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G. Conti
M. Antonelli
P. Navalesi
M. Rocco
M. Bufi
G. Spadetta
G. U. Meduri

Noninvasive vs. conventional mechanical ventilation in patients with chronic obstructive pulmonary disease after failure of medical treatment in the ward: a randomized trial

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G. Conti (✉) · M. Antonelli
Università Cattolica del S. Cuore,
Policlinico A. Gemelli,
Largo F. Vito, 00168 Rome, Italy
e-mail: g.conti@rm.unicatt.it
Tel.: +39-06-30154386
Fax: +39-06-3013450

P. Navalesi
Pneumologia Riabilitativa,
Fondazione S. Maugeri, Pavia, Italy

M. Rocco · M. Bufi · G. Spadetta
Università degli studi
di Roma La Sapienza,
Policlinico Umberto I, Rome, Italy

G.U. Meduri
University of Tennessee Health Science
Center, Department of Medicine,
Pulmonary and Critical Care Division,
Lung Research Program,
Memphis, Tenn., USA

Abstract *Objective:* We conducted a randomized prospective study comparing noninvasive positive pressure ventilation (NPPV) with conventional mechanical ventilation via endotracheal intubation (ETI) in a group of patients with chronic obstructive pulmonary disease who failed standard medical treatment in the emergency ward after initial improvement and met predetermined criteria for ventilatory support. *Design and setting:* Prospective randomized study in a university hospital 13-bed general ICU. *Patients:* Forty-nine patients were randomly assigned to receive NPPV (n=23) or conventional ventilation (n=26). *Results:* both NPPV and conventional ventilation significantly improved gas exchanges. The two groups had similar length of ICU stay, number of days on mechanical ventilation, overall complications, ICU mortality, and hospital mortality. In the NPPV group 11 (48%) patients avoided intubation, survived, and had a shorter duration of ICU stay than intubated patients. One year following hospital discharge the NPPV group had fewer patients readmitted to the hospital (65% vs. 100%) or requiring de novo permanent oxygen supplementation (0% vs. 36%). *Conclusions:* The use of NPPV in patients with chronic obstructive pulmonary disease and acute respiratory failure requiring ventilatory support after failure of medical treatment avoided ETI in 48% of the patients, had the same ICU mortality as conventional treatment and, at 1-year follow-up was associated with fewer patients readmitted to the hospital or requiring for long-term oxygen supplementation. An editorial regarding this article can be found in the same issue (http://dx.doi.org/10.1007/s00134-002-1503-3).

Keywords Acute respiratory failure · Chronic obstructive pulmonary disease · Noninvasive ventilation · Ventilator-associated pneumonia

Introduction

Randomized studies have provided supporting evidence for the early use of noninvasive positive pressure (NPPV) in mild to moderate hypercapnic acute respiratory failure (ARF) due to exacerbation of chronic obstructive pulmonary disease (COPD) [1, 2, 3, 4]. In these studies the use of NPPV in the intensive care unit (ICU) was associated with a reduction in the rate of endotracheal intubation (ETI), duration of mechanical ventilation, and ICU mortality. A recent study conducted in the United Kingdom has also shown that for similar COPD patients NPPV can be successfully used in the general ward [5].

Control studies are lacking on later use of NPPV as an alternative to conventional ventilation with ETI in COPD patients requiring ventilatory support after failure of medical treatment in the ward; this situation is very

common in many European countries where, for ICU bed shortage, COPD patients who initially respond to medical treatment are treated in the emergency or pneumology ward and admitted to the ICU only in presence of subsequent clinical deterioration when requiring mechanical ventilation. Only two previous uncontrolled reports have evaluated NPPV in patients with COPD and severe respiratory acidosis requiring mechanical ventilation after failure of medical treatment, reporting an intubation rate of approximately 30% [6, 7].

For this reason we compared the short- and long-term response to NPPV delivered via face mask vs. conventional ventilation delivered via ETI in COPD patients with ARF failing to sustain the initial improvement with conventional medical therapy in the emergency ward and meeting predetermined criteria for mechanical ventilation.

Materials and methods

Over the period of 28 months between October 1996 and January 1999 all nonintubated COPD patients with ARF caused by acute exacerbation admitted to La Sapienza University Hospital emergency ward, were screened for the study. For screening purposes ARF was defined as the presence of all the following criteria: (a) respiratory acidosis with pH values lower than 7.32, (b) bicarbonate levels higher than 30 mEq/l, (c) hypoxemia with PaO_2 values lower than 45 while breathing room air, (d) respiratory rate higher than 30 breaths/min, and (e) history of worsening dyspnea of less than 2 weeks duration. Exclusion criteria included: (a) the presence of a tracheostomy or endotracheal intubation performed before ICU admission; (b) facial deformities, upper airway obstruction, recent surgery, or trauma; (c) central nervous system alterations unrelated to hypercapnic encephalopathy; (d) the presence of cardiogenic pulmonary edema, pneumothorax, pulmonary tromboembolism, hemoptysis, neoplasms, septic shock; (e) the need for urgent intubation due to respiratory arrest, respiratory pauses, psychomotor agitation requiring sedation, heart rate below 60 beats/min, hemodynamic instability with systolic arterial pressure below 80 mmHg.

Before enrollment all patients received in the emergency ward a standard medical therapy consisting of low-dose oxygen via Venturi mask to achieve an O_2 saturation above 90% and medications including aerosolized salbutamol, anticholinergic, intravenous aminophylline and/or steroids, subcutaneous low-weight heparin, correction of electrolytes, and intravascular volume abnormalities. Heart rate, systemic arterial blood pressure, respiratory rate, and pulse oxymetry were continuously monitored. Blood gas was analyzed every 4 h, or more frequently if changes occurred in peripheral oxygen saturation or clinical status. In our institution all patients showing an initial improvement in gas exchange are treated in the emergency ward for 24 h or are transferred in a medical ward. The intensive care consultant is called only if gas exchanges and clinical condition worsen, suggesting the need of a ventilatory support.

Patients were defined as requiring ventilatory support in the ICU if they deteriorated despite medical treatment and met at least one of the following criteria: pH less than 7.20, arterial oxygen saturation higher than (SaO_2) 90% with a fraction of inspired oxygen (FIO_2) of 0.35 or higher, respiratory rate lower than 35 breaths/min, or severe deterioration in mental status with Kelly score equal to or higher than 4 [8]. Eligible patients meeting one or more of the above criteria were transferred to the ICU and randomly assigned to receive conventional ventilation with ETI (preferably via the oral route) or NPPV via full-face mask. Random assignment was made with sealed envelopes. The protocol was approved by the institutional ethics committee, and all patients or their next of kin gave written informed consent.

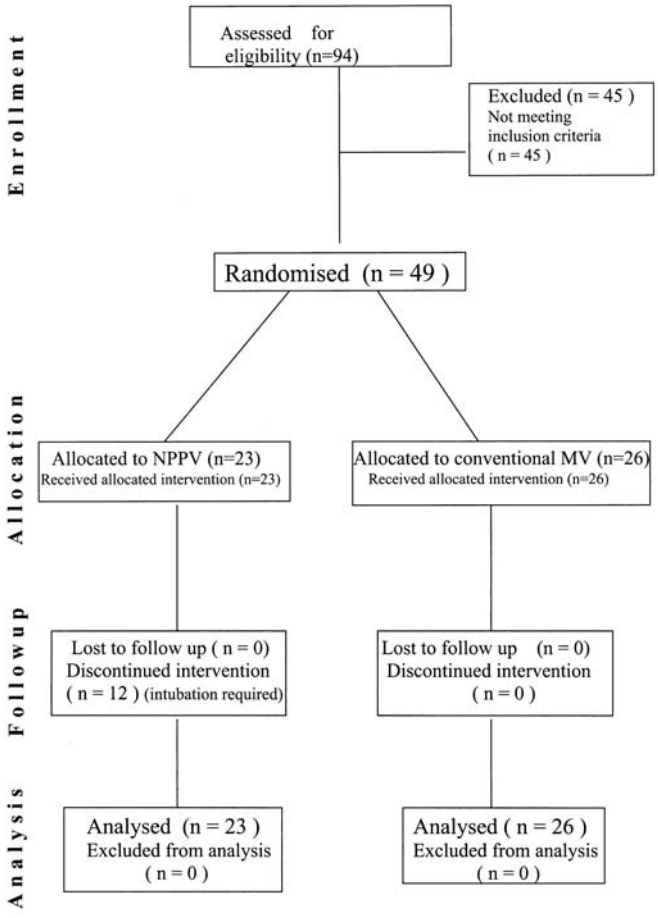

Fig. 1 Flow of the patients through each stage of the study

A total of 94 patients fulfilled our screening criteria; 23 were already intubated or tracheotomized or on home ventilation, and 22 improved with standard medical therapy. The condition of 49 patients initially improved with medical therapy, and they stayed in the ward, but their improvement was not maintained over time and after 14±11 h they met predetermined criteria for ventilatory support and were admitted to the ICU to receive mechanical ventilation (Fig. 1). After ICU admission 23 patients were randomized to NPPV and 26 to conventional ventilation. At study entry the two groups had similar baseline characteristics, physiological variables (Table 1), and criteria for inclusion in the study. In the year prior to study entry the two groups had had similar numbers of hospital and ICU admissions. Seven patients in the NPPV group and nine in the conventional ventilation group were on permanent oxygen supplementation.

Noninvasive ventilation group

Patients randomized to NPPV received continuous positive airways pressure with pressure support ventilation applied through a clear full-face mask (Gibeck, Upplands-Vasby, Sweden) connected to a conventional circuit to either a Servo 900c or a Puritan-Bennett 7200 ventilator. The mask was secured with head straps

Table 1 Baseline characteristics and number of hospital and intensive care unit admission in the year prior to admission

	Noninvasive ventilation group (*n*=23)	Conventional ventilation group (*n*=26)	*p*
Age (years)	72.5±7.7	71.1±8	0.25
Simplified Acute Physiology Score II	38.8±5.8	37.7±5.7	0.61
Kelly score	3±5	2.5±0.6	0.63
White blood cells (10^3/mm^3)	11.48±6.14	11.24±3.81	0.48
Albumin (g/dl)	28±4	27.9±3.9	0.21
Inorganic phosphate (mg/dl)	3.2±0.8	2.8±0.7	0.19
Body temperature (°C)	36.4±0.4	36.9±1	0.43
Body mass index	27±5	24±4	0.06
Respiratory rate (breaths/min)	33±2.6	33.7±2.4	0.55
Heart rate (beats/min)	104±18	99±21	0.96
Systolic arterial pressure (mmHg)	121±17	110±15	0.86
pH	7.2±0.05	7.2±0.05	0.91
PaO_2:FiO_2 ratio	168±38	171±38	0.49
$PaCO_2$ (mmHg)	85±16	87±14	0.38
Forced expiratory volume in 1 s (% predicted)	28±5	33±10	0.17
Forced vital capacity (% predicted)	43±13	45±14	0.79
Hospital admissions in the previous year (median/range)	32±1/0–2	37±1/0–2	0.97
ICU admissions in the previous year (median/range)	5±0/0–1	5±0/0–1	0.83
Functional limitations due to COPD[a]	4.6±1	5.3±0.8	0.056

[a] By visual analogic scale (1–10)

(avoiding a tight fit) and the head of the bed was kept elevated at a 45° angle. In most patients a hydrocolloid sheet was applied over the nasal bridge. For patients with a nasogastric tube a seal connector in the dome of the mask was used to minimize air leakage.

Patients initially received a level of pressure support (16± 2 cmH_2O) adjusted to obtain a tidal volume of 8–10 ml/kg and a respiratory rate of 25 breaths/min. All patients received continuous positive airways pressure of 5 cmH_2O to offset the inspiratory threshold induced by intrinsic positive end-expiratory pressure [9]. Ventilator settings were adjusted on the basis of continuous oximetry and measurements of arterial blood gases. The patients were not sedated. The trigger was set at –1 cmH_2O in all patients. During the first 12 h NPPV was administered continuously. Subsequently NPPV was interrupted by short periods of oxygen supplementations alone (FIO_2 28% by Venturi mask) to allow drinking and expectorating. Pressure support was reduced progressively, in accordance with the degree of clinical improvement, by 3 cmH_2O steps (twice a day) and was discontinued if the patient maintained a respiratory rate lower than 30 breaths/min with a pH higher than 7.35 and a SaO_2 higher than 90% with a FIO_2 of 0.28 in presence of a normal mental and hemodynamic status.

Failure of noninvasive ventilation and endotracheal intubation

Patients who failed NPPV underwent endotracheal intubation with cuffed endotracheal tubes (internal diameter 7.5–8.5 mm) and were mechanically ventilated. Predetermined criteria for endotracheal intubation included (a) the persistence of at least one of the previously described criteria for ventilatory support, despite receiving NPPV, (b) need to protect the airways (coma or seizure disorders) or to manage copious tracheal secretions, (c) any hemodynamic or electrocardiographic instability, (d) inability to improve dyspnea, or (e) intolerance of mask ventilation.

Conventional ventilation group

Patients randomized to the conventional ventilation were intubated with cuffed endotracheal tubes (internal diameter 7.5–8.5 mm). The initial ventilator setting was assist-control with a delivered tidal volume of 8–10 ml/kg and a respiratory rate of 10–14 breaths/min, and FIO_2 of 0.35. Positive end-expiratory pressure was set at 5 cm of water and trigger at –1 cm of water for all patients. Intravenous propofol (Diprivan) at 2 mg/kg was given for sedation at the time of intubation; none of the patients received a paralyzing drug. The head of the bed was kept elevated at 45° to minimize the risk of aspiration. When spontaneous breathing reappeared, the ventilator settings were changed to pressure support ventilation (14–20 cmH_2O) titrated to achieve a spontaneous tidal volume of 8–10 ml/kg, a respiratory rate less than 25 breaths/min, and disappearance of accessory muscle activity. After 24 h pressure support ventilation was progressively reduced by 3 cmH_2O steps (twice daily). Patients who tolerated a pressure support level of 8 cmH_2O underwent a 2-h t-piece trial at FIO_2 0.28. These patients then underwent extubation if they maintained a respiratory rate lower than 30 breaths/min, SaO_2 higher than 90%, pH higher than 7.35, normal mental status, and hemodynamic stability. If after 12 days the patients were still intubated and receiving mechanical ventilation, tracheostomy was performed, and the weaning process was restarted following the above protocol. If after 60 days the patient was still ventilator dependent, the physicians in charge had the option of discharging the patient on home-care ventilation. Patients were monitored for the development of infections and other complications. Sepsis, severe sepsis, and septic shock were defined according to consensus guidelines [10]. Infections were diagnosed using previously described strict criteria [11].

Twelve-month follow-up

At ICU discharge, by protocol 48 h after extubation or NPPV suspension, all patients were transferred to an internal medicine department for the definitive medical treatment and to be included in a program of rehabilitation and follow-up. After 1 year an investigator conducted at home interviews with all survivors to determine the number of exacerbations requiring ICU or hospital readmissions and the number of patients requiring permanent oxygen supplementation or open tracheostomy. All survivors were asked

to assess their functional limitations due to COPD on a visual analogical scale (0=no functional limitation, 10=maximal functional limitation). Patients were also asked to compare their 1-year visual analogue score with the baseline value prior to study entry.

Statistical analysis

Results are reported as mean ±SD. Demographic and physiological characteristics for the two groups were compared using the *t* test for continuous data (separate estimates of variance were used when variance differed significantly) and with the Mantel-Haenszel extended χ^2 test for categorical data. Fisher's exact test (two-tailed) was used when the expected number of cases per cell was below five. The odds ratios, relative risks, and 95% confidence interval (CI) are given with the χ^2 values and *p* values to illustrate the amount of risk associated with some of the effects

Results

After 1 h of mechanical ventilation the conventional ventilation group showed a more significant ($p<0.01$) improvement in partial pressure of arterial carbon dioxide ($PaCO_2$) and pH (Fig. 2). PaO_2:FiO_2 was similar between the two groups at baseline and after 1 h of mechanical ventilation. At discontinuation of mechanical ventilation PaO_2:FiO_2 was lower in the 23 patients randomized to NPPV (190±40 vs. 216±43, $p=0.02$). After 1 h of mechanical ventilation 8 of the 23 patients randomized to NPPV and 17 of the 26 patients randomized to conventional ventilation improved their pH to a value equal to or above 7.35 and/or showed an increase in pH greater than 0.1 ($p=0.06$).

Intubation was required in 12 (52%) patients randomized to NPPV. Nine patients were intubated within 2–6 h of study entry: two due to mask intolerance (both after 2 h of NPPV), five due to deterioration of mental status related to CO_2 retention (after 2 h in three patients, and after 3 h in the remaining two), and two due to difficult management of copious secretions (one patient after 2 h and one after 6 h of NPPV). After 2 days of NPPV two patients were intubated: one due to mask intolerance and one due to hemodynamic instability. Mean NPPV duration was 7±9 h in patients who failed and 28±11 in patients who were successfully treated ($p=0.001$). The subgroup of patients who failed NPPV showed at the moment of intubation high values of $PaCO_2$ and Kelly score (median and range: 80/50–108 and 5/3–5, respectively).

None of the patients required emergent intubation. The 12 patients who required ETI had a higher SAPS II score than those who avoided intubation ($p=0.04$), and a worse mental status by the Kelly score ($p=0.0001$; Table 2). At intubation their median $PaCO_2$ was 80 mmHg (range 50–108), median respiratory rate 36 breaths/min (range 31–38), and median Kelly score 4.5 (range 3–5).

The two groups (NPPV vs. conventional ventilation) had similar duration of mechanical ventilation (16±19 vs. 15±21 days, $p=0.30$) and ICU stay (22±19 days vs. 21±20 days, $p=0.21$). In the NPPV group those who avoided intubation had a shorter duration of mechanical ventilation and ICU stay (Table 2). Nine patients required a tracheostomy: three in the NPPV group and six in the conventional ventilation group ($p=0.29$). The 11 patients who avoided intubation were discharged from the ICU after a mean stay of 6.8±2.4 days, and one died in the hospital after ICU discharge, while five of the 12 patients who required intubation died in the ICU. Four patients randomized to conventional ventilation died, three in the ICU and one in the hospital ward. One patient randomized to conventional ventilation was not weaned and discharged on home ventilation after 93 days in the ICU.

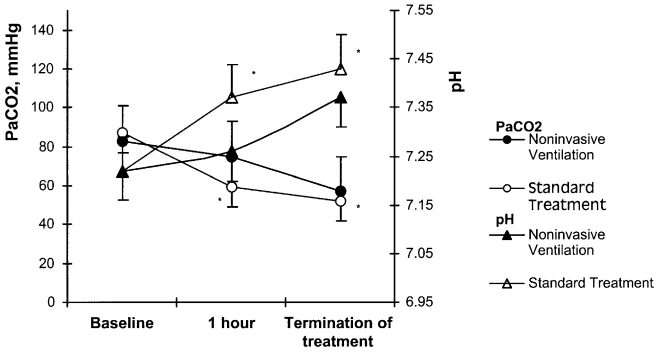

Fig. 2 Changes in the $PaCO_2$ and pH over time (mean ±SD); *$p<0.01$ vs. basal. A paired *t* test was used for the statistical comparison. Termination of treatment refers to the last arterial blood gas value obtained prior to discontinuation of treatment (intubation for those patients who failed NPPV) or discontinuation of the support for successful NPPV patients and patients in the conventional group

Complications and events leading to death are shown in Table 3. The two groups (NPPV vs. conventional ventilation) had similar number of serious complications after study entry [6 vs. 11; odds ratio (OR) 2.07, 95% CI 0.53–8.3, $p=0.37$], and complications leading to death (5 vs. 4;OR 0.65, 95% CI 1.21–3.4, $p=0.41$, after Fisher's correction). Patients randomized to NPPV, however, had a trend toward a lower rate of ventilator-associated pneumonia (3 vs. 9; $p=0.07$) and severe sepsis or septic shock (6 vs. 13; $p=0.07$). All complications observed in the NPPV group developed after intubation (six patients developed severe sepsis or septic shock, with acute renal failure in one case, and one developed a pneumothorax 2 days after endotracheal intubation).

One year following hospital discharge (Table 4) the NPPV group had a trend toward increased survival (74% vs. 54%;OR 1.95, 95% CI 0.49–7.93, $p=0.43$), and fewer patients readmitted to the hospital for acute exacerbation (65% vs. 100%; $p=0.016$) or requiring de novo permanent oxygen supplementation (0% vs. 36%; $p<0.01$). The total number of hospital and ICU readmission, however, was similar OR 0.65, 95% CI 0.12–3.42, $p=0.41$, after

Table 2 Characteristics of patients according to intubation requirement in the noninvasive ventilation group and survival in the conventional ventilation group

	Noninvasive ventilation group (*n*=23)			Conventional ventilation group (*n*=26)		
	Intubation not required (*n*=11)	Intubation required (*n*=12)	*p*	Survivors (*n*=22)	Nonsurvivors (*n*=4)	*p*
Age (years)	74.4±4	72.5±8	0.47	70±8	74±3	0.12
Simplified Acute Physiology Score II	35±2.3	39±6	0.04	37±4	43±9	0.2
Kelly score	1.7±0.4	3±0.5	0.0001	2.6±0.5	2.25±0.9	0.5
Number of invasive devices	3±0.5	4.6±0.7	0.0001	4.5±0.5	4.75±0.5	0.4
Patients improved at 1 h	4 (36%)	4 (33%)	0.61	13 (59%)	4 (100%)	0.16
Duration of mechanical ventilation (days)	3±1.4	16±19	0.03	15±22	19±17	0.68
Length of ICU stay (days)	7±2.4	22±19	0.02	21±21	21±14	0.9
ICU survivors	11 (100%)	7 (58%)	0.02	22 (84%)	0 (0%)	–
Hospital survivors	10 (91%)	7 (58%)	0.02	21 (81%)	n.a.	–
Septic complications[a]	0 (0%)	6 (50%)	0.009	9 (41%)	4 (100%)	0.047

[a] Patients in the NPPV group who required endotracheal intubation developed septic shock (one endocarditis, three pneumonia, one sepsis related catheter), and severe sepsis (one acalcholous cholecistitis). In the conventional ventilation group, five survivors developed severe sepsis (all pneumonia) and four sepsis (three pneumonia and one urinary tract infection), while all nonsurvivors developed septic shock (four pneumonia)

Table 3 Complications and lethal events

	Noninvasive ventilation group (*n*=23)		Conventional ventilation group (*n*=26)		*p*
	n	%	*n*	%	
Patients with complications	6	26	11	42	0.37
Patients with complications causing death	5	22	4	15	0.41
Deaths after discharge from the ICU	1	4.3	1	3.8	0.72
Ventilator-associated pneumonia	3	13	9	34	0.07
Septic shock	5	22	4	15	0.41
Sepsis or severe sepsis	1	4	9	34	0.009
Acute renal failure	1	4	0	0	0.46
Pneumothorax	1	4	0	0	0.46
Urinary tract infection	0	0	2	8	0.27
Gastrointestinal bleeding	0	0	1	4	0.58
Other	1	4	2	8	0.54
Tracheostomy	3	13	6	23	0.29
Home ventilation	0	0	1	4	0.53

Table 4 Follow-up 12 months after hospital discharge

	Noninvasive ventilation group (*n*=23)		Conventional ventilation group (*n*=26)		*p*
	n	%	*n*	%	
Number of survivors	17	74	14	54	0.24
Number of survivors readmitted to the hospital during the follow-up	11	65	14	100	0.016
Number of hospital readmissions	18	–	22	–	0.8
Number of hospital readmissions per survivor	1.05	–	1.6	–	
Number of ICU readmission	3	–	2	–	
Number of patients requiring permanent O_2 supplementation at home	0	0	5	36	0.01
Number of patients with open tracheostomy	2	12	6	42	0.16

Fisher's correction). At the 1 year follow-up, the 17 survivors in the NPPV group described a functional limitation due to COPD (on the visual analogue scale) similar to the baseline value prior to study enrollment, whereas the 14 survivors in the conventional ventilation group showed a significant increase in functional limitations due to COPD (visual analogue scale from 4.3±1.4 to 5.3±0.8, p=0.02).

Discussion

The present study compared NPPV and conventional mechanical ventilation with ETI in COPD patients with severe hypercapnic ARF who failed to sustain the initial response over time with medical therapy in the emergency or medical ward and required mechanical ventilation according to predetermined criteria. This study was conducted before the publication of the Consensus guidelines [12] that suggested an early application of NPPV to COPD patients with acute exacerbation and is the first study to describe a common situation of everyday clinical practice in many European hospitals: the use of NPPV or mechanical ventilation with ETI to COPD patients who initially improve after medical treatment and only subsequently deteriorate their clinical condition and gas exchanges requiring ICU admission for ventilatory support.

In this study, both NPPV and mechanical ventilation with ETI significantly improved gas exchanges, but the correction of gas exchange abnormalities with NPPV was slower. Failure to increase CO_2 clearance with NPPV, however, was the reason for the intubation in only five of the 12 patients who met predetermined criteria for intubation. The two groups (NPPV and conventional ventilation) had similar duration of mechanical ventilation, number of tracheostomies, length of ICU stay, ICU mortality, and hospital mortality. Patients randomized to NPPV, however, had a trend toward a lower rate of ventilator-associated pneumonia and severe sepsis or septic shock. One year following hospital discharge the NPPV group had a trend toward increased survival, and fewer patients readmitted to the hospital or requiring de novo permanent oxygen supplementation.

In the present study we did not observe the extent of benefit previously reported in randomized studies evaluating the early use of NPPV in patients with COPD and mild to moderate ARF. In comparison to those studies, the rate of intubation (52%) was at least twice as large (range 7–26%) [2, 3, 4], and we did not observe a reduction in either hospital stay [3, 4], or mortality [3]. A likely explanation for the different results is that the later use of NPPV in patients with severe respiratory failure may be less effective in avoiding endotracheal intubation. However, a similar clinical approach is diffuse in many hospitals where NPPV programs are not implemented in the emergency ward, and the patients with acute exacerbation of COPD who initially respond to medical treatment are treated in the emergency or medical ward, while only the nonresponders are transferred to the ICU for receiving mechanical ventilation [5]. It is also important to note that some of the endpoints of the study only showing a trend could have been significant with a larger sample size (type II error).

In comparison to the prior randomized studies [2, 3, 4] evaluating an earlier use of NPPV, our patients had worsen abnormalities in gas exchange. Patients recruited in the studies by Brochard et al. [3] and Celikel et al. [4] had a higher mean pH (7.27±.1 and 7.27±.07, respectively) and a lower mean $PaCO_2$ (70±12 and 69±15, respectively).

Despite the later use of NPPV we confirmed [13, 14, 15] that patients randomized to NPPV had a lower rate of infections, and that avoidance of intubation is associated with improved outcome. Since the two groups were similar at study entry, the reduction in the incidence of sepsis is most likely related to the ability of NPPV to reduce the rate of ventilator-associated pneumonia, the leading cause of sepsis in this study. This is in agreement with recent epidemiological observational studies [13, 14, 16] and prior randomized studies [3, 15].

To our knowledge, this is the first randomized study in COPD patients reporting long-term benefits. One year following hospital discharge, with similar treatment and rehabilitation programs, the NPPV group had fewer patients readmitted to the hospital for acute exacerbations or requiring de novo permanent oxygen supplementation. Moreover, the NPPV group had a trend toward increased survival (74% vs. 54%). Two prior studies have reported an increased 12 month survival in COPD patients treated with NPPV vs. historically controls treated with conventional ventilation [17, 18]. The reasons for improved long-term outcome are not clear, but it is possible that a reduction in septic complications may play an important role. Recent studies have reported a reduction in 1-year survival for septic patients surviving the ICU admission [19, 20].

According to the results of the present study, a correct selection of patients who may have the most beneficial effects with NPPV is crucial: our data suggest that patients who were more likely to fail NPPV have a higher Simplified Acute Physiology Score II and a worse mental deterioration as defined by Kelly score and a poor prognosis, as previously reported. These data underline the role played by mental status in response to NPPV; greater caution should probably be exercised in using NPPV with less alert patients who have weaker cough reflexes and are less cooperative.

In conclusion, our findings suggest early use of NPPV during the course of acute exacerbation of COPD patients. However, also if NPPV is started later, after the failure of medical treatment, it is comparable to invasive

mechanical ventilation in terms of survival; considering that in patients successfully treated with NPPV several short- and long-term advantages can be expected, and NPPV failure does not result in a worse outcome, an initial trial of NPPV in ICU should be considered also in COPD patients with advanced decompensation.

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