Manual Therapy, Posturology & Rehabilitation Journal
formerly REVISTA TERAPIA MANUAL

RESEARCH ARTICLE

http://dx.doi.org/10.17784/mtprehabjournal.2015.13.265

Use of noninvasive ventilation for acute respiratory failure in intensive care unit.

Uso da ventilação não invasiva na insuficiência respiratória aguda em unidade de terapia intensiva.

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ABSTRACT

Introduction: The noinvasive ventilation (NIV) has been an important resource for the management of acute respiratory failure (ARF) in intensive care unit (ICU). Several factors related to the patient, the healthcare team and the equipment used can influence in the success or failure of this therapy. Therefore, it is beneficial to analyze the use and effectiveness of NIV in everyday practice, which may lead to shorter hospital staying, reduce costs, and decrease mortality rate. **Objective:** To observe the use of NIV in patients with ARF in ICU. **Methods:** Prospective and observational study, assessing 37 patients aged over 18 years, who undergone NIV in ICU for ARF. The volunteers were assessed for clinical characteristics, physiological parameters, and outcome. The sample was divided into success group - SG (nonintubated patients after NIV use) and failure group - FG (intubated patients after NIV use). **Results:** The NIV was successful in 18 (48.6%) subjects and failed in 19 (51.4%) of them. Acute pulmonary edema was the main reason (62.4%) of ARF found. The FG compared to SG showed longer duration of NIV use ($p = 0.05$), lower arterial pH ($p = 0.00$), higher $PaCO_2$ ($p = 0.02$) greater accumulated water balance within 24 hours ($p = 0.03$) and 72 hours ($p = 0.05$) prior to the last use of NIV. It was also observed that the FG patients had higher hospital mortality rate, as follows: 73.8% versus 16.7% of FG SG ($p = 0.00$). **Conclusion:** The FG had a longer ICU staying and higher mortality rate. Moreover, the consciousness levels, the pH level, $PaCO_2$ and cumulative fluid balance appear to contribute to the success or the failure of NIV.

Keywords: Noninvasive ventilation; Positive-pressure respiration; Respiratory Insufficiency; Intensive care units; Intensive care.

RESUMO

Introdução: A ventilação não invasiva (VNI) tem se mostrado um recurso importante para o manejo da insuficiência respiratória aguda (IRpA) em unidade de terapia intensiva (UTI). Diversos fatores relacionados ao paciente, a equipe de saúde e ao equipamento utilizado podem influenciar no sucesso ou insucesso dessa terapia. Por isso, torna-se salutar analisar o uso e a eficácia da VNI na prática cotidiana, o que pode levar a menor tempo de internação, reduzir custos, e diminuir a taxa de mortalidade. **Objetivo:** Observar a utilização da VNI em pacientes que apresentaram IRpA em UTI. **Método:** Estudo observacional e prospectivo, avaliando 37 pacientes, maiores de 18 anos, submetidos à VNI por IRpA em UTI. Os voluntários foram avaliados quanto a características clínicas, parâmetros fisiológicos, e desfecho. A amostra foi dividida em grupo sucesso – SG (pacientes não intubados após uso da VNI) e grupo falência – FG (pacientes intubados após uso da VNI). **Resultados:** A VNI obteve sucesso em 18 (48,6%) sujeitos e falhou em 19 (51,4%). O edema agudo de pulmão foi o principal motivo (62,4%) de IRpA encontrado. O FG, em relação ao SG, apresentou maior tempo de uso da VNI ($p=0,05$), menor pH arterial ($p=0,00$), maior $PaCO_2$ ($p=0,02$), maior balanço hídrico acumulado dentro das 24h ($p=0,03$) e 72h ($p=0,05$) antes da ultima utilização da VNI. Observou-se também que os pacientes do FG apresentaram maior taxa de mortalidade hospitalar, a saber: 73,8% do FG *versus* 16,7% do SG ($p=0,00$). **Conclusão:** O FG teve maior tempo de internamento na UTI e maior mortalidade. Além disso, o nível de consciência, os níveis de pH, de $PaCO_2$ e balanço hídrico acumulado parecem contribuir para o sucesso ou a falência da VNI.

Palavras-chave: Ventilação não invasiva; Respiração com pressão positiva; Insuficiência Respiratória; Unidades de Terapia Intensiva; Terapia Intensiva.

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Financial support: This study was developed with own resources.

Submission date 15 June 2015; Acceptance date 16 September 2015; Online publication date 28 September 2015

INTRODUCTION

The role of noninvasive ventilation (NIV) in the management of acute respiratory failure (ARF) is recognized, particularly in patients with chronic obstructive pulmonary disease (COPD) exacerbated or acute pulmonary edema (APE). In such cases, it has been observed the decrease in length of hospital stay, in the intubation rate and complications related to invasive mechanical ventilation (IMV).[1-3]

The NIV indications are expanding. There are studies proving its benefits in a number of respiratory dysfunction, among them: hypoxemia, hypercapnia, atelectasis, apnea, laryngeal edema, aid in the early weaning from IMV, and prevention of complications after extubation time. For this reason, its use in intensive care units (ICU) are becoming more frequent and safe.[4-6]

Nevertheless, the management of ARF creates a dilemma of professional assistants, especially in relation to ready endotracheal intubation (EI) or attempting institution of NIV. Failure to perceived severity of the patient by the team contributes to the failure of NIV, which is related to a worse prognosis possibly postpone elective EI.[7]

Accordingly, the use of NIV is related to variables that can lead to success or failure of therapy, among these: the clinical condition and careful patient selection, site particularities where treatment is provided, and the technical skill of staff of health. Currently, there are still emergency rooms and ICUs that do not use NIV due to lack of equipment and trained staff.[8,9]

Such factors can be the cause for discrepancies between results of clinical trials and clinical practice. So it becomes important to evaluate the use and effectiveness of NIV, not only in clinical trials, but also in daily practice, which could lead to shorter hospital stays, reduce costs, and decrease mortality rates.[8]

Based on these, the aim of this study was to analyze the use of NIV in patients with ARF board after admission to the ICU of a high complexy university hospital.

METHOD

This is a prospective observational study, with a quantitative approach, developed in intensive care units (ICU) of the Universitary HospitalOnofre Lopes - UHOL from February 2012 to June 2013.

The sample consisted of subjects who used NIV after ICU admission, recruited consecutively for convenience. They were eligible those aged over 18 years who required NIV for ARF. Thus, they should present at least two of the following criteria: a) respiratory rate > 25 breaths per minute; b) use of accessory muscles or paradoxical breathing; c) PaO_2 < 60 mmHg or SaO_2 < 90% on room air or oxygen; d) $PaCO_2$ > 45 mmHg with pH < 7.35.[10]

In turn, individuals with tracheostomy or with insufficient information for the evaluation form fill, and those who had no indication for EI did not participate in the study.

For admission to the research, the participants and their parents were informed about objectives, procedures and methodological character of the work and signed the free and informed consent form (ICF). It is worth noting that this research was conducted according to Resolution 466/12 of the National Health Council (CNS) and approved by the Research Ethics Committee of UHOL, under protocol 532/2011.

Individuals eligible for the study were followed up daily output (discharge or death) from the ICU and the hospital. Data collection was performed using a standardized form designed for research. This instrument was filled with information obtained from medical records of patients.

The main data collected in the form were: age, gender, reason for admission to the ICU, pathological history, type of admission (surgical or clinical), hospital stay in the ICU and in the hospital, reason for the ARF, time of use of NIV, variables physiological pre-installation of NIV (Glasgow coma scale - GCE, vital signs, hydric balance - HB, leucogram and arterial blood gases). In addition, intervention data were recorded (need for supplemental oxygen, inspiratory positive airway pressure - IPAP, expiratory positive airway pressure - EPAP), necessity and because of post NIV intubation and ultimately patient outcome (discharge or death).

The prognostic index at the time of ICU admission was evaluated through the simplified acute physiology score 3 - SAPS 3. The SAPS 3 has the main objective of estimating mortality in the ICU. It is composed of 20 variables, divided into three groups: demographic variables; reasons for ICU admission; and physiological variables. The lower value assigned by the score is 16 and the highest is 217 points.[11, 12]

During the study, subjects were divided into two groups according to their clinical evolution, namely: success group (SG), characterized by the non-EI after use of NIV, and failure group (FG), characterized by the EI by up to 72 hours after use of NIV.[13]

The decision on the use of NIV and the EI fell to the multidisciplinary team studied unit. It is noteworthy that, in the studied hospital, there is no protocol implemented for such procedures. However, among clinical criteria for EI usually practiced in the institution where the study was conducted are: worsening of the underlying disease, worsening level of consciousness with GCS <10, hemodynamic instability or cardiac arrhythmias, agitation who needed sedation, patient's inability to clear secretions, worsening of respiratory acidosis despite repeated adjustments in the NIV, refractory hypoxemia and imminent risk of cardiac arrest.

The data were processed with the software Statistical Package for Social Sciences version 20.0 (SPSS Inc., Chicago, IL, USA, 2011). Initially we applied the Kolmogorov-Smirnov normality test. Comparisons between quantitative variables

were performed using the Student's t-test or Mann-Whitney, and expressed as mean (standard deviation) or median (min-max) respectively. To assess the association between qualitative variables, we used the χ2 test. I was considered level ofsignificance value less than 5%.

RESULTS

During the study period, 37 patients met the inclusion criteria. The NIV was successful in preventing the EI in 18 of these patients (48.6%), which constituted the SG. In turn, 19 subjects (51.4%) who developed the EI and were allocated to the FG. The main clinical characteristics of the patients at the time of ICU admission are described in the Table 1. The main causes found for the appearance of ARF in this study, the APE constituted more than half (62.4%) cases.

Regarding to the technical characteristics of NIV, no differences were found between the groups (Table 2). However, patients in the FG spent more days in the ICU and in this group there was a higher number of deaths. The main reason for EI after the use of NIV and hence therapeutic failure in our study was the ARF (68.4%), followed by the lowering level of consciousness (47.4%).

Table 1. Characteristics of individuals at the time of ICU admission according to success group (SG) and failure group (FG).

	SG (n=18)	FG (n=19)	*p*
Sex			
Men	9 (50.0%)	10 (52.6%)	0.873
Women	9 (50.0%)	9 (47.4%)	
Age (years)	57.1 (+21.9)	63.2 (+14.4)	0.320
SAPS 3			
Score	50.2 (+14.4)	57.0 (+9.4)	0.096
Probability of death (%)	24.7 (+18.4)	31.1 (+17.7)	0.284
Reason for ICU admission			
Clinic	6 (33.3%)	11 (57.9%)	0.134
Surgical	12 (66.7%)	8 (42.1%)	
Reason for ARF			
APE	13 (72.2%)	10 (52.6%)	0.219
Others †	5 (27.8%)	9 (47.4%)	
Comorbidities			
Hypertension	8 (44.4%)	9 (47.4%)	0.858
Diabetes	5 (27.8%)	5 (26.3%)	0.920
Cardiac insufficiency	6 (33.3%)	6 (31.6%)	0.909
Asthma	0 (0.0%)	2 (10.5%)	0.157
COPD	0 (0.0%)	2 (10.5%)	0.157
Renal insufficiency	5 (27.8%)	3 (15.8%)	0.376

SAPS= *Simplified acute physiology score*, ARF = Acute respiratory failure, APE = Acute pulmonary edema, COPD = Chronic obstructive pulmonary disease; † Four cases of pneumonia, two cases of COPD and one case of each of the diagnosis: asthma, upper gastrointestinal bleeding, infection clarify, sepsis without specific focus.

Regarding the physiological parameters and laboratory tests, both groups were similar before the first use of NIV. At the end of the intervention, there was no difference between groups with respect to blood pressure, heart rate and respiratory rate obtained before the first and last use of NIV. However, it was found that the FG at the time before last of NIV, showed lower scores on the GCS, blood pH more acidic, and higher CO_2 concentrations in the blood when compared to the SG. In addition, differences were found between the two groups regarding the accumulated HB of 24 and 72 hours (Table 3).

DISCUSSION

In this study, it was shown that approximately 51% of patients who used the NIV for ARF progressed failed, thus requiring EI. These patients had greater length of stay in ICU and hospital had a higher mortality rate than patients who were successful with NIV. Heart failure and hypertension were the most frequent comorbidities these are among the most common causes of EAP, the main reason for the appearance of ARF in patients evaluated.

Delgado et al.[14] in a recent study enrolled 2131 patients with ARF in ICU and required mechanical ventilation. Of these individuals, 529 (25%) made use of NIV as first choice and failed in 50% of cases.

Probably the FG patients had worse outcomes due to greater severity at the end of use of NIV, since this group had lower GCS, lower pH levels and increased $PaCO_2$.

Table 2. Directions fxor use of NIV and patient assessment according to the success group (SG) and failure group (FG).

	SG (n=18)	FG (n=19)	*P*
Modality of NIV			
IMV (PSV)	11 (38.9%)	10(52.6%)	0.372
BIPAP	7 (61.1%)	9 (47.4%)	
Initial IPAP (cmH_2O)	18 (10-30)	15 (11-30)	0.958
Final IPAP (cmH_2O)	14 (10-30)	15.5 (12-27)	0.391
Initial EPAP (cmH_2O)	7.5 (5-10)	7.5 (5-10)	0.611
Final EPAP (cmH_2O)	7 (6-10)	6.7 (5-10)	0.317
ICU days	10.5 (2-38)	17 (4-60)	0.008
Death in the ICU			
No	17 (94.4%)	8 (42.1%)	0.002
Yes	1 (5.6%)	11 (57.9%)	
Days of hospitalization	43.8 (+29.3)	46.6 (+37.2)	0.802
Death in hospital			
No	15(83.3%)	5 (26.3%)	0.001
Yes	3 (16.7%)	14 (73.7%)	

NIV = Noinvasive ventilation, IMV = Invasive mechanical ventilation, BIPAP = *Bilevel positive pressure airway*, IPAP = Inspiratory positive airway pressure, EPAP = Expiratory positive airway pressure, ICU = Intensive care unit.

Table 3. Physiological and laboratory parameters just before the last use of NIV with respect to success group (SG) and failure group (FG).

	SG *(n=18)*	FG *(n=19)*	*P*
Glasgow			
≥ 10	18 (100%)	10 (52.6%)	0.001
< 10	0 (0%)	9 (47.4%)	
Blood pressure (mmHg)			
Systolic	129.8 (+26.3)	110.4 (+28.9)	0.065
Diastolic	74.6 (+10.7)	65.1 (+18.8)	0.098
Heart rate (breaths per minute)	94.6 (+18.8)	98.1 (+16.9)	0.600
Respiratory rate (beats per minute)	23.07 (+6.9)	21.71 (+5.4)	0.565
Arterial blood gases			
pH	7.43 (+0.05)	7.31 (+0.12)	0.002
PaO_2 (mmHg)	115.7 (+50.5)	96.7 (+43.1)	0.325
$PaCO_2$ (mmHg)	34.3 (+4.7)	54.0 (+29.5)	0.023
SaO_2 (%)	97.1 (+2.3)	91.8 (+8.53)	0.061
Leukocytes (/mm³)	14.10³ (+5.10³)	17.10³(+12.10³)	0.091
Hydric balance (ml)			
24h	-448.9 (+1172.3)	565.2 (+1415)	0.035
72h	125.6 (+2065.7)	1992.4 (+3074)	0.046

24 = cumulative water balance of the 24 hours immediately before the last installation of NIV, 72h = cumulative water balance of the 72 hours immediately before the last installation of NIV; p <0.05 = comparison between SG and FG with statistical significance.

Passarini et al.[15] observing patients with COPD and APE, found that higher scores on the GCS were predictive of success of NIV. Similarly, Confalonieri et al.[16] found that patients with GCS below 11, pH ≥ 7.25, respiratory rate ≥ 30 breaths per minute, and high level predictive of mortality on admission had risk > 70% of failure of NIV.

In observational studies, Yamauchi et al.[13] and Azevedo et al.[7] found a significant relationship between the failure of NIV and lower levels of pH and worse prognosis, explicit through the longer length of stay in ICU and a higher mortality.

Our study also showed a significantly higher cumulative HB in FG than in SG, found in 24 to 72 hours before the last application of NIV, which suggests the need for greater attention to this variable with respect to its relationship to the success or failure of NIV. In this sense, Azevedo et al.[7] found an association between HB accumulated in the first three days of ICU and the failure of NIV. This author suggests that there is a control and close monitoring of the HB in patients with NIV, in order to improve outcomes in this scenario and avoid IMV.

Among the main pulmonary complications of a positive HB are pulmonary congestion and consequent APE, main reason of ARF in this study. Currently, there is clear evidence that, in patients with APE, the use of NIV can avoid EI and its complications, and result in a reduction in length of stay and savings in hospital costs.[17-19]

The EI reasons noted by this research include the ARF and the decreased level of consciousness. Similar results were also found by Yamauchi et al.[13] and Holland et al.[10], which emphasized these same points as the main causes of failure of NIV. Identification of predictive success or failure of NIV can both avoid unnecessary EI as to avoid a late EI and its complications.[20, 21]

In this sense, the implementation of therapy must follow strict criteria for the indication, patient selection and usage mode in order to increase the success rate of therapy without compromising the patient's evolution in case of failure.[22, 23] It is considered that the ability of the team and their level of experience in the use of NIV are critical to the success of the technique. The establishment of strategies based on protocols can assist the team in making decisions, reduce costs and variation of clinical ICU practices, and increase the uptake of evidence-based interventions and reduce errors.[24-26]

Aware that the study exposed here has limitations, it is necessary to expose some of them: the absence of a protocol or standardization for the use of NIV in the ICU studied, little presented sample size, and lack of information about the patient's progress (exams, physiological parameters) for the use of NIV. It is likely that the latter limitations have been intensified by the lack or shortage of information on the patient's chart.

CONCLUSION

The NIV was effective in about 50% of cases with ARF in the ICU, avoiding the need for tracheal intubation. Patients who developed failure of NIV had greater length of stay in the ICU and higher mortality rate. In addition, the level of consciousness, pH and $PaCO_2$ levels and accumulated HB seem to contribute to the success or failure of NIV. It is recommended that these parameters are taken into account in future studies in order to assist in the preparation of NIV use of protocols suitable for local conditions.

AUTHORS CONTRIBUTION

FESM: Design and development of hypothesis; methodological design; collection and processing of data; analysis and interpretation of results; review of the literature; writing of the manuscript. IDBN: methodological design; oversight (organization and execution of the project). ASF: Collecting the data processing; review of the literature. RNISV: methodological design; collection and processing of data. ISS: Statistical analysis, evaluation and presentation of results; critical review. PAMSN: Design and development of hypothesis; oversight (organization and execution of the project), critical review before the final presentation.

COMPETING INTERESTS

The authors declare no conflicts of interest.

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