INTRODUCTION

Acute heart failure (AHF) is one of the main causes of acute respiratory failure (ARF) and is generally treated with conventional oxygenation systems (nasal cannula, Venturi mask); however, newer means of ventilation are now available that are more effective and easier to use.¹⁻³ New respiratory devices make it possible to heat and humidify air flows administered through a nasal cannula, enabling use of higher flows of up to 60 l/min. These high-flow nasal systems with a built-in heated humidifier provide an alternative and effective means of oxygenation. They have been widely used in the home treatment of chronic respiratory failure patients, in post-surgical ARF, in intensive care of children and adult patients with ARF, but above all in cases of hypoxemia and dyspnea that do not respond to treatment with traditional Venturi masks. These systems provide a higher and more constant oxygen fraction, reduce respiratory dead space, generate positive airway pressure, and offer improved comfort and tolerance.⁴⁻⁶

We describe our experience with the humidified high-flow oxygen therapy via nasal cannula to treat 5 patients initially treated with noninvasive ventilation but who developed hypoxemia and dyspnea following noninvasive ventilation. All the patients were successfully treated with HFT, showing clinical and gasometric improvement and no complications or technical failures. We report our experience and discuss different aspects related to this oxygenation system.

METHODS

The clinical profile of 5 patients with AHF due to acute pulmonary edema (APE) treated with a high-flow system via nasal cannulas with a built-in heated humidifier (HFT) (ie, the Optiflow® by Fisher and Paykel with a rotameter of up to 60 l/min) was detailed. The patients suffered dyspnea and refractory hypoxemia
at 24 h after admission and were treated with conventional oxygenation systems (Venturi mask with unheated Aqua-pack®-type humidifier and a rotameter of up to 15 l/min) in a short stay unit (SSU). Both systems used a theoretical fraction of inspired oxygen (FiO₂) of 1.

Clinical variables collected include degree of dyspnea (modified Borg scale), blood oxygen saturation (SaO₂) measured by pulse oximeter, heart rate, respiratory rate, and systolic blood pressure. Arterial gasometry was performed at 24 h after admission and 24 h after treatment with the HFT system.

We also recorded the patients’ degree of comfort, complications, and total time of high-flow oxygenation. Drug therapy followed European Society of Cardiology recommendations.

### Statistical Analysis

Quantitative variables were examined using the Shapiro-Wilk W test for normality. The assumption of normality was only rejected in the case of SaO₂ at 24 h. The rest of the variables were analyzed using a Student T test for the intrasubject comparison of 2 means. Variables not meeting the assumption of normality were analyzed using a Wilcoxon T test. Qualitative variables were compared with the chi-square test. Statistical analysis was carried out using the SPSS 15 software.

### RESULTS

Of the 5 patients in the study, 3 were women (60%); the mean age was 84.2 ± 4.6 years; all were highly dependent in basic activities of daily living (Barthel index 36 ± 38 points), with high rates of comorbidity (Charlson index 6 ± 1); 100% were hypertensive and had chronic heart failure; 60% had permanent atrial fibrillation and chronic ischemic cardiopathy; and 20% suffered chronic obstructive pulmonary disease (Table 1).

All 5 patients were treated with non-invasive ventilation in the emergency room, 3 with constant positive airway pressure and 2 with bi-level PAP.

The clinical and gasometric parameters and the degree of dyspnea showed significant improvement after 24 h of treatment with the HFT system (Table 2). In patients with moderate or severe dyspnea, the intensity of the condition improved significantly, becoming mild in 80% of the patients, with a reduction in respiratory effort and tachypnea.

The degree of patient comfort with the HFT system was high: 2 patients had a feeling of tracheal discomfort, which was self-limited after the adaptation period and did not require withdrawal of the treatment.

Mean length of HFT system use was 62.4 ± 21.4 h.

### DISCUSSION

It is common to find patients with AHF who, after being stabilized, maintain a level of dyspnea or hypoxemia which does not improve with conventional oxygenation systems and cannot be attributed to deterioration in functional level or a need to optimize medical treatment. In our case, the HFT system was effective with all the patients and improvement was observed in the evolution of the disease: significant reduction in the intensity of the dyspnea, improved respiratory effort and tachypnea, and the disappearance of hypoxemia.

Active HFT systems have been used for years to treat chronic respiratory failure in adults (sleep apnea syndrome and neuro-muscular diseases), as they offer dyspnea control and efficient oxygenation with good tolerance.

### Table 1 Demographic Characteristics and Comorbidity of the 5 Patients

| Age (years) | 84.2 ± 4.6 |
| Women | 3 (60) |
| Arterial hypertension | 5 (100) |
| Diabetes mellitus | 1 (20) |
| Chronic heart failure | 5 (100) |
| COPD | 2 (40) |
| Atrial fibrillation | 3 (60) |
| Chronic kidney disease | 1 (20) |
| Dyslipidemia | 4 (80) |
| Ischemic heart disease | 2 (40) |
| Barthel index | 36 ± 38 |
| Charlson index | 6 ± 1 |

COPD, chronic obstructive pulmonary disease.

Data are expressed as N (%) or mean ± standard deviation.

### Table 2 Clinical and Gasometric Parameters Before Administering High-Flow Oxygen and After 24 h

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Before high-flow oxygen; FiO₂ 100%</th>
<th>After 24 h of high-flow oxygen</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>PaO₂ (mmHg)</td>
<td>73.4 ± 4.3</td>
<td>98.8 ± 4.76</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>PaCO₂ (mmHg)</td>
<td>53.2 ± 13</td>
<td>47.4 ± 8</td>
<td>.109</td>
</tr>
<tr>
<td>pH</td>
<td>7.33</td>
<td>7.39</td>
<td>.047</td>
</tr>
<tr>
<td>SaO₂ (%)</td>
<td>85.4 ± 2.41</td>
<td>99.4 ± 0.89</td>
<td>.042</td>
</tr>
<tr>
<td>HCO₃⁻</td>
<td>38.5 ± 7.59</td>
<td>40 ± 4.69</td>
<td>.188</td>
</tr>
<tr>
<td>HR (bpm)</td>
<td>103 ± 7</td>
<td>91 ± 3</td>
<td>.024</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>154 ± 21</td>
<td>149.6 ± 15</td>
<td>.379</td>
</tr>
<tr>
<td>RR (bpm)</td>
<td>35 ± 2</td>
<td>24 ± 3</td>
<td>.002</td>
</tr>
</tbody>
</table>

Degree of dyspnea: Mild, 0; Moderate, 20; Severe, 80.

bpm, breaths per minute; bpm, beats per minute; FiO₂, fraction of inspired oxygen; HR, heart rate; PaCO₂, partial pressure of CO₂ in arterial blood; PaO₂, partial pressure of O₂ in arterial blood; RR, respiratory rate; SaO₂, Saturation level of O₂ by pulse oximeter; SBP, systolic blood pressure.

a Wilcoxon T test.

b In accordance with Borg’s modified scale.
There is little evidence of treating ARF adults with HFT systems. In 2010, Roca et al. compared the comfort and efficacy of an HFT system with a conventional Venturi mask in 20 ARF patients of diverse etiology who were treated in an intensive care unit. They obtained statistically significant results in favor of the HFT system, which produced fewer side effects. These data are in agreement with those from our patients, although ours remained on high-flow treatment longer (62 h compared to 30 min) and all were admitted due to APE.

The improvements in clinical and gasometric parameters with this system have two main causes: first, HFT systems provide a more constant FiO₂, and second, the use of a nasal cannula as the interface reduces the amount of respiratory dead space and generates a constant positive pressure directly proportional to the flow used and to the resistance created during expiration, which contributes to increased oxygenation.

Other beneficial characteristics of note are that the active humidification and heating of the gas facilitates bronchial secretion clearance, improves the sensation of dyspnea and bronchial hyperreactivity, reduces the likelihood of atelectasis due to mucus accumulation, and increases patient tolerance when used for long periods.

Even in elderly patients with functional dependence, like those in our series, the degree of comfort is significant because the use of a cannula as the interface enables patients to speak, eat, and take medication without interrupting oxygenation. It is important to highlight two aspects of this system: that it is easy to learn and use, and that it can be used in conventional hospital rooms without the need for constant monitoring.

As in the study by Roca et al., the reduction in respiratory rate (a sign of clinical improvement) was at no time associated with changes in arterial CO₂ pressure or pH.

The most commonly described side effects in the literature with respect to the use of HFT systems are: cervical and tracheal discomfort, feeling hot, and nasal mucosal lesions. The first 2 are mild and disappear in most cases after the adaptation period, as was the case in 2 of our patients. Mucosal lesions are reported less frequently and disappear in most cases after the adaptation period, as a sign of clinical improvement was at no time associated with need for constant monitoring. Even in elderly patients with functional dependence, like those in our series, the degree of comfort is significant because the use of a cannula as the interface enables patients to speak, eat, and take medication without interrupting oxygenation. It is important to highlight two aspects of this system: that it is easy to learn and use, and that it can be used in conventional hospital rooms without the need for constant monitoring.

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In short, the use of HFT systems is a good alternative to traditional oxygenation systems for the treatment of patients with ARF secondary to AHF due to APE that have dyspnea and refractory hypoxemia. The system is well tolerated and produces significant improvements in clinical and gasometric parameters after 24 h.

CONFLICTS OF INTEREST

None declared.

REFERENCES