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ORIGINAL RESEARCH

Non-invasive ventilation in a university hospital intensive care unit: aspects related to success and failure

Ventilação não invasiva na unidade de terapia intensiva de um hospital universitário: características relacionadas ao sucesso e insucesso

Ventilación no invasiva en la unidad de terapia intensiva de un hospital universitario: características relacionadas con el éxito y el fracaso

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ABSTRACT | The objective of this study was to describe the aspects of success and failure of the use of non-invasive ventilation (NIV) in the intensive care unit (ICU) of a university hospital. This is a prospective observational study that included 75 patients, with 58.3±18.8 years as the mean age. Of these, 12 required the use of NIV more than once, for 92 uses in total. Among these, the success rate was 60.9% (56). The failure group had more males (p=0.006) and a higher number of patients diagnosed with extrapulmonary infection (p=0.012). No differences were found between success and failure groups for the variables mode, model, mask, total length of stay and reasons for NIV installation. In the failure group, inspiratory positive airways pressure (Ipap) and flow volume (FV) were higher (p=0.029 and p=0.011, respectively). Peripheral oxygen saturation (p=0.047), pH (p=0.004), base excess (p=0.006) and bicarbonate (p=0.013) presented lower values. This study concluded that male individuals diagnosed with extrapulmonary infection and whose picture evolved with metabolic acidosis evolved with more failure in NIV use. These patients required higher Ipap and FV parameters.

Keywords | Critical Care; Artificial Breathing; Lung Ventilation.

RESUMO | O objetivo deste estudo foi descrever características de sucesso e insucesso do uso da ventilação não invasiva (VNI) na unidade de terapia intensiva (UTI) de um hospital universitário. Trata-se de um estudo observacional prospectivo no qual foram incluídos 75 pacientes, com idade média de 58,3±18,8 anos. Desses, doze necessitaram do uso da VNI por mais de uma vez, totalizando 92 utilizações. Evidenciou-se que, delas, a taxa de sucesso foi de 60,9% (56). O grupo insucesso apresentou mais indivíduos do sexo masculino (p=0,006) e número maior de pacientes com diagnóstico de infecção extrapulmonar (p=0,012). Não foram encontradas diferenças entre os grupos de sucesso e insucesso nos quesitos de modo, modelo, máscara, tempo total de permanência e razões para a instalação da VNI. No grupo insucesso, a pressão positiva inspiratória nas vias aéreas (Ipap) e o volume corrente (VC) foram superiores (p=0,029 e p=0,011, respectivamente). A saturação periférica de oxigênio (p=0,047), o pH (p=0,004), *base excess* (p=0,006) e o bicarbonato (p=0,013) apresentaram valores inferiores. Concluiu-se que os indivíduos do sexo masculino com diagnóstico de infecção extrapulmonar e que evoluíram com acidose metabólica evoluíram com mais insucesso na utilização da VNI. Esses, necessitaram de parâmetros elevados de Ipap e VC.

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Descritores | Cuidados Críticos; Respiração Artificial; Ventilação Pulmonar.

RESUMEN | El objetivo de este estudio fue desarrollar las características del éxito y del fracaso con el uso de la ventilación no invasiva (VNI) en la unidad de terapia intensiva (UTI) de un hospital universitario. Se trata de un estudio observacional prospectivo en el cual fueron incluidos 75 pacientes, con edad media de 58,3±18,8 años. De estos, 12 necesitaron utilizar la VNI por más de una vez, que totalizó 92 utilizaciones. Se evidenció que, de estas, el índice de éxito fue del 60,9% (56). El grupo que no obtuvo el éxito esperado presentó más individuos del sexo masculino (p=0,006) y número mayor de pacientes con diagnóstico de infecciones extrapulmonares (p=0,012). No fueron encontradas diferencias entre los grupos con éxito y sin éxito en las cuestiones de modo, modelo, máscara, tiempo total de permanencia y razones para la instalación de la VNI. En el grupo sin éxito, la presión positiva inspiratoria en las vías aéreas (Ipap) y el volumen corriente (VC) fueron superiores (p=0,029 y p=0,011, respectivamente). La saturación periférica de oxígeno (p=0,047), el pH(p=0,004), *base excess* (p=0,0006) y el bicarbonato (p=0,013) presentaron valores inferiores. De este modo, se concluye que los individuos del sexo masculino con diagnóstico de infecciones extrapulmonares y que progresaron con acidose metabólica avanzaron más sin tener éxito en la utilización de la VNI. Además, necesitaron de parámetros elevados de Ipap y VC.

Palabras clave | Cuidados Críticos; Respiración Artificial; Ventilación Pulmonar.

INTRODUCTION

The use of non-invasive ventilation (NIV) for the treatment of patients with acute respiratory failure or acute chronic respiratory failure disease has been growing, being under growing development and having great importance in the field of mechanical ventilation[1].

NIV use in patients with severe chronic obstructive pulmonary disease (COPD)[2-5]and acute pulmonary edema (APE)[6-9] is responsible for decreasing the need for orotracheal intubation (OTI), mortality, and therapy costs[10-12]. Moreover, NIV is used as a weaning strategy in patients with repeated failures in the spontaneous breathing test and as a preventive way to prevent extubation failure in patients with risk factors[13,14].

Searching for an effective, preventive and not as risky therapy for patients, studies in large hospitals have been developed to identify the profile of patients who use NIV[15-21], in addition to those with a strong recommendation for use (COPD and APE patients). The daily observation of the use of NIV in clinical practice and its limitations are potential targets for improving results in intensive care units (ICU), to improve the therapy offered to patients and to enable future research. Given this context, this study aimed to describe aspects of success and failure of the use of NIV in the ICU of a university hospital.

METHODOLOGY

This is a prospective observational study conducted from May to October 2014. Inclusion criteria were: patients older than 18 years old, of both sexes, who used NIV in the ICU of the University Hospital of Universidade Federal de Santa Catarina (HU/UFSC). The exclusion criterion was the lack of data in patients' records.

Patients were evaluated and observed daily from admission to discharge from the ICU and hospital, or even death. Individuals who used NIV more than once during the hospitalization period were considered as a new individual, i.e., data analysis considered the total number of NIV uses. The decision for indicating and setting the NIV, and its parameters, was made by the multiprofessional team of this ICU.

Participants and/or responsible family members signed an informed consent form. This research was approved by the Research Ethics Committee on Human Beings of UFSC under CAAE no. 25677213.5.0000.0121.

Data were obtained from the filling of an evaluation form prepared by the authors and based on the literature. The analyzed variables were age, sex, origin, consciousness level, severity score, and clinical diagnosis. Regarding NIV: reason for use, total length of stay, modes, model, masks and parameters, arterial blood gas and vital signs.

Success in the use of NIV was considered as OTI prevention and not using NIV for more than 72 hour after discontinuation[20]. The need for OTI, regardless of the time of NIV use, was defined as failure[20].

Continuous variables were expressed as mean and standard deviation (SD). Categorical variables were presented in frequency. Data normality was tested by the Kolmogorov-Smirnov test. Significant difference between groups was analyzed by the independent t-test

for the normal variables and by Mann-Whitney's U test for non-parametric variables. The association between the categorical variables was analyzed using the Chi-square test or Fisher's exact test. A p-value ≤0.05 was considered. All analyses were performed using the software SPSS Statistics, version 22.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

During the study period (five months), 328 patients were admitted to the ICU, of whom 80 used NIV. Five patients were excluded due to lack of information in their medical records. Twelve patients used NIV more than once during the hospitalization period, totaling 92 uses.

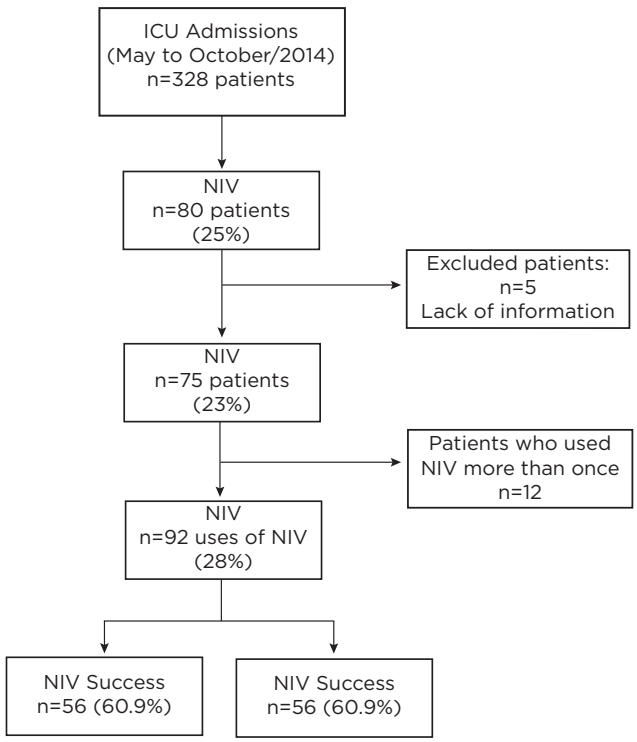

Figure 1. Study design flowchart
ICU: Intensive Care Unit; NIV: Non-invasive ventilation.

Table 1 presents the values referring to sample characterization. The failure group had more males (p=0.006) and a higher number of patients diagnosed with extrapulmonary infection (p=0.012).

The success rate of NIV use was 60.9%. No differences were found between success and failure groups for the variables mode, model, mask, total length of stay and reasons for NIV installation. The most used mode was Bilevel (94.6%), on the Synchrony model (77.2%) and V60 (12.0%) with total face mask (98.9%). Most subjects were kept for less than 24 hours on NIV (51.1%), followed by those who used NIV for more than 48 hours (35.9%). Regarding the initial NIV parameters, it was observed that inspiratory positive airway pressure (Ipap) and flow volume (FV) were higher in the failure group (p=0.029 and p=0.011), with an overall Ipap 15.9±2,8cmH_2O mean and FV 575.6±165.2mL mean.

Table 1. Sample characterization

Variable	Total n=75	Success n=45 (60%)	Failure n=30 (40%)	p-value
General characteristics, mean±SD				
Age (years)	58.3±18.1	56.3±20.1	61.3±14.4	0.414
Males, n (%)	33 (44)	14 (31.1)	19 (63.3)	0.006
Consciousness level (Glasgow scale)	13.3±2.03	13.4±1.9	13.2±2.1	0.718
SAPS III (points)	66.1±14.4	63.7±15.8	69.8±11.5	0.058
SAPS III (%)	49.2±25.1	45.2±27	55.2±21.2	0.08
Diagnosis for ICU admission, n (%)				
Post-operative abdominal surgery	20 (26.7)	14 (31.1)	06 (20)	0.425
Lung infection	15 (20)	10 (22.2)	5 (16.7)	0.556
COPD	12 (16)	8 (17.8)	4 (13.3)	0.752
Extrapulmonary infection	10 (13.3)	2 (4.4)	8 (26.7)	0.012
APE	6 (8)	3 (6.7)	3 (10)	0.678
Onco-hematological diseases	3 (4.6)	1 (2.2)	2 (6.7)	0.56
Asthma	2 (2.7)	2 (4.4)	0 (0)	0.514
Neuromuscular diseases	1 (1.3)	1 (2.2)	0 (0)	
Others	6 (8)	4 (8.9)	2 (6.7)	
Origin				
Emergency	30 (40)	17 (37.8)	13 (43.3)	0.63
Surgical center	18 (24)	12 (26.7)	6 (20)	0.508
Other hospitals	15 (20)	10 (22.2)	5 (16.7)	0.556
Hospital Stay	12 (16)	6 (13.3)	6 (20)	0.44
Length of stay				
Hospital (days)	27.5±26.7	25.7±19.3	30.3±35.2	0.918
ICU (days)	13.6±16	10.2±8.6	18.6±22.3	0.058

Method: Chi-square test. Fisher's test. Student's t-test. Mann-Whitney's U test.
SAPS: Simplified Acute Physiology Score; ICU: Intensive Care Unit; COPD: Chronic Obstructive Pulmonary Disease; APE: Acute Pulmonary Edema.

Table 2 shows the analyses of arterial gases (n=83) and vital signs (n=92) prior to NIV use. Peripheral oxygen saturation value (p=0.047); pH, base excess and bicarbonate values were lower in the failure group (p=0.004, p=0.006 and p=0.013, respectively). The three later variables indicate metabolic disturbances.

Table 2. Analysis of arterial gases and vital signs prior to NIV use

Variables	Total n=83	Success n=51 (61.45%)	Failure n=32 (38.55%)	p-value
Gasometry, mean±SD				
pH	7.36±0.09	7.38±0.09	7.33±0.1	0.004
pCO_2 (mmHg)	44.8±15.2	46.2±15.6	42.4±14.3	0.247
pO_2 (mmHg)	113.6±46.4	115.4±49.2	110.7±41.9	0.658
$SatO_2$(%)	95.1±8.2	94.7±9.8	95.8±4.4	0.614
BE (mEq / l)	0.4±9.7	2.6±9.5	-3.2±8.9	0.006
BIC (mEq/l)	26.4±12	28.9±13.1	22.1±8.5	0.013
Vital signs, mean±SD	**Total n=92**	**Success n=56 (60.9%)**	**Failure n=36 (39.1%)**	
SBP (mmHg)	134.2±30.1	137.3±31.8	129.3±26.8	0.214
DBP (mmHg)	74.4±16.8	76.5±16.1	71.2±17.5	0.143
FC (bpm)	101.8±19.8	101.3±18.5	102.6±21.9	0.753
FR (rpm)	24.6±9.5	24.2±8.2	25.2±11.3	0.63
SpO_2(%)	93±7.9	94.9±5.1	90.1±10.4	0.047

Method: Student's t-test. *Mann-Whitney's U test*.
Pre-NIV: prior to the use of non-invasive ventilation; pH: potential hydrogen; pCO_2: partial carbon dioxide pressure; pO_2: partial oxygen pressure; $SatO_2$: arterial oxygen saturation; BE: base excess; BIC: bicarbonate; SBP: systolic blood pressure; DBP: diastolic blood pressure; HR: heart rate; RR: respiratory rate; SpO_2: Peripheral oxygen saturation.

DISCUSSION

This study showed the use of NIV in different clinical conditions in the daily practice of an ICU, with a 60.9% success rate, confirming data found in other studies, which present success rates between 60 and 70%[15,17,20,22-25].

Regarding the general characteristics of individuals, Yamauchi et al.[20] identified that age was greater in individuals who evolved with NIV failure (p=0.003). This mean is similar to the one found in our study, however, we did not find differences between the groups.

Like Azevedo et al.[21], Yamauchi et al.[20] demonstrated that a high severity score at ICU admission is associated with NIV failure (SAPS II>34), but this was not found in our study.

The main diagnoses were post-operative of abdominal surgery, pulmonary infection, COPD and extrapulmonary infection. Similar rates of pulmonary and extrapulmonary infection, APE and COPD have been found in other studies[21,26]. We must highlight that patients admitted to the ICU with a extrapulmonary infection diagnosis evolved with NIV failure, probably due to the severity of the clinical picture.

In this study, there was no difference in the mean number of hospitalization days in the ICU and in the general hospital between groups, achieving results similar to those found by other authors[21,25]. However, some prospective studies have found that individuals who progressed with NIV failure remained hospitalized for longer periods in the ICU[15,19,20]. In the study by Antonelli et al.,[15] it was demonstrated that NIV failure was related to a high risk of remaining in the ICU for more than seven days, as well as developing complications and progress to death in the ICU.

In most cases, NIV was used in a preventive measure to OTI (48.9%). As the first treatment option, NIV was used in 71% of the cases in the study by Girault. et al.[25]. On the other hand, other studies have shown rates ranging from 15 to 20%[21,22]. NIV as prevention measure for OTI is being used mainly in COPD patient, due to recommendations made for this population[27]. However, NIV use in different clinical conditions has also been observed[28], such as in post-operative abdominal surgery, extrapulmonary infection and onco-hematologic diseases.

Literature presents great variation regarding the time of use of NIV. Some studies have shown a time of use from five hours to periods that exceed 72 hours[24–26]. In this study, NIV use for less than 24 hours was predominant and no differences in time of use were found between groups.

Regarding the initial NIV parameters, the failure group required mean Ipap values and higher FV values than the success group. Likewise, Yamauchi et al.[20] identified higher Ipap values in the failure group (14-16cmH_2O), similar to this study. Probably due to more severe cases such as individuals who required higher values in NIV in an attempt to avoid OTI or reintubation.

Regarding gasometry prior to NIV use, the failure group presented acidotic pH, similar to that found in Carlucci et al.[22]. However, these authors attributed the low pH to high partial CO_2 pressure values. Differently from the findings of our study, in which acidosis was due to low bicarbonate values. *Base excess* and bicarbonate values were lower in the failure group. Rana et al.[16] suggest that patients with low bicarbonate levels may be more susceptible to NIV failure.

Vital signs such as respiratory rate, heart rate, and systolic blood pressure found in this study were similar or lower, when compared to other findings in the literature[16,17,29]. The oxygenation analysis of the individuals in this study was performed through peripheral oxygen saturation, which was lower in the failure group. Rana et al.[16] used the gas exchange index and, likewise, showed that the failure group had lower values when compared to the success group.

NIV failure incidence (39.1%) found in this study was similar to the rates described by other authors[15,17,20,22,24,25]. On the other hand, some studies describe higher rates,

such as 50-74%[16,19,21]. The variation in NIV failure rate seems to be related to the cause of IRpA and to the severity of the disease[15]. In some studies, NIV failure was associated with factors such as clinical severity, presence of acute respiratory distress syndrome, age>40 years, positive water balance, SAPSII>34, pH<7.40, PaO_2:$FiO_2$146 after 1 hour using NIV and Ipap[15,16,21]. Values similar to those found in the failure group of this study, such as: SAPS III> 69, pH=7.33 and Ipap>16.

The non-standardization of gasometric collection made it impossible to obtain blood gas values for comparing prior to and post-NIV use, and the non-establishment of a NIV protocol were the limitations of this study. A larger sample and other statistical analyses are required to infer predictive factors for failure in the ICU population.

CONCLUSION

Non-invasive ventilation was successfully used in most patients and in various clinical conditions in the ICU. Among patients admitted to the ICU during the study period, those with a diagnosis of extrapulmonary infection, males and with metabolic acidosis were the most unsuccessful cases. In addition, those whose clinical picture progressed with NIV failure required higher ICP and FV parameters.

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