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Noninvasive ventilation for acute respiratory failure. Quite low time consumption for nurses

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Noninvasive ventilation for acute respiratory failure. Quite low time consumption for nurses. G. Hilbert, D. Gruson, F. Vargas, R. Valentino, L. Portel, G. Gbikpi-Benissan, J.P. Cardinaud. ©ERS Journals Ltd 2000.

ABSTRACT: Methods of noninvasive pressure support ventilation (NIPSV) are not always easy to apply in patients with acute exacerbations of chronic obstructive pulmonary disease (COPD).

The assistance time spent by nurses in relation to ventilatory time was prospectively studied, when NIPSV was used, in a sequential mode, in COPD patients with either acute exacerbations (58 patients, group I) or postextubation hypercapnic respiratory insufficiency (42 patients, group II) in a medical intensive care unit.

During the first 24 h after enrolment, NIPSV was used for 6.7±3.2 h (mean±SD) in group I and 5.6±3.1 h in group II; the duration of NIPSV sessions and the nurse time consumption per session were respectively 47±12 and 11±7 min in group I, and 46±12 and 11±6 min in group II. After the first 24 h of the study, the duration of NIPSV was 4.7±3.2 h·day^{-1} in group I and 4.9±3.5 h·day^{-1} in group II, and the nurse time consumption dropped significantly: the duration of NIPSV sessions and the nurse time consumption per session were respectively 44±10 and 7±4 min in group I, and 47±14 and 7±3 min in group II. Between the first 24 h and the subsequent period of 24 h, the nursing time dropped significantly (98 *versus* 59 min in group I ($p<0.05$), and 85 *versus* 52 min in group II ($p<0.05$)). There was no difference in the duration of NIPSV sessions, or in the overall assistance time per session, between the two groups of patients.

In conclusion, the study seems to favour a quite low assistance time spent by nurses in relation to ventilatory time when noninvasive pressure support ventilation is used in chronic obstructive pulmonary disease patients with either acute exacerbations or postextubation hypercapnic respiratory insufficiency.

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Methods of noninvasive pressure support ventilation (NIPSV) are being proposed more and more for patients with chronic obstructive pulmonary disease (COPD) and acute respiratory failure [1–6]. NIPSV can avoid the need for endotracheal intubation and its increasingly documented complications [7]. Nevertheless, this method of ventilation requires the presence of nurses familiar with the technique, and this may be time-consuming [3, 8]. Moreover, according to certain reports [2, 4, 9, 10], some patients do not tolerate noninvasive ventilatory support, and side-effects of these techniques occur quite frequently [3, 11].

Three articles have demonstrated that the institution of noninvasive mechanical ventilation is not significantly more time-consuming for personnel than traditional medical therapy [4, 12] or invasive mechanical ventilation [13]. However, two of these studies [12, 13] were performed in respiratory intensive care units (ICUs) with a specialized activity, and where patient/staff ratios are generally lower than in general ICUs [13]. The authors consider that the problem lies not in comparing the workload linked to utilization of NIPSV with that linked to standard treatment or invasive mechanical ventilation, since it is advisable to use NIPSV to avoid intubation. It is more a question of knowing whether or not utilization of this technique is compatible with the existing activity and organization of an ICU.

Thus the objective of the present work was to prospectively study, in a medical ICU, the assistance time spent by nurses in relation to ventilatory time in cases in which NIPSV was used in COPD patients with either acute exacerbations or postextubation hypercapnic respiratory insufficiency. Two groups of patients were included to prospectively assess the nurse time spent on NIPSV treatment of COPD patients with acute exacerbations of their disease, which represents the most usual indication of NIPSV [1–6], and those with another indication of NIPSV, *i.e.* postextubation hypercapnic respiratory insufficiency [14]. The amount of time spent by nurses in the first 24 h of the protocol and the period of ventilation recorded after the first 24 h of NIPSV were also compared. For the first 24 h after enrolment, these assistance times per ventilation session were also compared between patients successfully ventilated with NIPSV and those who failed with NIPSV.

Materials and methods

The experimental protocol was approved by the institutional review board of Pellegrin hospital and all patients gave their informed consent prior to participation.

Pellegrin Hospital is a 1,100-bed general university hospital located in an urban region. Approximately 1,000 patients·yr^{-1} are admitted to the 16-bed medical ICUB. The ward is divided into four units of four beds each. One nurse and one nurse′s aide are in charge of the four patients in one unit. This organization, unchanged for many years, is the same during the day, the night and the weekend. A single respiratory therapist, present for eight daytime hours only, works in this ICU and in another 16-bed medical ICU. During the weekend, a single respiratory therapist works, in addition, in a 32-bed post-ICU. If the role of respiratory therapist was preponderant when the techniques of NIPSV were developed in this ICU, nearly 10 yrs ago, nowadays the application of the technique lies almost exclusively in the hands of nurses, qualified to begin a session of NIPSV, according to prescriptions from the medical doctor in charge of the patient, at any time of day or night. A nurse′s aide can occasionally help to the smooth running of a session of NIPSV in cases in which an action requires the presence of more than one person.

Subjects

One hundred COPD patients (78 male and 22 female) admitted in the period 1995–1997 were prospectively studied. The diagnosis of COPD was made according to stan-dard American Thoracic Society criteria [15]. The patients were included in two groups. Group I consisted of 58 patients who were admitted to the ICU with an acute exacerbation of COPD, defined as a recent increase in dyspnoea, cough and sputum production, of sufficient severity to warrant hospital admission, and refractory to conventional treatment with bronchodilators and systemic corticosteroids. The precipitating cause of acute respiratory failure was respiratory tract infection without evidence of pneumonia on chest radiography. In the ICU, NIPSV was added to conventional medical therapy; all patients received oxygen therapy, nebulized β_2-agonists, subcutaneous heparin, systemic corticosteroids, diuretics and antibiotics as required. Additional criteria for enrolment in the study were: 1) a recent worsening of dyspnoea, 2) a respiratory frequency (f_R) of >30 breaths·min^{-1}, and 3) acute respiratory acidosis, defined as a pH of <7.35. Group II consisted of 42 COPD patients with hypercapnic respiratory insufficiency after weaning from mechanical ventilation. This category comprised patients who had been intubated for acute exacerbations of COPD. Eight of these patients had received a trial of NIPSV before they were intubated. In all other patients, the intubation had been performed either a short time before admission to the ICU or promptly after admission. The decision to perform endotracheal intubation was made by the patient′s attending physician, according to the usual criteria used in the ICU, *i.e.* rapid deterioration in neurological status and a Glasgow Coma Scale (GCS) score of ≤8 [16], major agitation requiring sedation, increase in f_R and gas exchange deterioration, and shock. All patients underwent weaning with pressure support (PS) ventilation. The criteria for initiating weaning with PS ventilation were similar in all patients, *i.e.* vital capacity >10 mL·kg^{-1}, arterial oxygen saturation (S_{a,O_2}) >90% at an inspiratory oxygen fraction (F_{I,O_2}) of 40% and maximal inspiratory pressure of >-25 cmH_2O. The procedure was similar in all patients, and the decision to perform endotracheal extubation was made by the patient′s attending physician according to the usual criteria used in the ICU, *i.e.* the patient was able to tolerate spontaneous breathing with 6 cmH_2O of PS for a period of 6 h. The mean duration of intubation and ventilatory assistance was 11±4 days (mean±SD). The diagnosis of postextubation hypercapnic respiratory insufficiency was established if, within 72 h of discontinuation of mechanical ventilation, the patients presented with respiratory distress, defined as the combination of an f_R >25 breaths·min^{-1}, an increase in arterial carbon dioxide tension of ≥20%, compared with the postextubation value measured during spontaneous breathing with supplemental O_2, and a pH of <7.35 [14]. The period between extubation and diagnosis of hypercapnic respiratory insufficiency was 20±14 h. In both groups, all patients with a GCS score of ≤8, inconsistent with NIPSV use, and requiring immediate endotracheal ventilation were excluded. Haemodynamic instability with a sustained systolic arterial blood pressure of <80 mmHg or failure of more than two organs [17] were also exclusion criteria.

Ventilation

NIPSV was delivered to the patient through a full-face mask (La Cigogne®, Pessac, France). The correct mask size was chosen for each patient. If the patient felt pain when the mask was applied, or if redness was observed on the skin compressed by the mask, a wound care dressing was used on the bridge of the nose under the mask. The mask was adjusted and connected to a ventilator. Two types of ventilator were used. In group II patients, the same ventilator was used to perform weaning from mechanical ventilation and NIPSV, *i.e.* an Evita-ventilator (Dräger, Lübeck, Germany) set in the PS mode with positive end-expiratory pressure (PEEP). In group I patients, a simpler machine designed for ventilation at home, *i.e.* the bilevel positive airway pressure (BiPAP) (BiPAP®, Respironics Inc, Murrysville, PA) ventilator, set in the spontaneous mode, was used. PS was fixed at 16±3 and 16±4 cmH_2O in groups I and II respectively, and PEEP at 6±2 and 5±1 cmH_2O in groups I and II respectively. The oxygen flow delivered through the connecting tube near the mask during ventilation with the bilevel ventilator was 3±2 L·min^{-1}; the F_{I,O_2} was adjusted to 28±5% during ventilation in group II. In all patients, NIPSV was used in a sequential mode [6, 14]. The sequential mode used consisted of periods of ventilation alternated with periods of spontaneous breathing. The ventilation periods lasted for ≥30 min, and were performed at very regular intervals, *i.e.* every 3 h in group I and 4 h in group II. The nurse was asked to maintain periods of ventilation for as long as possible, mainly at the beginning of the protocol, taking into account the patient′s tolerance and trying to encourage, in all cases, a minimal duration of ventilation of 30 min. Nurses stopped NIPSV sessions after 30 min of ventilation in patients in whom ventilation sessions must be carefully negotiated, *i.e.* the patient would tolerate 30 min of ventilation but asked to be disconnected shortly

after the 30 min of NIPSV, because of discomfort or anxiety. In other patients with better tolerance and/or compliance to the technique, nurses stopped the ventilation sessions after 60 min of NIPSV, or precociously if the patients presented discomfort or anxiety. Between periods of ventilation, patients received a minimal oxygen flow adjusted to blood gas analysis data, under continuous monitoring of cardiac frequency, blood pressure, f_R and S_{a,O_2}, as measured by a bedside pulse oximeter (Oxisensor, Nellcor®, Hayward, CA, USA). Nurses decided to return the patients systematically to NIPSV when criteria determined by the medical staff were present, *i.e.* S_{a,O_2} was <85%, or dyspnoea worsened with an f_R of >30 breaths·min^{-1}. After the first 24 h of the protocol, if the patient improved, with an f_R of <30 breaths·min^{-1} and a partial correction of acidosis, the interval between ventilation sessions could be increased. NIPSV was withdrawn when patients reached a pH of >7.37 during spontaneous breathing without worsening for 24 h. Therapy was considered to be a success when intubation was avoided and the patient was transferred from the ICU. The decision to perform endotracheal intubation was made by the patient′s attending physician, according to the usual criteria used in the ICU, *i.e.* severe encephalopathy, major agitation requiring sedation, increase in f_R and gas exchange deterioration, and shock.

Evaluation of the assistance time spent by the nursing staff

The nurses in charge of the patients were asked to report systematically, on a grid, the duration of each NIPSV session, and the duration of nursing care required for each ventilation session. The nurses evaluated their workload themselves. A clock with a second hand was used for precise assessment of ventilatory times and the amount of time spent on interventions in each patient. The nurse time was evaluated in relation to ventilatory time, and the tasks during the nurse time were specifically related to the NIPSV ventilation sessions. Nurses were involved in the study and the list of tasks retained for evaluation of the assistance time was established by both nurses and medical doctors. The overall assistance time was also detailed under the headings "technical support time" and "psychological help time". Under technical support time, they entered the time required for the following interventions: 1) aspiration of bronchial secretions before and at the end of the session, 2) mask: good position and fitting maintenance, eventual repositioning in case of leaks around the mask or face pain, and withdrawal, 3) setting of wound care dressing on the bridge of the nose under the mask, if the patient felt pain when the mask was applied, or if redness was observed on the skin compressed by the mask, and 4) clinical and monitoring evidence of deterioration in cardiorespiratory function, and verification of the quality of the continuous recording of S_{a,O_2}. Under psychological help time, they entered the time required for the following interventions: 1) explanation of the necessity of performing ventilation sessions at very regular intervals, 2) encouragement to accept periods of ventilation for as long as possible, mainly at the beginning of the protocol, taking into account the patient′s tolerance, and trying to encourage, in all cases, a minimal duration of ventilation of 30 min, and 3) coaching to encourage the patient to relax and any other action aiming to reassure and comfort the patient so that the session of NIPSV could be performed under favourable conditions. In cases in which an action required the presence of a nurse and a nurse′s aide, the time of assistance was obviously multiplied by two.

Analysis

Results are presented as mean±SD. Analysis of variance was used to compare, in groups I and II, the mean duration of a ventilation session, and the mean overall time/technical support time/psychological help time given by the nurses for a ventilation session, during the first 24 h of the protocol and after the first 24 h of NIPSV. Five consecutive periods of 24 h were selected, and analysis of variance was used to compare the mean duration of NIPSV·24 h^{-1}, and the mean duration of assistance·24 h^{-1} given by the nurses specifically for the ventilation sessions during the first 24 h of the protocol and each subsequent period of 24 h. The duration of the NIPSV sessions, and the overall assistance time per session were compared in the two groups of patients using unpaired t-tests. Unpaired t-tests were also carried out to compare, in groups I and II, 1) the characteristics of the patients successfully ventilated with NIPSV and those who failed with NIPSV, 2) the number of NIPSV sessions per day, and 3) for the first 24 h of the protocol, the mean duration of assistance per ventilation session, between patients successfully ventilated with NIPSV and those who failed with NIPSV. A p-value of <0.05 was considered significant.

Results

The demographic and steady-state functional characteristics of all of the patients are shown in table 1. The functional characteristics of the patients at the time of inclusion are shown in table 2. Fourteen of the 58 (24%) patients in group I and eight of the 42 (19%) patients in group II required endotracheal intubation; the period between inclusion in the study and intubation was 14±12 h (range 2–46 h, and median 12 h) for the 14 patients in group I and 17±13 h (range 4–49 h, median 14 h) for the eight patients in group II. The mean duration of noninvasive ventilatory assistance in the ICU was 6±3 days (range 2–10 days) in the 44 patients successfully treated with NIPSV in group I and 4±2 days (range, 2–9 days) in the 34 patients successfully treated with NIPSV in group II.

In groups I and II, the number of NIPSV sessions per day, the mean duration of a ventilation session and the mean overall ventilatory time technical support time/psychological help time of assistance given by the nurses for a ventilation session are reported in table 3; the comparisons of all these parameters between the first 24 h after enrolment and the period of ventilation recorded after the first 24 h of NIPSV are also shown in table 3. Figure 1 shows the comparison of the mean duration of NIPSV per 24 h and the mean time of assistance given per 24 h by the nurses specifically for the ventilation sessions between the first 24 h of the protocol and each subsequent period of 24 h recorded after the first 24 h. There was no difference in the duration of NIPSV sessions or in the overall assistance time per session between the two groups of patients. As shown in table 4, there was no

Table 1. – Demographic and steady-state functional characteristics of patients

	Group I*			Group II+		
	Total	Success	Failure	Total	Success	Failure
Subjects n	58	44	14	42	34	8
Age yrs	66±8	65±7	67±8	68±9	69±9	68±8
FEV_1 L#	0.71±0.18	0.72±0.17	0.70±0.18	0.70±0.15	0.69±0.17	0.70±0.14
FEV_1 % pred#	33±10	34±10	32±9	34±8	33±9	34±8
VC L#	1.96±0.63	1.99±0.59	1.94±0.58	1.84±0.66	1.82±0.62	1.85±0.68
VC % pred#	53±14	54±12	52±15	51±12	50±11	51±12
FEV_1/VC %#	37±11	37±10	37±11	39±10	38±10	39±11
P_{a,O_2} kPa§	7.8±0.9	7.9±0.9	7.7±0.8	7.8±1.1	7.7±0.9	7.9±1.2
P_{a,CO_2} kPa§	8.0±0.9	7.9±0.9	8.1±0.9	8.1±0.8	8.1±0.9	8.2±0.8
Bicarbonate mM	30±3	29±3	31±3	31±4	30±3	31±4

Data are presented as mean±SD. *: patients with acute exacerbations of chronic obstructive pulmonary disease (COPD); +: COPD patients with postextubation hypercapnic respiratory insufficiency; #: obtained from previous spirometric tests in 39 group I patients and 27 group II patients and within 2 months after inclusion in 17 group I patients and 14 group II patients data were recorded, in the sitting position, using a Sensormedics® spirometer (Sensormedics®, Yorba Linda, CA, USA)); §: data recorded on air during spontaneous breathing (measurements were performed using a blood gas analyser (Chiron Diagnostics®, Emeryville, CA, USA)). None of the parameters measure were significantly different between patients in whom noninvasive pressure support ventilation was successful and those in whom it failed. FEV_1: forced expiratory volume in one second; VC: vital capacity; P_{a,O_2}: arterial oxygen tension; P_{a,CO_2}: arterial carbon dioxide tension.

difference, during the first 24 h of the protocol, in the mean time of assistance per ventilation session between patients successfully ventilated with NIPSV and those who failed with NIPSV.

Discussion

The study shows that, when NIPSV was used in COPD patients with either acute exacerbations or postextubation hypercapnic respiratory insufficiency, the nurse time consumption was 25% and only 15% of the ventilatory time, respectively, during the first 24 h after enrolment and after the first 24 h of the study. These results contradict the findings of a previous study concluding that noninvasive ventilation was "a very time-consuming procedure for nurses" [8]. There was no difference in the duration of NIPSV sessions or in the overall assistance time per session between the two groups of patients. During the first 24 h after enrolment, the mean nurse time consumption was 25% of the ventilatory time. NIPSV was used in a sequential mode, and the mean ventilatory time during the first 24 h of use of NIPSV was 6.7±3.2 h in group I and 5.6±3.1 h in group II. Subsequently, the assistance time spent by nurses during the first 24 h was relatively low.

Success rates were 76% in group I and 81% in group II. The physiological and clinical severity of the present patients (tables 1 and 2) were comparable to those reported in the majority of studies dealing with the use of NIPSV in patients with acute exacerbations of COPD [1, 3, 5, 6, 19, 20], allowing evaluation of the results of the present study with those of other studies. The present study confirms results from previous studies concerning the efficacy of NIPSV in avoiding endotracheal intubation in COPD patients during episodes of acute exacerbation of their lung disease [1, 3–6, 19, 20]. The physiological and clinical severity of the patients in group II (tables 1 and 2) were comparable to those of the patients included in both studies dealing with the use of noninvasive ventilation in patients with postextubation hypercapnic respiratory insufficiency [14, 21]. The present study also confirms the results from these previous studies, thus supporting the idea that early use of NIPSV may be advantageous in this indication.

Few studies have reported the workload of the nursing staff linked to the use of NIPSV in COPD patients with

Table 2. – Characteristics of patients at inclusion

	Group I*			Group II+		
	Total	Success	Failure	Total	Success	Failure
Subjects n	58	44	14	42	34	8
SAPS II	25±6	24±6	25±7	26±7	25±6	27±7
pH#	7.29±0.04	7.30±0.04	7.29±0.03	7.33±0.04	7.33±0.03	7.32±0.04
Respiratory frequency breaths·min^{-1}	34±3	34±2	34±3	30±3	30±2	31±3
$P_{a,O_2}/F_{I,O_2}$#	29.1±5.7	29.6±5.1	28.7±6.1	30.4±5.4	30.5±5.1	30.4±5.7
P_{a,CO_2} kPa#	9.8±0.9	9.7±0.9	9.9±0.9	9.2±1.0	9.2±0.9	9.2±1.0
Cardiac frequency beats·min^{-1}	102±12	99±11	104±12	95±10	94±11	97±9

Data are presented as mean±SD. *: patients with acute exacerbations of chronic obstructive pulmonary disease (COPD); +: COPD patients with postextubation hypercapnic respiratory insufficiency; #: the measurements performed using a blood gas analyser (Chiron Diagnostics®, Emeryville, CA, USA). None of the parameters measured were significantly different between patients in whom noninvasive pressure support ventilation was successful and those in whom it failed. SAPS II: Simplified Acute Physiology Score II [18]; P_{a,O_2}: arterial oxygen tension; F_{I,O_2}: inspiratory oxygen fraction; P_{a,CO_2}: arterial carbon dioxide tension.

Table 3. – Duration of noninvasive pressure support ventilation (NIPSV) and assistance time given by the nurses during and after the first 24 h after enrolment

	Group I*			Group II^{+}		
	First 24 h	After first 24 h	p-value	First 24 h	After first 24 h	p-value
Subjects n	58	47		42	36	
NIPSV duration	6.7±3.2	4.7±3.2	<0.05	5.6±3.1	4.9±3.5	ns
Daily NIPSV sessions n	8±3	6±3	<0.05	7±2	6±2	ns
NIPSV sessions duration min	47±12	44±10	ns	46±12	47±14	ns
Overall assistance time per session min	11±7	7±4	<0.05	11±6	7±3	<0.05
Technical support time per session min	5±3	3±1	<0.05	5±3	3±2	<0.05
Psychological help time per session min	7±4	4±3	<0.05	6±3	4±2	<0.05

Data are presented as mean±SD. *: patients with acute exacerbations of chronic obstructive pulmonary disease (COPD); $^{+}$: COPD patients with postextubation hypercapnic respiratory insufficiency. During the first 24 h after enrolment, 11 of the 58 patients in group I and six of the 42 patients in group II were intubated.

acute respiratory failure. CHEVROLET *et al.* [8], in a study of six patients, three of whom had COPD, showed that, in the case of COPD patients, the nursing time spent with the patient was close to the ventilatory time. However, it is necessary to point out that these results were based solely on three patients whose respiratory insufficiency was very severe, and in whom noninvasive ventilation had failed, demonstrating limited experience of this method. As MEDURI *et al.* [21] and PENNOCK *et al.* [22] demonstrated recently, it is likely that some training is necessary for personnel before optimal routine daily use of NIPSV can be expected. In the study of KRAMER *et al.* [12], the nurse time consumption was 20% of the ventilatory time during the first 16 h of use. In the study of NAVA *et al.* [13], the nurse time consumption was 50% of the ventilatory time during the first 3 h of use and 17% of the ventilatory time during the following 42 h of use. However, both of these studies were performed in respiratory ICUs with a specialized activity, in which the role of the respiratory therapists is preponderant, and in which patient:staff ratios are normally lower than in general ICUs [13]. Indeed, in the study of NAVA *et al.* [13], the patient:nurse ratio was 2:1 (compared with 4:1 in the present study), and the patient:respiratory therapist ratio was 3:1 (compared with 32:1 in the present study). Consequently, it is difficult to compare the results of the present study, which was performed in a medical ICU, to those of studies performed in respiratory ICUs [12, 13]. The durations of ventilation on the first day of the protocol were close to those noted in other studies in which NIPSV was administered discontinuously. In the study of FOGLIO *et al.* [2], patients were submitted to a mean of 4 h of NIPSV. The mean duration of treatment in the study of BROCHARD *et al.* [1] was 7.6 h·day^{-1}. In the study of BOTT *et al.* [4] patients received 7.6 h of ventilation per day. Furthermore, the time required to improve patients′ conditions can be very short. Thus, in the study of FERNANDEZ *et al.* [23], NIPSV was performed for a period of only 8±4 h. In addition, the relatively low ventilatory time per day in the present study did not seem to be associated with an overlong duration of ventilation. Indeed, the patients successfully treated with NIPSV were ventilated for 6±3 days in group I and 4±2 days in group II. Very different mean durations of noninvasive ventilation have been reported in the literature. In the study of BROCHARD *et al.* [5], of COPD patients at a similar disease stage as the present group I patients, the duration of use of NIPSV was shorter, *i.e.* 4 days. Conversely, in the study of CONFALONIERI *et al.* [20], the patients were ventilated for 9.8 days, despite the fact that the technique was used continually. In the study of BOTT *et al.* [4], NIPSV was used for 6 days, as for patients in group I in the present study; however, respiratory acidosis was more significant for patients in the present study than in that of BOTT *et al.* [4]. Some authors have previously proposed administering NIPSV discontinuously [1, 4, 5, 20, 23, 24]. The sequential mode used on the present study is also a

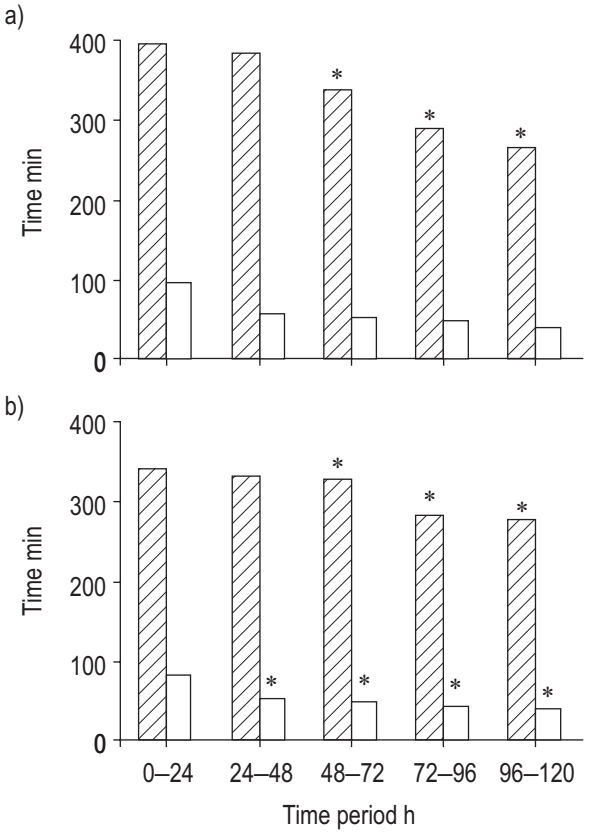

Fig. 1. – Mean duration of noninvasive pressure support ventilation per 24 h (▨) and mean time of assistance given per 24 h by the nurses specifically for the ventilation sessions (□) were compared between the first 24 h of the protocol and four, subsequent consecutive periods of 24 h in: a) group I (n=58, 47, 44, 36 and 28 for the five consecutive periods); and group II (n=42, 36, 31, 20 and 15). *: p<0.05 *versus* 0–24 h.

Table 4. – Duration of noninvasive pressure support ventilation (NIPSV) sessions and assistance time given by the nurses in successful and unsuccessful episodes during the first 24 h after enrolment

	Group I*		Group II^{+}	
	Success	Failure	Success	Failure
Subjects n	44	14	34	8
NIPSV session duration min	48±12	46±11	46±11	45±14
Overall assistance time per session min	11±6	12±8	10±7	12±8
Technical support time per session min	5±3	5±3	5±3	5±2
Psychological help time per session min	6±3	6±5	6±2	7±4

Data are presented as mean±SD. *: patients with acute exacerbations of chronic obstructive pulmonary disease (COPD); $^{+}$: COPD patients with postextubation hypercapnic respiratory insufficiency. None of the parameters measured were significantly different between patients in whom NIPSV was successful and those in whom it failed.

discontinuous mode, thus allowing comparison of the present results with those of other studies, with some specificity, *i.e.* the predetermination of the duration of the ventilation sessions, and of the time between the NIPSV sessions. In previous experience with NIPSV used in the sequential mode personnel have had to motivate some patients regularly to encourage them to undergo ventilation for ≥30 min [6, 14]. This sometimes resulted in a genuine "contract" between the patient and the nurse in charge of them, *i.e.* the patient would tolerate 30 min of ventilation but asked to be disconnected shortly after the 30 min of NIPSV, because of discomfort or anxiety. Nevertheless, in many patients, it was possible to perform ventilation sessions of >30 min, but rarely >60 min. Thus it was decided, in the present study, to stop the ventilation sessions after 60 min of NIPSV, or precociously if the patients presented discomfort or anxiety. The method of sequential ventilation is appreciated by the nursing staff of this ICU. Indeed, most of the ventilation sessions are planned in the same way as the majority of other treatments performed in the ICU. Between ventilation periods, the safety of patients is assured by continuous monitoring of their haemodynamic state (f_R and S_{a,O_2}) and the possibility of returning them to NIPSV if their S_{a,O_2} is <85% or when dyspnoea worsens with an f_R of >30 breaths·min^{-1}. The method of sequential ventilation has also contributed to the standardization of techniques of NIPSV in Pellegrin Hospital ICU. It has not been necessary to modify the organization of the unit since the introduction of these new techniques. This is in keeping with the experience of PENNOCK *et al.* [22], based on several years of practice of noninvasive ventilation. Nevertheless, the impact of the sequential mode used on nurse time consumption can be demonstrated only by a comparison with other methods. In the present study, nurses evaluated their workload themselves; it would be equally interesting to study a comparison between methods of NIPSV use in which the amount of time spent on interventions would be measured by a person not involved in the study.

During the first 24 h after enrolment, there was no difference in the amount of time spent by nurses on a ventilation session between patients successfully ventilated with NIPSV and those who failed with NIPSV. Similarly, the mean durations of NIPSV sessions were comparable between success and failure patients. Thus it would appear that only a minority of failures of NIPSV could be related to major difficulties in the application of the technique. It is likely that failures of the method are more often due to the severity of the acute respiratory failure as demonstrated by AMBROSINO *et al.* [25], and especially to the lack of rapid improvement in blood pH [4, 6, 21, 24, 25, 26].

After the first 24 h after enrolment, the nurse time consumption dropped significantly and was only 15% of the ventilatory time. Between the first 24 h and the subsequent period of 24 h, the mean duration of NIPSV was not different (397 *versus* 384 min in group I and 340 *versus* 330 min in group II); conversely, the nursing time dropped significantly between these periods (98 *versus* 59 min in group I ($p<0.05$), and 85 *versus* 52 min in group II ($p<0.05$)). This is in accord with the results of the study of VITACCA *et al.* [3], in which nurse workload appeared concentrated on the first day of ventilation. The significant drop in nurse workload was observed for both the technical and psychological parts of the overall assistance time, and this for both groups of patients. It is equally important to remember that failures of NIPSV recorded in the present study occurred at an early stage. The period between inclusion in the study and intubation was 14±12 h (median 12 h) for the 14 patients in group I and 17±13 h (median 14 h) for the eight patients in group II requiring intubation. It would appear, therefore, that once the patient has managed to complete the first 24 h, NIPSV becomes easier to administer. The initial beneficial effects of NIPSV can be considered as a means of encouraging the patient and personnel to continue the sessions of ventilation under favourable conditions until a complete recovery from acute respiratory failure is achieved.

Concerning the detail of the nurse workload, the psychological help time given by the nurses for a ventilation session has been found, for the overall study and for both groups of patients, to be, at the very least, equal to the technical support time. This clearly underlines the importance of the patient/personnel relationship in the application of NIPSV. The motivation of the personnel, their training in providing detailed explanations to the patients and the experience acquired through several years of utilization of NIPSV techniques are the basis of a quality relationship with the patient. The authors are in agreement with MEDURI *et al.* [21] who stated that an educational and supervision programme is essential for successful implementation of the methods of noninvasive ventilation. In Pellegrin Hospital ICU, the personnel benefit from training in the techniques of ventilation provided by the medical doctors, respiratory therapists and most experienced nurses.

In conclusion, the nurse time was not different between the two populations in the study; the nurse time consumption per session was 25% of the ventilatory time during the

first 24 h after enrolment, and dropped significantly to 15% of the ventilatory time after the first 24 h. The study seems to favour a quite low assistance time spent by nurses in relation to ventilatory time when noninvasive pressure support ventilation is used in selected chronic obstructive pulmonary disease patients. These good results, recorded within a medical intensive care unit in which the nurses are very experienced in the techniques of noninvasive pressure support ventilation, do not have to mask difficulties met during the apprenticeship of these techniques and/or when noninvasive pressure support ventilation is indicated in patients whose acute respiratory failure is more severe than that of the patients included in the present study. Nevertheless, the experience gradually acquired by the different units, regular training of personnel and further technological improvements in interfaces and ventilators are likely to improve conditions for performing noninvasive pressure support ventilation in the future.

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