CLINICAL SCIENCE

Noninvasive positive-pressure ventilation in clinical practice at a large university-affiliated Brazilian hospital

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OBJECTIVES: To describe noninvasive positive-pressure ventilation use in intensive care unit clinical practice, factors associated with NPPV failure and the associated prognosis.

METHODS: A prospective cohort study.

RESULTS: Medical disorders (59%) and elective surgery (21%) were the main causes for admission to the intensive care unit. The main indications for the initiation of noninvasive positive-pressure ventilation were the following: post-extubation, acute respiratory failure and use as an adjunctive technique to chest physiotherapy. The noninvasive positive-pressure ventilation failure group was older and had a higher Simplified Acute Physiology Score II score. The noninvasive positive-pressure ventilation failure rate was 35%. The main reasons for intubation were acute respiratory failure (55%) and a decreased level of consciousness (20%). The noninvasive positive-pressure ventilation failure group presented a shorter period of noninvasive positive-pressure ventilation use than the successful group [three (2-5) versus four (3-7) days]; they had lower levels of pH, HCO_3 and base excess, and the FiO_2 level was higher. These patients also presented lower PaO2:FiO2 ratios; on the last day of support, the inspiratory positive airway pressure and expiratory positive airway pressure were higher. The failure group also had a longer average duration of stay in the intensive care unit [17 (10-26) days vs. 8 (5-14) days], as well as a higher mortality rate (9 vs. 51%). There was an association between failure and mortality, which had an odds ratio (95% CI) of 10.6 (5.93 – 19.07). The multiple logistic regression analysis using noninvasive positive pressure ventilation failure as a dependent variable found that treatment tended to fail in patients with a Simplified Acute Physiology Score II$\geq$34, an inspiratory positive airway pressure level$\geq$15 cmH2O and pH$<$7.40.

CONCLUSION: The indications for noninvasive positive-pressure ventilation were quite varied. The failure group had a longer intensive care unit stay and higher mortality. Simplified Acute Physiology Score II$\geq$34, pH$<$7.40 and higher inspiratory positive airway pressure levels were associated with failure.

KEYWORDS: Artificial ventilation; Noninvasive Ventilation; Intensive Care Unit; Cohort Study.

Yamauchi LY, Travaglia TC, Bernardes SR, Figueiroa MC, Tanaka C, Fu C. Noninvasive positive-pressure ventilation in clinical practice at a large university-affiliated Brazilian hospital. Clinics. 2012;67(7):767-772.

Received for publication on March 8, 2012; **First review completed on** March 21, 2012; **Accepted for publication on** March 22, 2012

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INTRODUCTION

Mechanical ventilation without the use of an invasive artificial airway is defined as noninvasive ventilation (NIV). Noninvasive positive-pressure ventilation (NPPV) using a mask (or interface) that conducts gas from a positive-pressure ventilator into the airways has become the predominant means of administering NIV. NPPV has long been used to treat chronic respiratory failure, but in more recent years it has increasingly been used to treat patients with various forms of acute respiratory failure (1). A recently published guideline has suggested the following guidelines: bilevel NPPV should be the first option for patients with either a severe exacerbation of chronic obstructive pulmonary disease (COPD) or cardiogenic pulmonary edema; continuous positive airway pressure delivered by mask appears to be as effective as bilevel NPPV for patients with cardiogenic pulmonary edema; patients with acute respiratory distress or hypoxemia, either in the postoperative setting or in the presence of immunosuppression, can be considered for a trial of bilevel NPPV; patients with COPD can be considered for a trial of early extubation to bilevel NPPV in centers with experience in the

No potential conflict of interest was reported.

use of this technique (2). All of these suggestions were based on an extensive systematic review of published randomized controlled trials.

Clinical NPPV experience has been reported by some authors (3-6,9,10). This information can elucidate the feasibility of NPPV in all of the indications mentioned in the guidelines as well as identify any issues that arise during clinical practice. This type of research may inform the identification of issues related to technical or even local characteristics that could interfere with patient outcomes.

Our aim was to describe the clinical, demographic and technical characteristics related to noninvasive positive-pressure ventilation (NPPV) use in clinical practice, as well as factors associated with NPPV failure and the prognosis of critically ill adult patients at a large university-affiliated hospital. We then compared our findings with the current evidence.

MATERIALS AND METHODS

The institutional ethics committee approved the study protocol. This observational, non-interventional, prospective cohort study was performed over the course of eight months (May - December 2007) in all consecutive adult patients who underwent NPPV in 11 intensive care units at a university-affiliated hospital with a total of 140 ICU beds. Patients meeting the inclusion criteria were observed daily until ICU discharge or death. Patients with do-not-resuscitate or do-not-intubate orders were excluded.

The researchers carried out the data collection through a form specially developed for this study. These researchers had been trained for three months before gathering the data. The form was tested and revised during the same period. The units were visited daily by the researchers. The prospective data were obtained from the patient's chart and from the ICU staff at the moment of data collection. All of the decisions about the use of NPPV were made by the ICU healthcare teams. Patients whose data were incomplete during collection were excluded from the analysis.

The variables studied were selected through review of the relevant literature. These included the following information: demographic data, Simplified Acute Physiology Score (SAPS II) for the first 24 hours of ICU hospitalization (7); NPPV features; reason for installing NPPV (COPD exacerbation, asthma, neuromuscular disease, acute respiratory failure [acute lung injury or acute respiratory distress syndrome, acute cardiogenic pulmonary edema, congestive heart failure, pneumonia, trauma, upper airway obstruction]); post-extubation, preventive NPPV application (defined as the use of NPPV in patients without signs of respiratory failure with a risk of worsening, for example during the process of fluid balance adjustment, or any patient considered to be at risk of respiratory distress by physicians, such as burn patients (8), or as an adjunctive technique associated with chest physiotherapy treatment (to assist in resolving atelectasis or airway clearance in patients not responding to routine deep breathing exercises and incentive spirometry)) (9-11); days of NPPV use; time between ICU admission and NPPV initiation; time between extubation and NPPV initiation for post-extubation NPPV; type of equipment (CPAP-flow generator, Bipap Vision®, Bipap ST/D-30®, ICU conventional ventilators) at the onset and on the final day of application; NPPV parameters at the onset and on the last day of use; type of mask (nasal, full face, total face); arterial blood gas levels at NPPV onset and at the time when support was discontinued; tolerance to NPPV or the lack thereof; and NPPV-related complications (skin lesions, gastric distension due to aerophagia, eye irritation, vomiting, hypotension, others); cough characteristics; the need for nasotracheal suctioning; the incidence of nosocomial pneumonia, as clinically defined according to the CDC (Centers for Disease Control and prevention) criteria (12). The study end-points were the following: NIV outcome, ICU length of stay and mortality rate. NIV success was defined as the avoidance of orotracheal intubation and independence from NPPV within 72 hours after its discontinuation, and failure was defined as a need for intubation.

Data analysis

A descriptive analysis of the overall study population was carried out. The quantitative variables were expressed as the mean (standard deviation) or median (interquartile range) when more appropriate. Categorical variables were presented as proportions. Associations between categorical variables were analyzed with the chi-square test. Fisher's exact test was applied when the expected value was not sufficient for use of the chi-square test. Continuous data with a normal distribution were compared using Student's t-test; otherwise, the non-parametric equivalent was applied. NPPV outcome was considered as the primary endpoint. All the tests were two-tailed with a significance level of 5% ($p \leq 0.05$). Factors independently associated with NPPV outcome were identified using a logistic regression model. A univariate analysis was initially performed, and all variables considered clinically relevant with a p value less than 0.20 were included in the model. Continuous variables (age, SAPS II score, IPAP, EPAP and pH) were dichotomized based on the median values of the distribution. In the preliminary stage of the analysis, we studied the possible associations between the explanatory variables examined in this study. The goodness-of-fit was assessed using the Hosmer-Lemeshow test. Statistical analyses were performed with SPSS® version 16.0

RESULTS

Between May 1st and December 31st, 2007, all of the ICU patients over 18 years old who underwent NIV treatment were studied. During the study, 407 patients were treated with NIV, and 392 of them were included in the analysis.

The patient characteristics are presented in Table 1. The patient age and SAPS II score were higher in the NPPV failure group. At the time of ICU admission, 4% of the patients came from other hospitals, and most patients came from the ward (41%) and emergency room (28%). Medical disorders (59%) and elective surgery (21%) were the most common reasons for admission. Previous ICU admissions had occurred in 15% of the patients. The previous use of invasive mechanical ventilation was observed in 15% of patients, and 9% had already been treated with NPPV on another occasion. The main indications for NPPV initiation were the following: post-extubation, acute respiratory failure and use as an adjunct to chest physiotherapy.

The NPPV failure rate in this population was estimated to be 35%. The main reasons for intubation (Table 1) were acute respiratory failure (55%) and a decreased level of consciousness (20%).

Table 1 - Baseline characteristics of the study group according to the outcome of noninvasive positive-pressure ventilation.

Characteristics	All patients N = 392	Success N = 254	Failure N = 138	*p*-value, failure vs. success
Age, mean (SD), years	56 (20)	55 (19)	61 (16)	0.003
Male gender, n (%)	218 (56)	134 (53)	84 (61)	0.150
SAPS II, mean (SD)	36 (14)	34 (14)	38 (14)	0.010
Types of admission, n (%)				
Medical	234 (60)	156 (61)	78 (57)	0.403
Elective surgery	83 (21)	47 (19)	36 (26)	0.104
Emergency surgery	74 (19)	50 (20)	24 (17)	0.675
Other*	1 (0.2)	01 (0.4)	0 (0)	
Reasons for installing NPPV n (%)				
Post-extubation	173 (44)	113 (45)	60 (44)	0.931
Acute respiratory failure	106 (27)	65 (26)	41 (30)	0.448
COPD*	9 (2)	7 (3)	2 (1)	
Asthma*	1 (0,3)	1 (0,4)	0 (0)	
Neuromuscular disease*	4 (1)	1 (0,4)	3 (2)	
Other chronic respiratory disease*	3 (1)	1 (0,4)	2 (1)	
Chest ***physiotherapy***	73 (19)	53 (21)	20 (15)	0.157
Preventive NPPV use	16 (4)	11 (4)	5 (4)	0.943
Unknown*	5 (1)	0 (0)	5 (4)	

NPPV = noninvasive positive-pressure ventilation, COPD = chronic obstructive pulmonary disease.
*not analyzed due to an insufficient number of cases.

The prevalence of smoking was 15.5% in the group in which treatment was successful and 20.7% in the group in which NPPV failed, but this association was not significant (p = 0.259).

The time between ICU admission and NPPV initiation was estimated. The overall mean (SD) time was 1.4 (2.4) days. In the successful NPPV group, this mean (SD) period was 1.6 (2.7) days. In the NPPV failure group, it was 1.1 (1.9) days. This difference was not statistically significant (p = 0.201).

The overall median (interquartile range) for the time between extubation and NPPV initiation for post-extubation respiratory failure cases was zero (0-1) days. No difference was found between groups (p = 0.390).

The median (interquartile range) overall length of NPPV use was four (2-6) days. The NPPV failure group presented a shorter period of use than the group in which NPPV was successful [three (2-5) versus four (3-7) days, p = 0.034, respectively].

The data related to arterial blood gas analysis (ABG) at the time of NPPV onset and on the last NPPV day were also collected (Table 2). Some patients had no ABG on these specific days. At the time of NPPV onset, 336 patients had ABG; on the final day of NPPV, this value was 223 patients. The PaO_2/FiO_2 ratio was not available in all charts, and all recorded data are presented below. There were no differences in ABG values between the groups studied at the time of NPPV initiation, but on the last day, the failure group presented lower levels of pH, bicarbonate and base excess. Patients with NPPV failure presented a lower PaO2:FiO2 ratio from the time of NPPV onset onward (Table 2).

The data related to the equipment and NPPV parameters were compared according to outcome at NPPV onset (Table 3) and on the last day of application (Table 4). The full-face mask was the used the most frequently. There was no association between the NPPV interfaces and outcome.

Table 2 - Arterial blood gas analysis at NPPV onset and on the last noninvasive positive-pressure ventilation day.

Characteristics	Success	Failure	*p*-value, failure *vs.* success
ABG at NPPV onset, n = 336	***N = 221***	***N = 115***	
pH	***7.37 (0.08)***	***7.37 (0.06)***	***0.612***
PCO_2	38.7 (10.3)	38.4 (10)	0.815
HCO_3	23.6 (18.5)	21.9 (6.3)	0.319
Base excess	- 2.5 (5.6)	- 2.18 (8.1)	0.670
PaO_2/FiO_2 ratio[a]	283.9 (139)	226 (89)	***0.034***
ABG on the last day of NPPV, n = 223	***N = 120***	***N = 103***	
pH	***7.40 (0.07)***	***7.35 (0.09)***	***<0.001***
PCO_2	***40 (9.7)***	***41 (11.9)***	***0.536***
HCO_3	***24.3 (6.3)***	***21.7 (5.5)***	***0.001***
Base excess	***- 0.57 (6.7)***	***- 3.18 (5.6)***	***0.002***
PaO_2/FiO_2 ratio[b]	***312 (137)***	***245 (123)***	***0.020***

NPPV = noninvasive positive-pressure ventilation.
[a]N = 97 (success 65, failure 32), [b] N = 86 (success 44, failure 42).

Initially, the CPAP flow generator was used most commonly for NPPV, followed by the BIPAP Vision and ICU ventilator. At onset, the equipment used to perform NPPV was not associated with success or failure. On the last day of NIV use, the prevalence of CPAP flow generator use was lower, with an increase in BIPAP Vision® use and a reduction in the use of ICU ventilators. Patients examined with a BIPAP Vision presented a higher NPPV failure rate.

The NPPV parameters were also analyzed according to two sets of results collected at onset and on the last day of NPPV application. The initial IPAP and EPAP and CPAP levels were not associated with the NPPV outcome, but the FiO_2 levels were significantly higher in the failure group (p = 0.006). On the last day of support, the IPAP, EPAP and FiO_2 levels were significantly higher in the NPPV failure group (Table 3).

The rate of complications related to NPPV use was estimated during the study. Vomiting, either associated with aspiration or not, was the most common occurrence. There was a significant association between the occurrence of complications and NPPV failure. Another event associated

Table 3 - Technical characteristics of noninvasive ventilation: final equipment and parameters applied, according to the noninvasive ventilation results.

Characteristics	All patients N = 392	Success N = 254	Failure N = 138	*p*-value, failure *vs.* success
NPPV equipment, n (%)				
CPAP- flow generator	187 (48)	130 (51)	57 (41)	0.078
BIPAP Vision®	150 (38)	87 (34)	63 (45)	0.035
BIPAP ST/D-30®	29 (7)	17 (7)	12 (9)	0.602
ICU ventilator	17 (4)	11 (4)	6 (4)	0.801
Others*	9 (2)	9 (4)	0 (0)	
NPPV final parameters, median (IR)				
IPAP cmH_2O	14 (12-16)	***14 (12-15)***	***14 (14-16)***	***0.002***
EPAP cmH_2O	***10 (8-10)***	***9 (8-10)***	***10 (8-10)***	***0.001***
CPAP cmH_2O	***10 (10-10)***	***10 (10-10)***	***10 (10-10)***	***0.114***
FiO_2 (%)	35 (30-40)	30 (25-35)	40 (35-50)	<0.001

NPPV = noninvasive positive pressure ventilation, CPAP = continuous positive airway pressure, ICU = intensive care unit, IR = interquartile range, IPAP = inspiratory positive airway pressure, EPAP = expiratory positive airway pressure, FiO_2 = inspired oxygen fraction.
*not analyzed due to an insufficient number of cases.

Table 4 - Events associated with NPPV use.

Events associated with NPPV use, n(%)	Total N = 392	Success N = 254	Failure N = 138	*p*-value, failure vs. success
NPPV ***complications***	21 (5)	9 (4)	12 (9)	0.050
Complications*				
Vomiting and aspiration	10 (3)	5 (2)	5 (4)	
Skin lesion	3 (1)	2 (1)	1 (1)	
Gastric distension	2 (1)	0 (0)	2 (1)	
Arterial hypotension	1 (0)	0 (0)	1 (2)	
Intolerance to NIV	69 (18)	47 (18)	22 (16)	0.619
Air leakage	8 (2)	6 (2)	2 (1)	0.718
Productive cough	109 (28)	62 (24)	47 (34)	0.055
Ineffective cough	162 (41)	108 (42)	54 (39)	0.587
Nasotracheal ***suctioning***	115 (29)	64 (25)	51 (37)	0.020
Hypersecretion	65 (17)	36 (14)	29 (21)	0.247
Nosocomial pneumonia	22 (6)	15 (6)	7 (5)	0.910

NPPV = noninvasive positive-pressure ventilation.
*Not analyzed due to insufficient data.

with failure was the need for nasotracheal suctioning (Table 5).

The incidence of clinically defined nosocomial pneumonia in the overall study population was 6%. There was no difference between the groups.

The patients with NPPV failure had a higher length of stay in the ICU when compared to the NPPV success group [17 (10-26) days vs. 8(5-14) days]. The overall mortality rate was 24%, and the NPPV failure group also presented a higher mortality rate (9 vs. 51%). There was an association between NPPV failure and mortality, with an estimated odds ratio (95% CI) of 10.6 (5.93 – 19.07).

The multiple logistic regression analysis model using NPPV failure as the dependent variable found that patients with a SAPS II ≥ 34, IPAP level≥15 cmH2O and pH<7.40 were independently associated with NPPV failure and were kept in the final logistic model (Table 6). The goodness-of-fit was confirmed by the Hosmer-Lemeshow test (p = 0.991).

DISCUSSION

Aside from the classic indications of NPPV use, such as post-extubation and acute respiratory failure, we have identified two distinct indications for NPPV: prophylactic application and use as an adjunct to chest physiotherapy. The prophylactic application was defined as the use of NPPV in cases where the indication was based on clinical criteria, such as patients who needed additional support but did not require ventilatory support immediately, as in cases of fluid replacement. This indication rate was only 4%.

Table 5 - Factors associated with noninvasive ventilation failure – multiple logistic regression, final model.

Variables	OR	Lower	Upper	*p*-value
Age	1.094	0.887	1.349	0.400
EPAP	0.089	0.013	0.617	0.014
IPAP	4.452	1.529	12.968	0.006
FiO2	0.829	0.640	1.073	0.155
EPAP by FiO2	1.029	1.000	1.059	0.051
EPAP by age	1.026	1.001	1.051	0.040
Age by IPAP	0.979	0.962	0.995	0.011

OR = odds ratio, EPAP = expiratory positive airway pressure, IPAP = inspiratory positive airway pressure, FiO2 = inspired oxygen concentration.

Another indication that stood out was the use of NPPV in association with chest physiotherapy (19%). In this case, the objectives of positive pressure use were to assist in resolving atelectasis and normalizing pulmonary function in patients not responding to routine incentive spirometry and deep breathing. The use of NPPV to assist patients in improving ventilation and recruiting additional gas exchange units to maintain functional residual capacity and vital capacity with relatively little discomfort is instrumental to its success (8). Although most epidemiological studies do not highlight that NPPV indication, this technique is routine in our country and is part of the procedures used in routine hospital practice. The studies that report this type of NPPV application were published as long as 30 years ago (9-11).

The multiple logistic regression analysis model using NPPV failure as the dependent variable identified that patients with IPAP levels≥15 cmH_2O, SAPS II≥34, and pH<7.40 were independently associated with NPPV failure.

The severity of illness, as evaluated by the SAPS II score at the time of ICU admission, was high in our population and independently associated with NPPV failure. Our study also found that a SAPS II score≥34 at the time of ICU admission was independently associated with NIV failure. This finding was similar to that reported by Antonelli et al. (23), which recommended avoiding NPPV in ARDS patients with SAPS II≥34 due to the high levels of mortality observed in those in whom NPPV had failed. Although our study population was not comprised entirely of ARDS patients, we observed that even in patients without ARDS, SAPS II≥34 was

Table 6 - Factors associated with noninvasive ventilation failure – multivariate analysis.

Variables	OR	95% CI	*p*-value
SAPS II, points			
<34	1.0		
≥34	2.97	1.31-6.99	0.010
IPAP, cm H_2O			
<15	1.0		
≥15	3.13	1.34-7.71	0.010
pH			
≥7.4	1.0		
<7.4	2.72	1.21-6.28	0.017

OR = odds ratio, IPAP = inspiratory positive airway pressure.

associated with treatment failure. Another study by Carlucci et al. (14) also found that SAPS II was an independent risk factor for secondary intubation. The authors maintain that the SAPS II score indicates that the most severely ill patients are poor candidates for NPPV. However, they recommended that the severity score cannot be used as such on an individual basis.

In relation to the NPPV pressure levels used, in the multivariate analysis, the value of IPAP≥15 cmH_2O was independently associated with NPPV failure. Among the studies that evaluated NPPV parameters, only the study by Antonelli et al. (23) reported higher IPAP values in the failure group, but this association was not maintained in the multivariate analysis. Other studies (6,20) did not report such a relationship, and we observed lower levels of IPAP and EPAP in both studies. Our findings suggest that the use of higher values of IPAP (≥15 cmH_2O) indicate a higher probability of NPPV failure.

The failure group presented lower levels of pH, bicarbonate and base excess, and the $PaCO_2$ did not differ between groups. According to Rana et al. (18), the presence of metabolic acidosis was predictive of NPPV failure, even when shock was not present at the time NPPV was initiated. Although patients who failed NPPV tended to have a higher level of serum lactate, this did not reach a statistically significant value, suggesting that not only tissue hypoperfusion but also metabolic acidosis per se, may be associated with poor NPPV outcomes. Their finding are consistent our results. We also suggest that lower levels of pH may be a good marker for a poor outcome after NPPV, as shown in Tables 2 and 6.

The overall time between extubation and NPPV initiation for post-extubation respiratory failure cases was estimated. Half of the patients used NPPV on the same day of extubation, and only 25% used NPPV after the first postoperative day. No difference was found between the groups. We observed that clinical practice reflects the findings of the literature, which recommends the early use of NPPV after extubation (19-22).

The time of NPPV use in patients with failure was shorter. This finding is similar to that reported in the literature (13,24). Our hypothesis is that this is most likely due to the negative impact of delayed intubation patients on the prognosis (25).

In this unselected patient sample, we observed that the NIV failure rate was similar to that reported in other cohort studies (3,5). We considered the overall failure rate because our study did not classify patients according to arterial blood gas values. During the study period, there was no standardized NPPV utilization protocol, and some patients did not have arterial blood gas samples. Rather, both studies mentioned were based on standardized protocols. The study by Meduri et al. (5) applied a protocol in a large group of medical patients, and Girault et al. (3) presented two years of NIV experience at a specialized medical ICU with 22 beds. Another study by Schettino et al. (6) reported data related to NIV use over a period of one year at a university-affiliated hospital. All patients submitted to NIV at this hospital were included. The authors estimated the rate of NIV failure in the ICU setting to be 49%. They considered that ICU-managed patients were the sickest and that this population was composed of patients that could not be managed in the general ward. Patients maintained on the ward were able to breathe spontaneously for at least one hour. One important difference between our study and that reported by Schettino et al. (6) is that our study population included only a small proportion of those with chronic respiratory disease.

The availability of a CPAP flow generator in the ICU contributed to the frequent use of this type of equipment at the time of NIV onset. We observed that this device was shifted to the bilevel setting during treatment. At that time, NIV was performed using a CPAP flow generator, Bipap STD 30, Bipap Vision or conventional ICU ventilator. We did not find any association with NIV outcome. A recently published guideline by Keenan et al. (2) did not describe any influence of the ventilatory mode or equipment on the NIV outcome.

Univariate analysis showed that NIV was likely to fail in patients requiring nasotracheal suctioning. This procedure was required due to a cough that occurred in 29% of the study population. It seems important to evaluate cough severity, even in patients with NIV support. According to the literature, patients with weak coughs after planned extubation may benefit from NIV, but this procedure requires staff with expertise in invasive airway management (2). In a prospective multicenter survey, Carlucci et al. (14) estimated that 52 of the 108 patients (48%) submitted to NPPV discontinued the treatment prematurely. This was due to an inability to manage copious secretions in 32% of the patients. Our study estimated that 37% of the patients in the NPPV failure group required nasotracheal suctioning.

The overall incidence of nosocomial pneumonia was 6%. Despite differences in the diagnostic criteria, we observed a similar rate in the literature (15). A matched case-control study compared the rates of nosocomial infections among patients submitted to NPPV and those submitted to invasive mechanical ventilation. The study concluded that the use of NPPV was associated with a lower risk of nosocomial infections and better outcomes.

Patients with NIV failure had a poor prognosis as well as a high mortality rate (51%). The overall mortality rate was 24%. Alsous et al. (13), in a retrospective study at a community teaching hospital, also found a higher mortality among those in whom BIPAP had failed. They considered some factors that contributed to this fact: 1) a ''do-not-intubate'' order from 7 of 18 patients, 2) less physiological derangement among the subcohort of BIPAP success patients, and 3) the attempt at a trial of BIPAP rather than intubation may prolong cardiorespiratory decompensation and worsen patient outcomes. This study concluded that BIPAP success was associated with significantly better outcomes (ICU length of stay and mortality). This finding may indicate that NIV failure must be avoided through appropriate approaches, such as staff education. Two studies carried out at a medical ICU where there was a protocol and a well-trained staff presented lower mortality rates. The study by Girault et al. (3) conducted at a 22-bed medical ICU presented an overall mortality rate of 11%; this rate was 16% in another study by Meduri et al. (5).

An important point with respect to interpretation of our results is that the patients were not transferred to chronic respiratory units because this type of facility is rare in our country. Almost all patients remain in the ICU when they are dependent on ventilatory support. This factor may also have affected the observed mortality rates. We consider that educational approaches and the use of protocols can improve NIV outcomes, as observed in the studies mentioned above.

The present study provides information about NIV as part of the clinical practice at a large university-affiliated hospital. Our intention was to analyze the main features of this procedure in a non-controlled environment, as occurs during a clinical trial. During the study period, there was no standardized NIV protocol in the observed units, but we also consider that the activities of research and teaching may influence the results at a university-affiliated hospital. This study presented the demographic, clinical and technical features of NPPV use in clinical practice among the unselected ICU patients. Our results showed that patients with NPPV failure have a poor prognosis, with a high mortality rate and a prolonged length of stay in the ICU. The more severe patients (higher SAPS II score and lower pH) had higher failure rates. High levels of IPAP also indicate a higher risk of failure. In our study, we found that physiotherapy uses the NPPV for therapeutic purposes and not only in cases of acute respiratory failure.

A major objective of this study is to present the main features of the use of NPPV in patients admitted to the intensive care unit. We understand that the study design weakens some of our conclusions because it is an uncontrolled study without an intervention. However, our results are not discordant with those observed in most previously published studies.

ACKNOWLEDGMENTS

We are grateful to Felipe Granado de Souza and Fabio Montesano, statisticians at the Federal University of Sao Paulo, for their help in the analysis of these data.

AUTHOR CONTRIBUTIONS

Yamauchi LY participated in the study design, performed the statistical analyses, contributed to data analysis and interpretation, and drafted the manuscript. Travaglia TC participated in the study design, data collection, and drafted the manuscript. Bernardes SR and Figueiroa MC participated in the study design and data collection. Tanaka C contributed to the study analysis and data interpretation. Fu C participated in the study design, made substantial contributions to data analysis and interpretation, and drafted the manuscript. All authors have read and approved the final version of the manuscript.

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