Treatment of Obstructive Sleep Apnea with Continuous Nasal Airflow Delivered through Nasal Prongs*

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We describe a new device for treating obstructive sleep apnea (OSA) which is similar to nasal CPAP, but less cumbersome. The device consists of a 7 mm diameter flexible tube terminating at one end in nasal prongs covered with foam cylinders. The foam cylinders are compressed, inserted into the nostrils and released, forming a tight seal. The other end of the catheter is attached to a compressor delivering between 7 and 15 L/min of air. We studied four men and two women with OSA, the first night without treatment and the following night with continuous nasal airflow.

Obstructive sleep apnea (OSA) is a difficult disease to treat. While weight loss is the preferred therapy in obese subjects, it is not possible to achieve in most patients. Tracheostomy is usually effective, but is deforming and is associated with several complications. Respiratory stimulants such as medroxyprogesterone and protriptyline have been noted to benefit some patients.

Continuous positive airway pressure delivered through the nose (nasal CPAP) has been reported by Sullivan and colleagues to be remarkably effective in preventing apnea during sleep. The device they use to deliver nasal CPAP is cumbersome, requires an air compressor capable of generating at least 40 L/min of airflow, and has a Silastic nose piece which is molded to fit each patient and which tends to disintegrate with repeated use. Other investigators have used a child’s facemask or a nasal nitrous mask to cover the nose. Although the nasal mask is easier to put in place, it still is cumbersome and has been reported to cause a feeling of “suffocation” in some patients. With nasal CPAP, large tubing which attaches the nasal appliance to the air compressor must be used in order to transmit the 40 L/min flow. This tubing restricts the patient’s movement in bed.

The purpose of this report is to describe our experience with a variant of nasal CPAP, continuous nasal airflow, which avoids some of the problems associated with nasal CPAP. The nasal airflow device inserts into the nostrils and thus has no external nasal appliance. It also has small tubing permitting free movement in bed.

METHODS

Nasal CPAP

Our first patient was treated with nasal CPAP, as described by Sullivan et al., with a Silastic molded nose piece. An Emerson PEEP valve was used instead of resistance to maintain positive pressure throughout all phases of respiration. Because of a disintegrating nose piece after three months of treatment, and difficulty keeping the nose piece on at night, the patient was brought back and studied one night without nasal CPAP and the following night with continuous nasal airflow.

Nasal Airflow

All patients were treated with a device manufactured from nasal prong catheters used for delivery of oxygen (Fig 1), (Argyle, Division of Sherwood Medical). Foam cylinders are placed over the nasal prongs. The cylinders are compressed and inserted into the nostrils.

A desaturation index was calculated by multiplying the average number of desaturation episodes per hour of sleep times the average maximum desaturation per episode. With continuous nasal airflow there was a significant decrease in all parameters (p<.025). We conclude that continuous nasal airflow decreased oxyhemoglobin desaturation in patients with OSA and may be useful in patients with mild-to-moderate OSA and in patients who do not tolerate nasal CPAP.

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FIGURE 1. Cannula used to deliver continuous nasal airflow. The foam pads are placed in the patient nares. The other end of the cannula is connected to an air compressor.
one anxious 13-year-old boy who refused to continue nasal airflow after one hour of use. All patients were said to snore loudly. None had obstructive lung disease.

Sleep Studies

Patients were studied during a night's sleep in the University of Virginia Sleep Laboratory. Oxyhemoglobin saturation was measured with a Hewlett-Packard ear oximeter (4720A). Esophageal pressure was measured with a polyethylene catheter that had a 10 cm long balloon containing 0.5 ml of air on the end that was placed 37 to 44 cm from the nares. Airflow at the nose and mouth was detected with a face mask pneumotachometer constructed from a Venturi mask (Airlife, Inc) by gluing wire screens over the exhalation ports. By measuring the pressure inside and outside of the mask, a wide range of airflows could be detected qualitatively. In the last three patients, sleep was monitored with electroencephalograms, electrooculograms and segmental electromyograms. An electroencephalogram was not available when the first three patients were studied. In these patients, a sleep technician carefully observed patients and noted when they appeared to be asleep. Patients were studied without treatment the first night and with continuous nasal airflow the second night. Patients 5 and 6 were also studied after using continuous nasal airflow for 12 and ten days, respectively. Because of possible drying effects on the nasal mucosa from long-term use, the compressed air was humidified with a Cascade humidifier for these two patients. An esophageal catheter was not used when patients received continuous nasal airflow because of difficulties of sealing the nose with the catheter in place.

The severity of sleep apnea was measured by three indices. The first index, desaturations per hour of sleep, is the number of oxyhemoglobin desaturations of at least 4 percent per hour of sleep, associated with apnea or hypopnea. The second index is the average maximum desaturation per episode. This is the average of all the oxyhemoglobin saturation troughs subtracted from 100. The third indicator, the desaturation index, is the product of the first two indices. Thus, it reflects both the frequency and the severity of the oxyhemoglobin desaturations during sleep.

Statistical analysis was performed with the paired t test.

Results

All patients had OSA characterized by absent airflow at the nose and mouth despite subatmospheric esophageal pressure swings indicating respiratory effort. The awake baseline oxyhemoglobin saturation did not change from the control night to the nasal airflow night. Following treatment with continuous nasal airflow, all patients had marked reductions in the number of desaturations per hour of sleep, average maximum desaturation and the desaturation index (Fig 3-5). The decrease in desaturations per hour and average maximum desaturation after continuous nasal airflow was

Table 1—Patient Characteristics

<table>
<thead>
<tr>
<th>Patient No</th>
<th>Sex</th>
<th>Age</th>
<th>Ht (cm)</th>
<th>Wt (kg)</th>
<th>BMI (kg/m²)</th>
<th>Hct (%)</th>
<th>FIO₂ (%)</th>
<th>PO₂ (mm Hg)</th>
<th>PCO₂ (mm Hg)</th>
<th>pH</th>
<th>VC (%) liter</th>
<th>FEV/FVC %</th>
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<td>52</td>
<td>21</td>
<td>43</td>
<td>57</td>
<td>7.48</td>
<td>3.24(67)</td>
<td>88</td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>53</td>
<td>173</td>
<td>213</td>
<td>32.4</td>
<td>39</td>
<td>21</td>
<td>71</td>
<td>39</td>
<td>7.48</td>
<td>2.89(64)</td>
<td>79</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>34</td>
<td>181</td>
<td>178</td>
<td>54.3</td>
<td>51</td>
<td>21</td>
<td>43</td>
<td>53</td>
<td>7.41</td>
<td>2.48(46)</td>
<td>78</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>50</td>
<td>178</td>
<td>103</td>
<td>32.5</td>
<td>46</td>
<td>21</td>
<td>88</td>
<td>34</td>
<td>7.43</td>
<td>0.90(88)</td>
<td>80</td>
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<tr>
<td>5</td>
<td>F</td>
<td>41</td>
<td>162</td>
<td>168</td>
<td>38.9</td>
<td>50</td>
<td>2 L/m nasal prong</td>
<td>57</td>
<td>61</td>
<td>7.38</td>
<td>1.57(45)</td>
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<td>106</td>
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<td>61</td>
<td>37</td>
<td>7.47</td>
<td>3.24(94)</td>
<td>83</td>
</tr>
</tbody>
</table>
**Figure 3.** Effect of nasal airflow on the number of desaturations per hour of sleep. The column labeled CONTROL shows values the night when no treatment was given. The column labeled NFLOW shows values the first night of nasal airflow treatment. The column labeled NFLOW FOLLOWUP shows values after 12(*) and 10(+) days of nocturnal nasal airflow treatment.

**Figure 4.** Effect of nasal airflow on the average maximum desaturation per episode. The column labeled CONTROL refers to the night when no treatment was given and the column labeled NFLOW refers to the night of nasal airflow treatment. The column labeled NFLOW FOLLOWUP refers to 12(*) and 10(+) days nocturnal nasal airflow treatment.

**Figure 5.** Effect of nasal airflow on the desaturation index. The column labeled CONTROL refers to the night when no treatment was given and the column labeled NFLOW refers to the night of nasal airflow treatment. The column labeled NFLOW FOLLOWUP refers to 12(*) and 10(+) days of nocturnal nasal airflow treatment.

Airflow were highly significant (p<0.005). The decrease in the desaturation index after treatment was also significant (p<0.025). Patient 1, who was treated first with nasal CPAP and later, after three months of nighttime nasal CPAP use, with continuous nasal airflow, improved with both forms of treatment (Table 2).

None of the patients completing the study complained of discomfort from the nasal airflow. While nasal airflow was not humidified during the study, because of the possible drying effects on the nasal mucosa from long-term use, it was humidified for the two patients sent home with nasal airflow.

Although the patient with the most severe oxyhemoglobin desaturation and the highest BMI (number 5) improved after the first night of continuous nasal airflow treatment, she still had significant sleep apnea. After 12 more days of therapy, she improved further, but had not returned to normal. She noted marked symptomatic improvement, however, with complete loss of daytime hypersomnolence. In contrast, patient 6 demonstrated improvement only in her average maximum desaturation per episode after ten additional days of treatment.
After continuous nasal airflow treatment, all patients reported that their daytime hypersomnolence disappeared. Two of the three patients studied with polysomnography, numbers 5 and 6, spent a larger percentage of total sleep time in slow wave sleep (%SWS) after treatment (1.8 to 7.4 percent and 2.1 to 8.7 percent, respectively). Polysomnographic tracings from the third patient, number 4, did not have large enough signal amplitudes to clearly separate slow wave stages from other stages of sleep.

**DISCUSSION**

In this preliminary study, continuous nasal airflow delivered through nasal prongs significantly decreased, but did not eliminate the number of desaturations per hour of sleep. It also decreased the average maximum desaturation per apnea or hypopnea episode. Patients also reported that the treatment eliminated their daytime hypersomnolence.

The nasal prongs were tolerated better by patient 1 than was the Silastic nose piece which he initially used for nasal CPAP. Because the tubing attaching the prongs to the air compressor is smaller and more flexible than the large bore tubing required for nasal CPAP administration, the patient could turn more freely in bed without disconnecting the tubing from his nose. Alternatively, continuous nasal airflow significantly decreased the degree of oxyhemoglobin desaturation, it did not eliminate its in most patients. The improvement was significant enough, though, to decrease the patients’ assessment of their daytime hypersomnolence.

Nasal CPAP produced the largest fall in desaturation index, from 7,271 to 782 in patient 1 during his first night of therapy. In comparison, 12 days of continuous nasal airflow treatment lowered the desaturation index of patient 6 from 7,747 to 1,576. These limited data suggest that nasal CPAP is more effective therapy than continuous nasal airflow in patients with extremely severe obstructive sleep apnea. With nasal CPAP, a given pressure is always maintained in the tubing attached to the nose. With continuous nasal airflow, the flow rate in the tubing is lower and nasopharyngeal pressure probably drops more during inhalation than with nasal CPAP.

Continuous nasal airflow may have been effective in our patients because it acts as a pneumatic splint, as postulated by Sullivan and colleagues. Alternatively, it may be effective by stimulating upper airway receptors and alternating proprioceptive afferent excitation due to changes in function residual capacity.

It is unlikely that our results can be explained by the first night effect. A previous study demonstrated little variation in sleep between consecutive nights. While patient number 1 had less desaturation during his second control night compared to his first control night (Table 2), we attribute his improvement to three months of nasal CPAP therapy with amelioration of chronic sleep deprivation rather than to a first-night effect.

We conclude that continuous nasal airflow improves obstructive sleep apnea. It is less cumbersome than the nasal CPAP devices previously described, and appears to be easier for patients to keep attached to their nose during sleep. Nasal airflow may thus be useful in patients who do not tolerate nasal CPAP. Although continuous nasal airflow does not appear to be as effective as nasal CPAP in patients with severe OSA, it appears to be effective in treatment of mild-to-moderate disease. Further study of its effect on sleep time and structure and of patients’ ability to tolerate it is required, however, before it can be recommended as long-term therapy.

**REFERENCES**