Abstract

Continuous positive airway pressure (CPAP) remains the major treatment option for obstructive sleep apnea (OSA). The American Thoracic Society organized a workshop to discuss the importance of mask selection for OSA treatment with CPAP. In this workshop report, we summarize available evidence about the breathing route during nasal and oronasal CPAP and the importance of nasal symptoms for CPAP outcomes. We explore the mechanisms of air leaks during CPAP treatment and possible alternatives for leak control. The impact of nasal and oronasal CPAP on adherence, residual apnea–hypopnea index, unintentional leaks, and pressure requirements are also compared. Finally, recommendations for patient and partner involvement in mask selection are presented, and future directions to promote personalized mask selection are discussed.

Keywords: obstructive sleep apnea; continuous positive airway pressure; masks
among OSA patients, a nasal mask is usually the best option for most patients. Even though many patients do well with oronasal CPAP, it may compromise airway patency. Patients using oronasal CPAP may experience high leak, experience residual respiratory events, and require high levels of CPAP. Switching to a nasal mask should be considered.

- Management of nasal symptoms and impact on mask selection: nasal symptoms are common among patients with OSA and may compromise CPAP adherence. Humidification, nasal steroids, and nasal surgery are considered the main pillars of the management of nasal symptoms. Controlling nasal symptoms should be implemented both before and during CPAP use and may improve nasal CPAP adherence.

- Current evidence comparing nasal and oronasal masks for OSA treatment: most studies suggest that nasal CPAP results in better adherence, lower residual apnea–hypopnea index (AHI), and higher therapeutic levels as compared with oronasal CPAP. However, oronasal masks can be effective for many patients with OSA.

- Mechanisms of oral leak during nasal CPAP and management: oral leak may provoke patient discomfort, decrease CPAP efficacy, and impair adherence. Excessive leaks may occur through the mask because of an inappropriate mask seal or through the mouth. Two different mechanisms can be observed during nasal CPAP-associated mouth leak: leak due to mouth opening and expiratory leak due to palatal prolapse and expiratory flow limitation. Risk factors for oral leaks include nasal obstruction, aging, obesity, and male sex. Potential interventions include review of the mask seal, treatment of nasal obstruction, chinstraps, and heated humidification. Switching from nasal to oronasal CPAP needs to be closely monitored because of the risk of upper-airway narrowing and requirement of higher CPAP levels.

- Monitoring adherence and adverse effects: monitoring for residual AHI, leak, and adherence should be combined with patient complaints and obtained periodically. Active troubleshooting is important, especially during the first week of therapy.

- Patient participation in mask selection: patients and partners should be involved in the selection of CPAP masks and should receive adequate support under a proactive self-management model.

- Mask-fitting considerations: time and effort should be spent during initial mask fitting, while avoiding too many mask options that can be confusing for the patient.

Introduction

The health benefits of CPAP for OSA depends on its effectiveness and patient compliance. Although nasal CPAP is still the most frequently used CPAP interface, there has been an increasing trend in oronasal CPAP prescription. However, there is emerging literature demonstrating that clinical outcomes of using nasal and oronasal CPAP for OSA treatment may differ (1).

The primary objectives of this workshop were to discuss the importance of mask selection for OSA treatment with CPAP. Adherence and effectiveness of CPAP according to interface type were reviewed. Strategies to develop personalized selection of interfaces that include facial anatomy, nasal symptoms, and patient preferences were discussed. The long-term goal of this initiative is to promote individualized mask selection for treatment of OSA with CPAP that will likely improve patient outcomes, including higher effectiveness, higher adherence, and more comfort with therapy.

Methods

Clinicians and researchers were invited for this workshop on the basis of their recognized expertise and contributions in mask selection and CPAP adaptation for patients with OSA. The most relevant topics pertaining to the different mask choices for OSA treatment were selected by the chair and distributed to the participants. The literature was reviewed and presented by the participants according to their field of expertise. Discussion followed each presentation to reach expert agreement on the current knowledge and future directions.

Results

Breathing Route and Upper-Airway Patency

Mouth breathing may compromise airway patency by narrowing the upper airway because of posterior mandibular displacement (2) and by increasing upper-airway surface tension (3). Patients with OSA spend as much as 59% of the total sleep time breathing through the oronasal route (4). Oronasal breathing during sleep is associated with aging, nasal obstruction, OSA severity, neck circumference, and obesity (4–7). However, the exact mechanisms leading to mouth breathing during sleep among subjects with OSA are not completely understood. Jaw opening may occur during inspiration because of the activation of submental muscles and tracheal tug (8). Masseter inspiratory activity is believed to counterbalance jaw-opening forces. During obstructive apneas, dynamic jaw movement progressively increases toward the end of the apnea as respiratory effort and tracheal tug also increases (8), possibly promoting mouth breathing.

Mouth opening and oral air leak are potential adverse effects of CPAP, especially in patients with nasal obstruction (9). In a study that objectively detected nasal and oral breathing, patients with oral breathing were less adherent to nasal CPAP (10). To avoid CPAP intolerance, patients reporting oronasal breathing often receive an oronasal CPAP mask even before any symptom arises. However, the self-reported breathing route does not predict the objectively measured breathing track (4). In addition, the majority of patients with OSA with oronasal breathing switch to nasal breathing while on nasal CPAP (10).

Initial evidence that oronasal CPAP might not be as effective as nasal CPAP came from a study that measured pharyngeal collapsibility during nasal and oronasal CPAP (11). Increasing levels of CPAP were not able to open the airway in any patients during oronasal CPAP. The mechanisms through which oronasal CPAP may impair upper-airway patency are incompletely understood. Oronasal CPAP may reduce the airway splinting effect because of potential neutralization of the intraluminal positive pressure applied through the nose by the positive pressure coming through the mouth (Figure 1). A study that compared upper-airway patency on nasal and oronasal CPAP showed that the airway narrows when treatment is switched from nasal to oronasal CPAP, even while oral airflow was zero. Interestingly, when the mouth was taped shut, airway narrowing no longer occurred when treatment was switched from nasal to oronasal CPAP (12). Oronasal CPAP may also posteriorly displace the mandible (13). Taken together, the effects of oronasal CPAP on the upper airway may differ between individuals and may depend on the site of obstruction or OSA endotype.
Management of Nasal Symptoms and Impact on Mask Selection

Nasal symptoms are commonly reported by CPAP users and are common reasons for CPAP intolerance. Nasal congestion and rhinorrhea are reported by up to 45–69% of CPAP users (14, 15). Nasal congestion, mouth leak, and removing the CPAP mask at night are significantly associated with a decreased CPAP adherence (16).

An increased nasal resistance measured by anterior rhinomanometry before CPAP initiation significantly impairs patients’ initial acceptance of CPAP (17). This finding was also supported by the results of a study by Morris and colleagues, who could demonstrate that the cross-sectional area at the level of the inferior turbinate differed significantly between responders and nonresponders to CPAP (18). On the basis of acoustic reflection measurements, it has been shown that CPAP use was significantly lower in patients with a small minimal cross-sectional area (19).

Humidification, nasal steroids, and nasal surgery are considered the main pillars of the management of nasal symptoms during CPAP. On the basis of a blinded randomized controlled trial comparing CPAP treatment with CPAP plus humidification and CPAP with nasal steroid therapy with fluticasone, it has been demonstrated that heated humidification, and not nasal steroid therapy, was capable of decreasing the incidence of nasal side effects in patients with OSA initiating CPAP (20). It has been suggested that only patients with allergic rhinitis might benefit from intranasal fluticasone during CPAP initiation (21).

A cost-effectiveness analysis of nasal surgery to increase CPAP adherence in patients with OSA and nasal obstruction pointed out that nasal surgery is cost-effective in almost every patient with OSA and nasal obstruction, that turbinate reduction can be cost-positive in the short term, and that septoplasty can have a higher cost/benefit outcome after a longer time span (22).

Nasal symptoms should be adequately treated before CPAP initiation. The use of nasal corticosteroid therapy is probably only useful in selected patients, whereas nasal surgery leads to increased CPAP use, increased CPAP tolerance, and a reduced CPAP level and, therefore, should be regarded as being cost-effective as adjuvant therapy.

Current Evidence Comparing Nasal and Oronasal Masks for OSA Treatment

The initial description of CPAP (23) involved nasal positive pressure, believed to push the soft palate and tongue anteriorly, preventing oropharyngeal lumen obliteration. It was believed that pressure applied at both the nose and mouth could not effectively restore airway patency (11, 24). Subsequent experience showed that oronasal interfaces could be used successfully (25, 26). Advantages and disadvantages of nasal and oronasal masks are described in Table 1.

Although both types of interfaces are used clinically, the debate over the effectiveness of oronasal masks continues. Recent meta-analyses have found lower pressure (1) and residual AHI (1, 27) with nasal CPAP but have found no difference in sleepiness (27) and have found higher adherence with nasal masks in unselected studies, but not in randomized trials (1, 27). Overall, in unselected patients with OSA, any effective pressure differences are probably not clinically relevant (28, 29). However, in specific individuals, differences can be marked (13), particularly in more severe OSA (30). When pressure or adherence were similar, satisfaction was higher with nasal interfaces. In studies in which patients underwent nasal CPAP titration and were then randomized to several weeks each of nasal versus oronasal CPAP, nasal interfaces resulted in better adherence and reduced...
Table 1. Advantages and disadvantages of nasal and oronasal CPAP masks

| Mask     | Advantages                                      | Disadvantages                        |
|----------|-------------------------------------------------|--------------------------------------|
| Nasal    | More comfortable                                | Risk of mouth leak                    |
|          | Lower overall leak                               |                                      |
|          | Lower therapeutic pressure requirement           |                                      |
|          | Higher adherence                                 |                                      |
|          | Lower cost                                      |                                      |
|          | Less risk of aspiration                          |                                      |
|          | Lower risk of CO₂ rebreathing                   |                                      |
|          | Lower risk of aerophagia                         |                                      |
| Oronasal | Better control of mouth leak                     | Less comfortable                     |
|          | Better control of REM-associated leak            | Higher overall leak                   |
|          |                                                 | Higher therapeutic pressure requirement|
|          |                                                 | Lower adherence                       |
|          |                                                 | Higher cost                           |
|          |                                                 | Higher risk of aspiration             |
|          |                                                 | Higher risk of CO₂ rebreathing       |
|          |                                                 | Higher risk of aerophagia             |

Definition of abbreviations: CPAP = continuous positive airway pressure; REM = rapid eye movement.
Monitoring Adherence and Adverse Effects

Adherence to CPAP affects OSA treatment efficacy and has become a critical problem when treatment alternatives are limited or ineffective. Adverse effects of CPAP treatment are associated with poorer adherence (10, 33). The best predictors of CPAP adherence include early usage (41, 42), nasal passage size (19), inferior turbinate cross-sectional area (18), nasal resistance (17), excessive air leak (10), and intolerance related to dry mouth, nasal congestion, choking sensations, and perceived inconvenience (33). OSA severity is a weak predictor of adherence (33). Technological advancements, including heated humidification, APAP, bilevel, and expiratory pressure relief were evaluated by a Cochrane Systematic Review, and only APAP was shown to significantly improve adherence (43).

Overall, early usage has been the best predictor of long-term CPAP adherence (41, 44). Remote monitoring of the CPAP device allows for early identification of low adherence and excessive air leak. However, the results of remote monitoring on adherence have been mixed so far (38, 45). Approaches to improve compliance include psychological and educational interventions. A metanalytic study (43) revealed that cognitive behavioral interventions led to the greatest improvement in adherence, whereas short-term education did not lead to significant change. Ongoing support showed a nonsignificant trend toward improved adherence. The resolution of adverse effects should also be addressed early. Adaptive servo ventilation may improve positive airway pressure (PAP) adherence among patients with persistent or treatment-emergent central sleep apnea (46). Aerophagia is more common with oronasal CPAP than with nasal CPAP (47). Among patients on an oronasal mask who report aerophagia, switching to a nasal mask should be considered. Air leaks are common adverse effects of CPAP and are associated with poorer adherence (10). Unfortunately, each CPAP manufacturer reports air leak differently, and there is no consensus to discriminate between tolerable air leak and leak that deserves correction (48). Patient complaints and the magnitude of the reported leak should be interpreted together before implementing any correction. If oral leak is present despite addressing nasal symptoms and attempting pressure reduction, the use of a heated humidifier on the circuit may reduce nasal congestion, moisten the soft palate, and improve the soft palate–tongue seal (49). Unfortunately, chinstraps are not comfortable enough to be worn on a long-term basis, and in some patients may increase upper-airway resistance (50). Ultimately, a full-face mask can be considered if oral leak remains a significant complaint.

Patient Participation in Mask Selection

Despite recent CPAP technology advances that incorporate multiple features to improve comfort and pressure delivery, adherence to CPAP remains poor (43). Nonadherent users report negative early experiences, reinforcing a low belief in their ability to use CPAP (51). Although there is no conclusive evidence supporting that the technologic interface or level of pressure predict CPAP adherence, mask selection can have a significant impact on patients’ early experience with CPAP. Patterns of CPAP adherence are established within the first week of therapy (41, 44), and a dramatic decline of use in the first few days predicts poor long-term use (41, 52). CPAP interference with being intimate, together with being Black and having a high residual AHI, were salient predictors of poor first-week CPAP adherence (53). Socioeconomic status may also influence CPAP acceptance and adherence (54, 55). A more recent study...
experiences with CPAP

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use: bothersome equipment causing disruptions in sleep and bedtime routine, anxiety related to CPAP use particularly in the beginning of therapy, interruptions to	

intimacy, and concern about image change while wearing a CPAP mask (56).

Recommendations. First and foremost, OSA and its management, including mask selection, should move from the traditional
disease-focused model to a more proactive self-management model (57). Care for OSA
has been heavily dependent on clinicians and is primarily delivered at the sleep center. Less
motivated patients might just stop using CPAP if they perceive there is a problem that
cannot be addressed by their care provider. In
contrast, in the proactive self-management model, engaging patients early will build the
sense of being an “active care participant”
rather than a “passive care recipient.” Second, the significant other or partner of the patient
needs to be involved in the mask selection

and follow-up care, if possible. Third, the
critical time to support, troubleshoot, and motivate CPAP use should be before
treatment initiation and early within the first
week. Finally, more research is needed to
develop and test behavioral interventions to
promote long-term self-management. When clinicians work on the mask selection with the
patients, is it important to set up reasonable expectations and emphasize that it
may take more than one try to find the right
mask. Mobile health technologies, including
wearables and apps, which hold great
promise to deliver health-behavior interventions, improve communication, and
improve individual tailoring (58), can be
developed for both CPAP users and
their partners to promote effective
self-management.

Mask-Fitting Considerations

Manufacturers of CPAP devices have been innovative in offering a variety of different
types of masks: nasal, nasal-pillow, cradle, nasal–oral, and low-profile nasal–oral
masks. They were designed to tackle
different complaints and offer comfort, sealing, and stability. Even with recent
mask-fitting advances, we are still
encountering issues of compliance and complaints. We have found that there are
three main obstacles to overcome when
introducing masks to patients. Obstacle one
is dismantling preconceived notions and expectations of what PAP will and will not
accomplish through patient orientation.
Although some patients believe that PAP is
the answer to all of their problems, others
believe it will not help at all. Obstacle two
is combating claustrophobia. Patients
describe experiencing distinct types of
claustrophobia: 1) discomfort from having
a physical object on the face and 2) having a confining space to breathe into.
Determining which type of claustrophobia
the patient is describing will allow sleep
clinicians to choose an appropriate mask.
Obstacle three is the potential that oral leak
may influence the overuse of oronasal masks
as the initial mask choice. Durable medical
equipment companies may induce the use of
oronasal masks because of additional
potential reasons: higher profit margins of
oronasal masks as compared with nasal
masks, limited mask options and the
possibility of mask switching, and reduced
time for patient adaptation and education.

There are a few things to consider when
fitting a mask. As opposed to technicians
asking the patient, “Do you breathe through
your mouth at night?” technicians should
focus on whether this can be observed. This
is important because many patients
experience oral breathing throughout the
night, as they are trying to catch their breath
after apneic events. Also allow time to let the
patients buy into therapy, increasing their
confidence and gaining commitment. Lastly,
give a reasonable number of mask options to
avoid choice fatigue (59). All patients should
have a trial with pressurized air for proper
mask fit. Verification of leak is important; no
matter how small the leak is perceived to be,
the location of the leak may cause irritation.
There are troubleshooting materials, such as
nasal saline sprays, petroleum-free skin
moisturizers, mask wipes, dry-mouth oral
rinses, and PAP mask liners, to help mitigate
discomfort. Durable medical equipment
companies need to be easily reachable,
supportive, and flexible, particularly at
therapy initiation, as this period plays a
crucial role in maximizing long-term
adherence. Selecting a comfortable CPAP
interface during initial CPAP adaptation

Figure 3. Mechanisms involved in CPAP unintentional leak. Adapted by permission from Reference
38. APAP = autoadjusting positive airway pressure; BMI = body mass index; CPAP = continuous
positive airway pressure.
may improve CPAP adherence. Patients who are well adapted to the mask initially chosen have better long-term adherence than those who need mask switching (60). In addition, adherence may be compromised when a discontinued mask model needs to be switched to a newer model (60), highlighting the importance of a long life cycle for masks in the market.

Decreasing reimbursements demand more efficient mask fitting. Manufacturers have been offering fit packs (masks with all sizes in one package) for a select group of masks. These fit packs may be helpful to decrease sterilization needs and telehealth fittings, which likely improves efficiency. As telehealth fittings become more common, technology can provide education, engagement, and objective data about which masks work best for patient subsets (i.e., by ethnicity or anthropomorphic characteristics).

**Future Perspectives**

Current evidence suggests that the nasal interface should be the first option for most patients with OSA. However, many gaps remain to be studied to optimize interface selection for patients with OSA. Many different characteristics that have been poorly addressed, including facial and nasal anatomy, preferential breathing route, site of airway collapse, obesity, race, sex and age, may influence the therapeutic outcomes of the different CPAP interfaces. A personalized-medicine approach must be considered to individualize the CPAP interface according to the patient’s own facial anatomy (62).

The best option for patients with OSA and significant nasal obstruction also needs further assessment. The utility of imaging, nasal-resistance measurements, and preferential flow-route determination should be tested in controlled studies to guide the best approach for patients with OSA and nasal obstruction (i.e., nasal surgery or a trial of oronasal CPAP). In addition, the use of nasal steroids in selected patients with significant nasal symptoms should be tested.

This official workshop report was prepared by an ad hoc subcommittee of the ATS Assembly on Sleep and Respiratory Neurobiology.

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