Evaluation of Automated Oxygen Flowrate Titration (FreeO₂) in a Model of Induced Cyclic Desaturations in Healthy Subjects Reproducing Desaturations During Central Apneas

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Introduction

Sleep-disordered breathing is found in up to 80% of patients with heart failure, and is associated with increased overall morbidity and mortality[1,2]. Recent studies have raised concern about the efficacy of CPAP in this population[3]. Oxygen therapy reduces by 75% the frequency of the central apneas in these patients and corrects nocturnal desaturation[4], the better predictor of mortality in this population. However, optimal oxygen flowrate may vary from one subject to another and within a subject based on several factors (clinical condition, presence and severity of apneas, position in the bed...).

FreeO₂ is a device allowing automated titration of oxygen flowrate every second based on the patient’s needs[5]. We developed a model of cyclic desaturation in healthy subjects and evaluated automated oxygen titration with FreeO₂ to avoid both hyperoxia and hypoxemia in this setting.

Methods

We induced ten cycles of desaturation by inhalation of a hypoxic air/nitrogen mixture (30 sec period with FiO₂=10% alternating 30 sec with FiO₂=21%). We compared five periods in 5 healthy subjects exposed to 10 minutes of periodic desaturation: absence of oxygen (Air), constant oxygen flowrate (2 and 4 L/min), oxygen with FreeO₂ with a SpO₂ target set at 95% (with two different controllers). We evaluated the mean SpO₂, the % of time in the SpO₂ target (95 ± 2%), the % of time with hypoxemia (SpO₂ < 90%), the % of time with hyperoxia (defined as SpO₂ > 97%) and oxygen flowrates used.

Results

Figure 1: Method to induce cyclic desaturations in healthy subjects with an air/nitrogen mixture – associated with tested strategies to prevent desaturations: no oxygen (air), constant oxygen (2 and 4 L/min) and automated oxygen titration (FreeO₂)

Figure 2: Tracings of SpO₂ (blue line) oxygen flow rate (red line), heart rate (green line) and FiO₂ (cyclic hypoxia) (purple line) for the tested conditions (subject #1)

Figure 3: Tracings of SpO₂ (blue line) oxygen flow rate (red line), heart rate (green line) and FiO₂ (purple line) for constant O₂ at 4L/min and for FreeO₂ with subject #1 with and without cyclic induced desaturation

Table: Comparisons of oxygenation parameters and heart rate for the tested conditions (data are presented as mean±SD)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mean SpO₂ (%)</th>
<th>Oscillation rate SpO₂ standard deviation (%)</th>
<th>Minimum SpO₂ (%)</th>
<th>% of time within the target (SpO₂=93-97%)</th>
<th>% of time with hypoxemia (SpO₂&lt;90%)</th>
<th>Heart rate (bpm)</th>
<th>Mean O₂ flow (L/min)</th>
<th>Maximum O₂ flow (L/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>90.0±1.6</td>
<td>3.2±0.1</td>
<td>82.3±2.5</td>
<td>32±13</td>
<td>44±13</td>
<td>11±1</td>
<td>83±10</td>
<td>0.0</td>
</tr>
<tr>
<td>FreeO₂ (1)</td>
<td>94.5±0.4</td>
<td>2.2±0.2</td>
<td>88.0±0.7</td>
<td>76±7</td>
<td>6±7</td>
<td>3±0</td>
<td>84±14</td>
<td>1.2±0.2</td>
</tr>
<tr>
<td>FreeO₂ (2)</td>
<td>95.6±0.3</td>
<td>1.1±0.1</td>
<td>92.3±0.6</td>
<td>92±7</td>
<td>0±0</td>
<td>7±7</td>
<td>78±14</td>
<td>1.5±0.1</td>
</tr>
<tr>
<td>O₂ 2L/min</td>
<td>95.7±1.0</td>
<td>1.2±0.2</td>
<td>92.3±2.5</td>
<td>85±15</td>
<td>0±0</td>
<td>12±17</td>
<td>80±13</td>
<td>2.0</td>
</tr>
<tr>
<td>O₂ 4L/min</td>
<td>97.4±0.3</td>
<td>0.6±0.1</td>
<td>95.3±0.6</td>
<td>54±19</td>
<td>0±0</td>
<td>46±19</td>
<td>77±14</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Conclusions

- In this model of induced cyclic desaturations that simulates central sleep apneas, desaturations were reduced with constant oxygen flow and with automated oxygen titration with FreeO₂.
- Automated titration allows continuous adaptation of oxygen flowrate based on patient’s needs.
- Continuous oxygen flowrate may lead to hyperoxia in this model, especially in the absence of apnea.
- Automated titration of oxygen flowrate (FreeO₂) may reduce hyperoxia and avoid hyperoxia during cycling desaturations as those existing in central sleep apneas.

Reference:

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