

Non-Invasive Ventilation in Hypercapnic Acute Respiratory Failure: Hospital Outcomes and Home Follow-Up

Ventilation non invasive dans l'insuffisance respiratoire aiguë hypercapnique : Prise en charge à l'hôpital et suivi à domicile

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ABSTRACT

Introduction: Non-invasive ventilation (NIV) is beneficial in hypercapnic acute respiratory failure (ARF) for enhancing alveolar ventilation and reducing the need for intubation. Follow-up care is essential for effective management. Our study aims to identify best practices for acute NIV and home follow-up.

Methods: Observational study of hospitalized patients with hypercapnic ARF treated with NIV in the Pneumology Department.

Results: We included 64 patients with a sex ratio of 1.3. The mean age was 66.66 ± 2 years. Respiratory pathologies were dominated by chronic obstructive pulmonary disease (45.3%, n=29), obesity-hypoventilation syndrome (17.18%, n=11), and bronchiectasis (15.8%, n=10). On admission, all patients were in respiratory acidosis (pH = 7.32 ± 0.04 , PaCO₂ = 67.87 ± 11 mmHg, PaO₂ = 55.56 ± 10 mmHg). The mean total duration of NIV use was $7.21 \text{ days} \pm 2.7$. Three groups were defined: group 1 (G1: 46.8%, n=30) (including patients discharged without home NIV), group 2 (G2: 26.6%, n=17) including patients discharged on long-term NIV, and group 3 (G3: 26.6%, n=17) including patients with a delayed indication for NIV. Recurrence of ARF was noted in 26.56% of patients (n=17). The mortality rate was 7.8% (n=5).

Conclusion: A protocol for monitoring and prescribing NIV at home is needed to improve quality of life and survival and prevent ARF recurrence.

Key words: Non-invasive ventilation, Acute respiratory failure, Positive expiratory pressure, Inspiratory support, Hypercapnia

RÉSUMÉ

Introduction : La ventilation non invasive (VNI) trouve sa place dans l'insuffisance respiratoire aiguë (IRA) hypercapnique afin d'assurer une meilleure ventilation alvéolaire et d'éviter le recours à l'intubation. Un suivi ultérieur des patients est nécessaire pour une meilleure prise en charge.

Objectif : déterminer les bonnes pratiques de la VNI en aiguë et le suivi à domicile.

Méthodes : Étude observationnelle descriptive incluant des patients hospitalisés pour une IRA hypercapnique et traités par VNI.

Résultats : soixante-quatre patients ont été inclus (sexe ratio à 1,3, âge moyen à $66,66 \text{ ans} \pm 2 \text{ ans}$). Les pathologies respiratoires étaient dominées par la bronchopneumopathie obstructive chronique (BPCO) (45,3%, n=29), un syndrome d'obésité- hypoventilation (SOH) (17,18%, n=11), une dilatation des bronches (DDB) (15,8%, n=10). À l'admission, tous les patients étaient en acidose respiratoire (PH= $7,32 \pm 0,04$, PaCo₂= $67,87 \pm 11$ mmHg, PaO₂= $55,56 \pm 10$ mmHg). La durée totale moyenne d'utilisation de la VNI était de $7,21 \text{ jours} \pm 2,7$. Trois groupes ont été définis : groupe 1 (G1 : 46,8%, n=30) (incluant des patients sortants sans VNI à domicile), groupe 2 (G2 : 26,6%, n=17) incluant des patients sortants sous VNI au long cours, et groupe 3 (G3 : 26,6%, n=17) incluant des patients ayant une indication à la VNI mais de façon différée. Une récurrence de l'IRA était notée chez 26,56% des patients (n=17). Le taux de mortalité était de 7.8% (n=5).

Conclusion : Un protocole de suivi et de prescription de la VNI à domicile est nécessaire afin d'améliorer la qualité de vie, la survie et prévenir la récurrence de l'IRA.

Mots clés:

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INTRODUCTION

Acute respiratory failure (ARF) is a syndrome defined by an acute alteration in hematosiis related to the failure of one or more respiratory system components. A distinction is made between type I ARF, known as hypoxemic respiratory failure, and type II ARF, known as hypercapnic respiratory failure (1). A study carried out in the United States showed that the incidence of ARF was 137.1 per 100,000 people, with a high mortality rate estimated at 29% to 42% (2,3). This incidence increases almost exponentially every decade up to age 85 (2).

Hypercapnic ARF is considered a major and distracting event in the evolution of chronic respiratory diseases. Its therapeutic management requires a multidisciplinary approach involving several healthcare professionals and the patient's active involvement in managing their disease. The role of non-invasive ventilation (NIV) in this management is well established (4,5). It is a ventilatory assistance procedure designed to improve alveolar ventilation, reduce respiratory muscle work, and avoid invasive ventilation and its complications (6,7).

The development of portable ventilators and improved interfaces has enhanced home management for patients requiring long-term ventilation. A research study in France identified approximately 115,000 patients using continuous positive airway pressure (CPAP) or NIV, an increase of over 131% in the past decade. Despite the potential benefits of home NIV, the discussion remains contentious due to the high risk of recurrent ARF and possible fatal events in the following year (8,9).

Currently, there are few studies on the follow-up of patients who survive hypercapnic ARF requiring NIV, as well as on the indications for using NIV at home in a stable condition. Thus, this study aims to assess the frequency of NIV use in ARF, provide data on patient tolerance, and determine outcomes for those requiring NIV during the acute episode and afterward.

METHODS

Study Design and Setting

The Department of Respiratory and Sleep Medicine at Hedi Chaker University Hospital of Sfax, Tunisia, conducted a prospective observational cohort study. Data collection was performed from the end of October 2021 to the beginning of November 2022. Ethical approval was obtained from the local ethics committee (Comité d'éthique du CHU Hédi Chaker de Sfax, Tunisie). The work was conducted with full respect for patient confidentiality and anonymity.

Population

All Tunisian adults aged ≥ 18 who were hospitalized for ARF and required the use of NIV for the first time were eligible for the study. All patients under eighteen who were already on NIV or had a contraindication to NIV were not included in the study (10). Patients were followed up regularly at our consultation at 1, 3, 6, 9 and 12 months

after discharge.

Data collection

Baseline characteristics and clinical data

The study collected socio-demographic data, including age, gender, marital status, and socio-economic level.

Pathological history data were collected, including smoking and alcohol consumption habits, anthropometric characteristics, Charlson Score (CCI) (11), clinical, and therapeutic features. We noted the pharmacological treatment taken by each patient during hospitalization and at discharge. Several measures were used as follows:

- The Modified Medical Research Council (mMRC) Dyspnea Scale assesses the degree of baseline functional disability due to dyspnea (12).
- Visual analog scales (VAS) assess fatigue and pain during hospitalization, discharge, and each follow-up.
- The Epworth Sleepiness Scale (ESS) assesses sleepiness. A score above 9 indicates excessive daytime sleepiness.

Paraclinical data

Paraclinical features were collected and we used several measures as follows:

- Arterial blood gases were measured in room air during the day by puncture of the radial artery. Arterial blood gas (ABG) data were recorded at admission, and discharge, 15 days later, and every 3 months up to one year of follow-up. PH, carbon dioxide partial pressure (PCO₂) (mmHg), oxygen partial pressure (PaO₂) (mmHg), calculated bicarbonate level (HCO₃) (mmol/L), and arterial oxygen saturation (SaO₂) (%) were collected.
- Plethysmography: Simple spirometry and total body plethysmography were performed in stable conditions using a plethysmograph (Medisoft, Belgium) following the recommendations of the American Thoracic Society/European Respiratory Society ATS/ERS (13,14) and its 2022 updates. Forced expiratory volume at first second (FEV₁, in liters), forced vital capacity (FVC, in liters), FEV₁/FVC ratio (dimensionless, expressed as a percentage), and total lung capacity (TLC, in liters) were compared with local spirometric standards calculated from patient height, weight, and age using ERS equations. The Lower Limit of Normal (LLN), defined as the 5th percentile of predicted values, was used as the threshold for interpreting lung function results.
- An obstructive ventilatory disorder (OVD) was defined by an FEV₁/FVC ratio < LLN. Spirometric definition of COPD was defined by a post-bronchodilator FEV₁/FVC ratio < 0.70. Severity was classified based on FEV₁ % predicted, according to GOLD criteria (Mild: FEV₁ $\geq$ 80% predicted, Moderate: 50% $\leq$ FEV₁ < 80% predicted, Severe: 30% $\leq$ FEV₁ < 50% predicted, Very severe: FEV₁ < 30% predicted).
- A restrictive ventilatory disorder (RVD) was defined by a TLC < LLN. Severity was defined based on TLC % predicted, as follows: Mild: TLC 65–80% predicted, Moderate: TLC 50–64% predicted, Severe: TLC < 50% predicted.
- A mixed ventilatory disorder was defined by both FEV₁/

FVC ratio < LLN and TLC < LLN (15).

Nocturnal polygraph recording: A level-three portable ventilatory polygraph, including recording of oronasal flow (ornasal air pressure transducer), thoracoabdominal movements (respiratory inductance plethysmography), body position, nocturnal oxygen saturation (SpO₂, in %), heart rate (beats per minute) (pulse oximetry) and snoring (microphone placed on the anterior neck), was performed for all patients. Respiratory events were manually recorded by a sleep specialist according to the American Academy of Sleep Medicine (AASM) guidelines (15).

Nocturnal oximetry: assess the oxygen desaturation index per hour (ODI, events/hour), the average transcutaneous oxygen saturation during the night (nSpO₂, in %), and the total sleep time with nSpO₂ below 90% (T90%, in minutes or % of total sleep time).

Echocardiography: The following echocardiographic data were recorded: left ventricular ejection fraction (LVEF, in %), left ventricular (LV) mass index (in g/m²), left ventricular diastolic function, and pulmonary artery systolic pressure (PAPS, in mm Hg). Eccentric left ventricular hypertrophy was defined by a left ventricular mass index (LVM) > 47 g/m² with relative wall thickness (RWT) less than 0.45 (16). Left ventricular diastolic function was assessed by mitral E/A ratio and tissue Doppler evaluation (20). Pulmonary hypertension (PH) was suspected by an estimated PAPS > 35 mm Hg, while a pressure > 45 mm Hg was considered indicative of moderate to severe PH (16).

NIV characteristics and efficacy criteria

The characteristics of the NIV were collected [(Modalities, type of mask used, NIV machine level, Duration of use, and NIV parameters: positive inspiratory pressure (IPAP, in cm H₂O), positive expiratory pressure (EPAP, in cm H₂O), inspiratory aid (IA, in cm H₂O), and safety respiratory rate (SR)].

The clinical and paraclinical evolution was specified in all patients, as well as the tolerance and efficacy of NIV.

- NIV efficacy criteria (5) :

- No need for intubation with a favorable outcome.
- Respiratory rate < 25 cycles/minute.
- SpO₂ > 90%.
- Decrease in PaCO₂ (in mm Hg) after 1 to 2 hours of NIV use.
- Increase in pH 1 to 2 hours after initiation of NIV.

- NIV failure: NIV failure was defined by the need for intubation and transfer of the patient to intensive care or death.

Statistical Analysis

All statistical analyses were conducted using IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize the data.

Continuous variables were expressed as mean ± standard deviation (SD) for normally distributed data, and as median with interquartile range (IQR) when the distribution was non- normal (as assessed by the Shapiro–Wilk test). Categorical variables were presented as absolute frequencies (n) and relative frequencies (percentages, %).

Comparisons between groups were performed using the Student's t-test or Mann–Whitney U test for continuous variables, and the Chi-square test or Fisher's exact test for categorical variables, as appropriate. A p-value < 0.05 was considered statistically significant.

Additionally, box plot visualization and advanced data processing were performed using RStudio (Version [insert version], R Foundation for Statistical Computing, Vienna, Austria) to illustrate the distribution and variability of key continuous variables.

RESULTS

Clinical features

During the study period, 938 patients were hospitalized in the pneumo-allergology department of the CHU Hédi Chaker de Sfax for pulmonary pathology, of whom 64 (6.8%) were hospitalized for a first episode of hypercapnic ARF. The hospital frequency of hypercapnic ARF was 682 per 10,000 hospital admissions. The mean age of our patients was 66.66 ± 2 years, with a sex ratio of 1.3. More than half the patients lived in urban areas (61%). Active smoking was noted in 37.5% of cases, and seven patients had chronic alcohol consumption (11%). Several medical conditions were noted in the patients included in the present study, with a mean CCI of 3.63 ± 1.23.

Respiratory pathologies were dominated by chronic obstructive pulmonary disease (SOH) (45.3%, n=29), obesity hypoventilation syndrome (OHS) (17.8%, n=11), bronchiectasis (15.8%, n=10), and asthma (14%, n=9). Less common respiratory conditions included neuromuscular diseases (3.1%, n=2).

The main comorbidities observed in the overall sample were arterial hypertension (n=20; 31%), heart failure (n=10; 16%), coronary artery disease (n=9; 14%), and atrial fibrillation (n=5; 8%).

Dyslipidemia was noted in 13 patients (20.3%), diabetes in 11 patients (17.18%), and hypothyroidism in 3 patients (4.68%).

Chronic respiratory failure was noted in 12.5% of patients (n=8) (COPD: n=5, OHS: n=2, and bronchiectasis: n=1).

Paraclinical findings

Plethysmography was performed in 62.5% of patients (n=40). Patients with COPD had a mean post-bronchodilator FEV₁ of 1.1 L (51%), a mean FVC of 2.29 L (53.2%), and an obstructive profile confirmed by a mean FEV₁/FVC ratio of 59.15%. Obstructive ventilatory disorder was classified as severe to very severe in 10 cases. For patients with OHS, the mean TLC was 5.52 L (93%). A moderate to severe restrictive syndrome was noted in 4 patients (Table I).

Table 1. Plethysmography of patients according to pathology

Variables / Groups	COPD (n=20)	OHS (n=8)	Other (n=12)	Total (n=40)
FVC (L)	2,38(±1,6)	2,35(±1,2)	1,86(±0.83))	2,26(±1.4)
FVC (%)	53,26(±18)	63,14(±17)	52,36(±27.8)	53,52(±20)
FEV1 (L)	1,14(±0,55)	1,82(±0.8)	1,39(±0.688)	1,32(±0.78)
FEV1 (%)	51,80(±16)	62,57(±27)	1,39(±28)	43,20(±22)
FEV1/FVCratio (%)	59,15(±15)	76,62(±16)	78,37(±11.9)	67,31(±16)
TLC (L)	6,20(±1,6)	5,52(±1.4)	5,14(±1.5)	5,62(±1.8)
TLC (%)	102,70(34)	93.66(±17)	97,57(±40)	98,77(37)

FVC: Forced vital capacity. FEV1: Forced expiratory volume at first second. TLC: total lung capacity. COPD: chronic obstructive pulmonary disease. SOH: obesity hypoventilation syndrome

Thirty-two patients had undergone type 3 ventilatory polygraphy during the night. It was found that 5 patients (45.45%) with a history of OHS and 5 patients with a history of COPD (17.24%) were suffering from OSAHS. The

median T90% (time spent with oxygen saturation <90%) was 47%. The mean saturation was 87%. For patients with OHS, mean saturation was lower, at 85%, with a mean minimum saturation of 68% (Table II).

Table 2. Ventilatory polygraphy by respiratory pathology

Variable s / Groups	COPD (n=15)	OHS (n=10)	Other(n=7)	Total (n=32)
Mean AHI (/h)	21,14(±6)	35,62(±11)	11,49(±6.2)	11,5(±10)
Average SpO2 (%)	89,00(±4)	85,64(±4.7)	87,20(±6.9)	87,6(±5)
Minimum SpO2 (%)	74,55(±9)	68,23(±10.5)	73,66(±14.7)	73,6(±12)
IOD (/h)	24,35(±7.1)	35,57(±11)	14,74(±6.6)	14,5(±11)
Mean T90% (%)	47,94(±17)	34,84(±11)	58,59(±10.9)	59,2(±7)

AHI: Apnea Hypopnea Index. Average SpO2: Average pulse oxygen saturation during polygraph recording. Minimum SpO2: Minimum pulsed oxygen saturation during polygraph recording. IOD: Index of oxygen desaturation. T90%: Time spent with oxygen saturation <90%. COPD: chronic obstructive pulmonary disease. OHS: obesity hypoventilation syndrome.

Echocardiography was performed in 48 patients during hospitalization or within a few weeks of discharge. The mean LVEF was 57%, with extremes ranging from 30% to 70%. Seven patients had an LVEF ≤50%. All patients had LV hypertrophy, and the median mass index was 202 g/m² with extremes ranging from 111 to 35g/m² (normal value: male: 111-134/ female: 100-125). LV diastolic dysfunction was noted in 6 cases (9.3%). Twenty-four patients (37.52%) had moderate to severe pulmonary hypertension, 15 of whom (23.43%) had dilated right cavities. seventy percent of patients were on long-acting beta2mimetic bronchodilators (n=45), and 26.56% of patients (n=17) were on anticholinergic bronchodilators.

Twelve percent of patients (n=8) were on long-term home oxygen therapy, while 7% were on non-invasive home ventilation of the continuous positive airway pressure (CPAP) type. Nine patients (14%) were on diuretic therapy for right heart failure.

Characteristics of acute hypercapnic respiratory failure

In 65.62% of patients (n=42), hypercapnic ARF occurred in the course of known Chronic respiratory failure. The main triggers of hypercapnic ARF according to pulmonary pathology are described in Table (III).

Table 3. Main triggers of hypercapnic acute respiratory failure according to pulmonary pathology

Variables n(%) / Groups	COPD (n=29)	OHS (n=11)	Other(n=24)	Total (n=64)
Acute viral bronchitis	13(44,81%)	1(9%)	14(58,33%)	28(43,75%)
Acute bacterial bronchitis	5(17,24%)	5(45.45%)	1(4,16%)	11(17,18%)
Bacterial pneumonia	4(13,79%)	0	3(12,5%)	7(11%)
Extra-respiratory infection	0	0	1(4,16%)	1(1,56%)
Pulmonary edema	5(17,24%)	5(45,45%)	1(4,16%)	1(17,18%)
Pulmonary embolism	0	0	1(4,16%)	1(1,56%)
Rhythm disorders	0	0	1(4,16%)	1(1,56)
High O2 flow	2(6,89%)	0	2(8,33%)	4(6,25%)

COPD: Chronic obstructive pulmonary disease. OHS: Obesity Hypoventilation Syndrome

On admission, the mean Mmrc score was 3.61 ± 0.5 . Most patients (94%) had an MMRC dyspnea score greater than 2. The mean ESS score was 8.6. Thirty-seven percent of patients had excessive daytime sleepiness. All patients had daytime fatigue with pain averaging 5.19 and 5.03, respectively on the VAS. The mean body mass index (BMI) was $26.19 \text{ (Kg/m}^2\text{)}$. Only twelve patients (18.75%) had a BMI below 25. Neurological signs of hypercapnia were noted in 7 patients (10.9%). Thirty patients (46.8%)

had signs of right heart failure on clinical examination, 10 of whom were being monitored for OHS. All patients presented with respiratory acidosis: mean PH was 7.32, mean PaCO₂ 67.87mmHg, mean PaO₂ 55.56 mmHg, mean HCO₃⁻ 33.17 mmol/l with median SaO₂ 83.8%. Patients followed for SOH had a more acidic PH than others, with a mean value of 7.29 with higher PaCO₂ levels (mean PaCO₂ at 73 mmHg) (Table IV).

Table 4. Patients' arterial blood gases on admission by pulmonary pathology

Variables / Groupes	COPD (n=29)	OHS (n=11)	Other (n=24)	Total (n=64)
PH (Mean)	7,32(±0.03)	7,29(±0.05)	7,32(±0.047)	7,32(±0.04)
PaCO ₂ (mmHg) (Mean)	65,56(±15)	73,30(±19)	67,64(±13,9)	67,87(±11)
PaO ₂ (mmHg) (Mean)	54,57(±11)	55,33(±6,6)	56,83(±10,58)	55,56(±10)
HCO ₃ ⁻ (mmol/l) (Mean)	32,77(±5)	33,49(±7,4)	34,14(±7,1)	33,17(±6)
SaO ₂ (%) (Mean)	83,78(±9.2)	85,33(±7.3)	83,90(±10,40)	83,87(±9,7)

COPD: Chronic obstructive pulmonary disease. OHS: Obesity Hypoventilation Syndrome. PaO₂: Partial pressure of arterial oxygen (mm Hg), PaCO₂: Partial pressure of arterial carbon dioxide (mm Hg), HCO₃⁻: Bicarbonate concentration (mmol/L), SaO₂: Arterial oxygen saturation (%)

Level 1 NIV devices were used in the majority of patients (48, 76%). Seven patients used level 3 NIV devices, 2 of whom were being monitored for neuromuscular diseases. Fifty-eight patients (91%) used a face mask during hospitalization, of whom 4 patients (6%) changed to a nasal mask and only 2 patients (3%) used a nasal mask from the start. The mean IPAP was 10.5 (COPD: 9.5; OHS: 11.5). The safety frequency was between 12 and 16, with a mean frequency of 13.5/min. Most patients demonstrated good compliance with NIV, with an initial acceptance rate of 79.68%. The average daily use of NIV was 8 hours on the first day and 7 hours on subsequent days, with an average total duration of 20 days. The most common side effects of NIV were morning dry mouth (n=54, 84%), conjunctival irritation (n=28, 44%) and nasal irritation (n=24, 37.5%). Most patients had a good outcome with a mortality rate of 7.8%.

Ventilatory assistance at discharge

After the first episode of hypercapnic ARH, long-term NIV at home was indicated in 34 patients: on discharge in 17 patients and subsequently in 17 others. We divided then the patients into 3 groups (Figure 1):

- First group (G1): 30 patients (46.8%) were discharged without ventilatory treatment and did not require NIV after hospitalization.
- Second group (G2): 17 patients (26.6%) discharged on long-term home NIV.
- Third group (G3): 17 patients (26.6%) discharged without ventilatory therapy, but who subsequently required long-term home NIV.

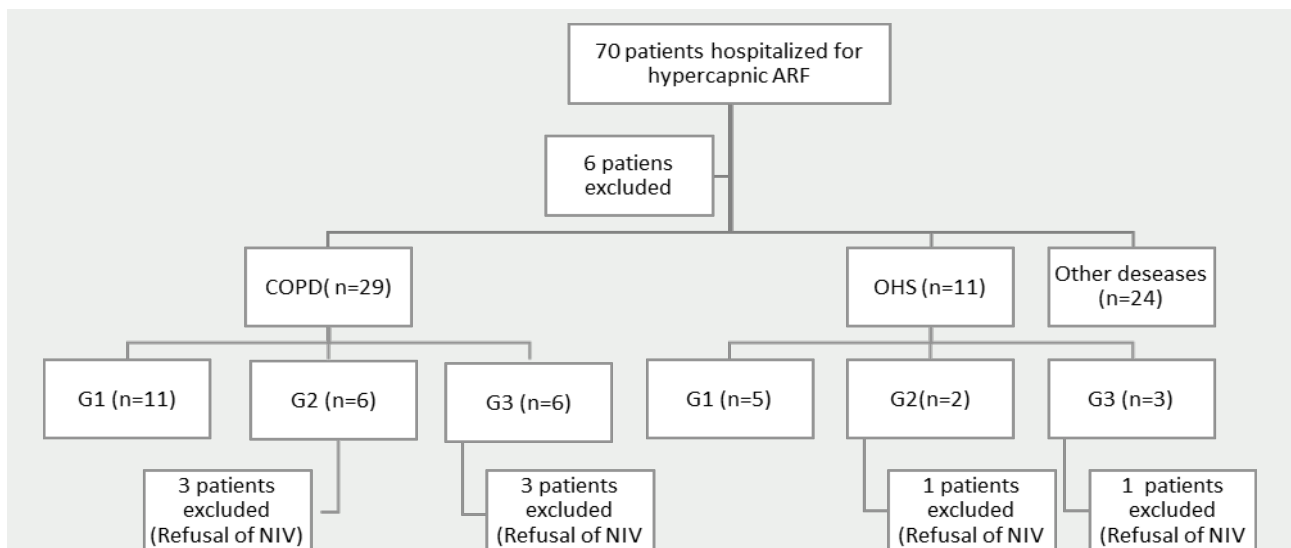


Figure 1. Flowchart of patients according to the need for long-term NIV

ARF: Acute Respiratory Failure, COPD: Chronic obstructive pulmonary disease, OHS: Obesity Hypoventilation syndrome, NIV: Non-Invasive Ventilation

Long-term outcome

Most patients showed positive clinical progress based on self-evaluation scores during admission, discharge, and follow-up consultations.

In the case of COPD patients, there was a partial improvement in dyspnea, which was more marked in G2 patients. Daytime sleepiness was less frequent in G2 patients, as were pain and fatigue. In patients with SOH, self-assessment scores for fatigue and pain improved in all patients but were slightly more marked in G1 and G2 patients. For daytime sleepiness, G1 patients were less symptomatic during the follow-up period.

For patients with SOH, PH improvement was more rapid than for patients with COPD. An increase in mean PaO₂ was noted in all patients. G2 had higher PaO₂ levels than the other subgroups. Patients with SOH had a lower mean PaO₂. Patients with COPD were found to have greater PaCO₂ variability during follow-up. However, patients discharged on NIV had lower PaCO₂ levels than the other groups. Twenty-three patients (92%) used a level 1 NIV device.

Sixteen patients (62%) had used a face mask. Outpatient ventilatory parameters were set during our consultations and depended on the type of chronic respiratory pathology as well as the analysis of flow-volume and pressure curves. Patients with COPD had a lower average Pressure support level than others, but a higher average safety frequency. Group G2 had a higher AI level and higher EPAP than Group G3. A higher AI level was set in SOH patients with a mean EPAP greater than 6, particularly in G3 patients.

The mean duration of NIV use was 146 days, with a mean daily use of 7 hours, reflecting an acceptable level of compliance in the different groups. Good compliance and tolerance were achieved in 19 patients (73.01%). However, seventeen patients (26.56%) were readmitted to the hospital for respiratory decompensation, with a readmission delay of 68.85 days and a median of 0.45/year. Patients with OHS had a higher readmission rate, at 54.54% of patients (n=6), particularly in G1 patients (patients without devices) (Table V).

The mortality rate was 7.8% (n=5), with a mean time to admission of 22.2 days. Mortality was higher in patients with OHS (SOH:9.09%, COPD:6.8%).

Table 5. Rehospitalization for respiratory decompensation

	COPD (n=29)					OHS (n=11)				
Variable s / Groups	total (n=29)	G1 (n=11)	G2 (n=9)	G3 (n=9)	Total (n=11)	G1 (n=5)	G2 (n=3)	G3 (n=3)	other (n=24)	Total (n=64)
Readmission n (%)	9 (31%)	2 (18,18%)	2 (22,22%)	5 (55,55%)	6 (54,54%)	3 (60%)	1 (33,33%)	2 (66,66%)	2 (8,33%)	17 (26,56 %)
Time to readmission (Days)	68,46 (±31)	52,5 (±27)	39 (±22)	98,33 (±25)	63,11 (±16)	52,5 (±25)	39 (±26,5)	98,33 (±24,6)	65,63 (±24,37)	68,85 (±20)
The average number of readmissions	0,58 (±0,2)	0,33 (±0,2)	0,38 (±0,18)	1 (±0,13)	0,35 (±0,044)	0,40 (±0,33)	0	0,67 (±0,14)	0,29 (±0,095)	0,45 (±0,25)

COPD: Chronic obstructive pulmonary disease. OHS: Obesity Hypoventilation Syndrome. **First group (G1):** patients discharged without ventilatory treatment and did not require NIV after hospitalization. **Second group (G2):** patients discharged on long-term home NIV. **Third group (G3):** patients discharged without ventilatory therapy, but who subsequently required long-term home NIV.

DISCUSSION

This study found that the incidence of hypercapnic ARF in hospitals was approximately 682 cases per 10,000 admissions. In Tunisia and the Maghreb, the incidence of ARF is largely unknown due to the lack of national studies. A 12-month study in the emergency department of Jendouba Regional Hospital involving 152 ARF patients reported a 7-day mortality rate of 22.36%, with 34 deaths (17).

The majority of our patients were over 50 years old (93.9%), which aligns with the literature indicating a mean age between 70 and 73 years (18,19). Indeed, the incidence of ARF increases almost exponentially every decade up to the age of 85 (18). The analysis conducted herein revealed that COPD was the most frequent respiratory pathology, followed by OHS and bronchiectasis, which is similar to data in the literature (20,21).

ARF complicates about 20% of acute COPD exacerbations, indicating advanced disease and a high risk of rehospitalization. It increases the mortality of a COPD

exacerbation by 8% to 30%, depending on the severity of respiratory acidosis (20).

Morbid obesity is now the second most common cause of ARF and has become the first indication of home NIV (20). Obesity is common in patients with COPD, asthma, and OSAHS.

A minority of obese persons develop OHS, defined by a BMI >30 kg/m², and chronic alveolar hypoventilation leading to daytime hypercapnia (22). Hypercapnic ARF may also be due to neuromuscular disease or chest wall deformity, asthma, DDB, and cystic fibrosis (20,23). Participants with both COPD and Obstructive Sleep Apnoea / Hypopnoea Syndrome (OSAHS) showed greater sleep disturbance and desaturation than those with OSAHS alone. However, mild COPD alone was associated with minimal impairment of sleep quality (24).

LV function is often impaired in chronic pulmonary heart disease, exhibiting diastolic dysfunction, septal thickening, reduced wall contractility from ischemic heart disease, and decreased compliance (25).

Respiratory decompensation can result from several causes, including respiratory tract infections, pulmonary

embolism, and right or left heart failure (26). The benefits of NIV are based on positive-pressure ventilation delivered via a mask firmly fitted over the patient's nose and/or mouth (27). In patients with ARF, NIV significantly reduces the work of breathing, lowers PaCO₂ levels, and improves respiratory acidosis (28–30).

Successful NIV, when compared to mechanical ventilation, decreases the length of stay in both the intensive care unit and hospital, reduces the number of hospital readmissions in the following year (31), lowers the incidence of pneumonia related to mechanical ventilation, and minimizes the need for tracheostomy (32).

In BIPAP mode, oronasal or nasal masks are most often used (33). The choice of an appropriate interface is essential for the success of NIV. The interface must provide a good seal and be tolerated by the patient (34).

The face mask is recommended as the first choice over the nasal mask or mouthpiece. The potential occurrence of skin complications leads to the use of other mask models (35).

Nevertheless, according to Buell et al (36), the face mask may aggravate pre-existing lung lesions, whereas the helmet interface may circumvent some of these problems thanks to a higher EPAP and a more uniform distribution of negative pleural pressure (34).

The oronasal mask is preferred for these patients. If it's not tolerated, nasal masks are an alternative. A total mask may be more acceptable for some and is equally effective as an oronasal mask (34).

New masks are currently being studied, especially the under-nose mask, which aims to reduce the risk of skin lesions (37).

Humidifying the inspired air is recommended to enhance NIV's tolerance. This can be achieved using either a heat and moisture exchange filter or a heated humidifier, especially in cases of significant hypercapnia (35).

BIPAP mode requires a ventilator that allows the adjustment of the inspiratory trigger, pressure rise gradient, maximum inspiratory time, and, on some machines, expiratory cycling (27).

For initial settings, EPAP is set between 5 and 10 cm H₂O, with starting aid typically at 6 to 8 cm H₂O, not exceeding 20 cm H₂O. Inspiratory support is adjusted to achieve a target expiratory tidal volume of 6 to 8 ml/kg. Exceeding 20 cm H₂O may increase leakage and cause stomach air insufflation (35). Several studies (37,38) suggest that home NIV may benefit hypercapnic COPD patients post-ARF by reducing clinical worsening and extending the time to readmission and death. Variations in study results highlight the importance of selecting patients, adjusting NIV settings, and ensuring compliance. The complexity of home treatments necessitates a personalized approach (39,40).

According to the literature (20,41), factors that predict the need for long-term NIV include altered gas exchange data, non-infectious causes of hypercapnic acute respiratory failure, the severity of chronic respiratory failure, and the rate of improvement in pH and PaCO₂ following NIV. Long-term NIV indications should be reassessed 2 to 4 weeks after respiratory failure resolution (42). For patients with OHS, NIV is recommended if OSAHS is absent. If OSAHS is

present and patients have persistent daytime hypercapnia (CO₂ levels > 55 mmHg), BIPAP- type NIV may be needed despite effective home CPAP treatment (20,43).

NIV is equally beneficial for obese patients with SOH, improving both survival and quality of life (43).

This study has several limitations, including a small sample size that hampers robust statistical analyses, the variability of functional tests conducted under non-uniform conditions, and the diversity of pathologies present.

Additional research is needed to identify the factors predicting the need for long-term NIV after an episode of hypercapnic ARF and to establish clear therapeutic protocols.

CONCLUSIONS

Proper NIV management significantly improves outcomes for patients with hypercapnic ARF, but there are no standardized weaning guidelines compared to invasive ventilation protocols. A structured home follow-up protocol is crucial for improving quality of life, prolonging survival, and preventing ARF recurrence.

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