 due to cardio-respiratory arrest, and 1 due to intolerance of both NPV and NPPV. The other 5 patients were intubated later (range 2–4 days): 3 due to severe hemodynamic instability, 1 due to cardio-respiratory arrest, and 1 due to severe psychomotor agitation.

In summary, among the 258 patients included in the study, 77% were treated exclusively with non-invasive mechanical ventilation (40% with NPV, 23% with NPPV, and 14% with the sequential use of both modalities of non-invasive mechanical ventilation) whereas 14% needed endotracheal intubation and invasive mechanical ventilation.

Side-effects and complications in patients treated with mechanical ventilation are shown in Table S1 (ESM). Upper airway obstruction and large air leaks were the reasons for failure of NPV and NPPV in 16 and 19% of cases, respectively. Major complications were infrequent and not significantly different in patients treated with NPV and NPPV (Table S1). Mortality rate in respiratory intensive care unit and hospital tended to be lower than that predicted according to the APACHE II score in patients as a whole, and in the subgroups of patients treated at first with NPV, NPPV, and invasive mechanical ventilation (Table 4).

Discussion

The major finding in the present study is that using both NPV and NPPV it was possible in "real life" to avoid endotracheal intubation in the large majority of patients with ACRF needing ventilatory support. Invasive mechanical ventilation was necessary only in 14% of patients admitted for ACRF to the respiratory intensive care unit of an acute care hospital, and in 7.4% of those treated with non-invasive mechanical ventilation as first-line treatment.

Before discussing these results it is pertinent to consider the limitations of our study. First, although we used objective criteria for the use of non-invasive and invasive mechanical ventilation, the results obtained using non-invasive mechanical ventilation are based on the assumption that patients treated with non-invasive mechanical ventilation had a real need for ventilatory support. Observational studies such as this one are not intended to replace randomised controlled trials since the former are more susceptible to bias [21]. Nevertheless, the former can be a powerful tool for understanding the "real life" effectiveness of certain interventions particularly for groups of patients who are generally excluded from controlled trials such as the aged and those with comorbidities [22]. This is the case of the present study in which 25% of patients were >79 years of age, and 55% presented at least 1 comorbid condition. Second, the present study was conducted in a specialised respiratory intensive care unit [23] staffed by chest physicians and nurses with great expertise in both non-invasive and invasive mechanical ventilation. As a consequence, our findings should not be generalised to settings with a lower level of care. Finally, the percentage of patients requiring mechanical ventilation in the present study was greater compared to that reported in two recent surveys [23, 24] on patients admitted to respiratory units (91% vs 71% and 81%, respectively). Although comparison with previous studies is difficult, it is important to observe the following points:

1. The critical care services of our hospital include a monitoring unit admitting patients who need monitor-

ing of cardiac and respiratory function but not mechanical ventilation; this could have contribute to reduce the admission to the respiratory intensive care unit of patients who did not require ventilatory support.
2. In spite of the optimisation of medical therapy, respiratory acidosis worsened without any significant change in oxygenation status before the start of non-invasive mechanical ventilation.

The present data should be placed in the context of previous studies. Evidence now exists to support the efficacy of NPPV [1, 2, 3, 4, 5] and to suggest the efficacy of NPV [12, 13, 19] in COPD patients with acute respiratory failure. However, positive results of non-invasive mechanical ventilation obtained in non-blinded randomised or case-control trials, in which patients were carefully selected, may differ from results obtained when routine implementation of the technique is performed. Only few studies have investigated the practical use of NPPV or NPV on a large scale, and no data are available on the use of both modalities of non-invasive mechanical ventilation. Observational studies performed in single, general intensive care unit reported that in patients with acute respiratory failure (with and without chronic respiratory diseases) NPPV was effective in avoiding endotracheal intubation in 61–65% of the cases [25, 26, 27, 28]. The incidence of use and effectiveness of NPPV have been recently studied in two multicenter surveys [17, 18]. Carlucci and coworkers reported that in 42 French ICUs NPPV represented the first-line intervention in 50% of patients requiring ventilatory support for hypercapnic acute respiratory failure [17]. In that survey NPPV was followed by endotracheal intubation in 40% of cases, a percentage similar to that of previous studies [25, 26, 27, 28]. In a prospective cohort study in 361 ICUs, NPPV was used in 17% of patients with exacerbation of COPD [18] and failed in 25.9% of cases [18]. Moretti and coworkers reported that failure of NPPV occurred in 22.6% of 137 COPD patients who required ventilatory support >24 h in 2 respirator intensive care units [29]. In the present study, with the routine implementation of both NPV and NPPV, we found that non-invasive mechanical ventilation could be applied as first-line treatment in 92% of unselected patients with ACRF needing mechanical ventilation, and that endotracheal intubation was necessary only in 7.4% of patients treated with non-invasive mechanical ventilation. Comparisons with previous series can be subjected to a number of biases, as inclusion criteria, arterial blood gas values at the start of mechanical ventilation, and ventilation modality are often different. The larger field of application of non-invasive mechanical ventilation, and the lower need for endotracheal intubation we found compared to previous studies [17, 18, 25, 26, 27, 28, 29] could, however, be explained, at least in part, by the use of both NPPV and NPV. First, the availability of both techniques allowed to select the first-line non-invasive mechanical ventilation on the basis of the characteristics of patients; second, due to the fact that the causes of failure of NPV and NPPV are usually different (i.e. upper airway obstruction and large air leaks, respectively), the sequential use of the alternative non-invasive mechanical ventilation technique allowed a further reduction of need for endotracheal intubation. This last finding, however, was obtained in a relatively small number of patients and it needs to be confirmed by further studies.

It is also important to stress that this large application of non-invasive mechanical ventilation was associated with a hospital mortality rate (21%) lower than both that predicted according to the APACHE II score (28%), and that reported in two series of patients with COPD admitted in ICU and mainly treated with invasive mechanical ventilation (28, and 32%, respectively) [17, 30]. As previously suggested [31], the low mortality rate associated with the use of non-invasive mechanical ventilation can be explained, at least in part, by the reduction in nosocomial infections and other major complications associated with invasive mechanical ventilation. In line with previous studies [1, 31, 32, 33] we found that major complications occurred infrequently with the routine application of both non-invasive mechanical ventilation techniques in a large unselected series of patients with acute respiratory failure on chronic respiratory disorders.

In conclusion we have shown that using both NPV and NPPV in a respiratory intensive care unit it was possible to avoid endotracheal intubation in the large majority of patients with ACRF needing ventilatory support. It also appears that this large use of non-invasive mechanical ventilation is associated with a low incidence of severe complications and a low in-hospital mortality rate. Randomised controlled studies are needed to confirm these findings.

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