Sleep and Breathing (2019) 23:885–888
https://doi.org/10.1007/s11325-018-01772-5

SLEEP BREATHING PHYSIOLOGY AND DISORDERS • SHORT COMMUNICATION

Adherence to CPAP with a nasal mask combined with mandibular advancement device versus an oronasal mask: a randomized crossover trial

Antoine Léotard[1,2] · Matthieu Lesgoirres[3] · Najeh Daabek[1,3] · Marius Lebret[1,3] · Sebastien Bailly[1,2] · Alain Verain[2] · Fréderic Series[4] · Jean-Louis Pépin[1,2] · Jean-Christian Borel[1,3]

Received: 15 August 2018 / Revised: 5 November 2018 / Accepted: 14 December 2018 / Published online: 28 January 2019

Abstract

Purpose Evidence for the management of CPAP-treated obstructive sleep apnea suggests that oronasal masks reduce mouth leaks at the expense of higher pressures and poorer adherence. Some authors have proposed the use of mandibular advancement devices in combination with nasal masks to address this. The aim of this study was to assess adherence to CPAP after 1 month's use of a nasal mask with a mandibular advancement device and to compare adherence with an oronasal mask.

Methods A randomized crossover trial design to assess whether a mandibular advancement device combined with a nasal mask would improve CPAP adherence compared to an oronasal mask.

Results There was no improvement in CPAP adherence and self-reported interface-related pain was significantly higher with the combined treatment.

Conclusions Although the combined treatment reduced pressures, likely by improving upper airway patency, it may only be appropriate for a small number of patients due to associated discomfort.

Trial registration NCT01889472

Keywords Continuous positive airway pressure · Nasal mask · Mandibular advancement device · Treatment adherence and compliance · Obstructive sleep apnea

Introduction

Continuous positive airway pressure (CPAP) is the first-line treatment for moderate-to-severe obstructive sleep apnea syndrome (OSAS). The first interface prescribed is usually a nasal mask [1]; however, nasal masks are associated with unintentional mouth leaks which reduce the efficacy and tolerance of CPAP. Some clinicians now prescribe oronasal masks (ONM) to reduce these problems [2]. Unfortunately, adherence to CPAP tends to be lower with ONM [3]. Moreover, ONM could reduce the patency of the upper airways by pushing the mandible posteriorly [4]. Other solutions are therefore required to improve adherence [5, 6]. Some authors have proposed that a combination of a nasal mask (NM) with a mandibular advancement device (MAD) (NM + MAD) might address this issue [6, 7].

We hypothesized that the combination of NM + MAD would reduce mouth leaks, reduce the level of pressure required [5], improve CPAP efficacy (reduce residual events), and increase adherence compared to ONM [6, 7]. The aim of this study was to assess CPAP adherence after 1 month of NM + MAD and to compare with ONM.

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s11325-018-01772-5) contains supplementary material, which is available to authorized users.

✉ Marius Lebret
mariuslebret@gmail.com

[1] HP2, INSERM U1042, University Grenoble Alpes, F-38000 Grenoble, France

[2] Sleep and Exercise Laboratory, Thorax-Vaisseaux Department, Grenoble-Alpes University Hospital, Saint-Martin-d'Hères, France

[3] AGIR à dom. Association, 36 bd du Vieux Chêne, F-38240 Meylan, France

[4] Centre de recherche de l'Institut Universitaire de Cardiologie et de Pneumologie de Québec (IUCPQ) Université Laval, Québec, QC G1V4G5, Canada

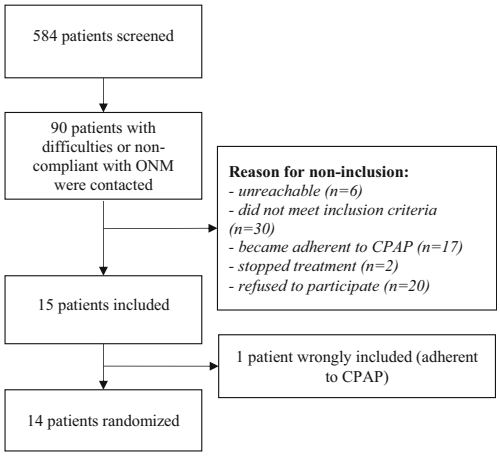

Fig. 1 Study flowchart

Methods (online supplement)

A bi-national (France and Canada) randomized crossover study was conducted (ClinicalTrials.gov Identifier: NCT01889472) between June 2013 and December 2016. Inclusion criteria were as follows: adults with OSAS treated with CPAP via a NM who self-reported annoying unintentional mouth leaks or who were already treated with an ONM but non-adherent (< 3 h a night). A computer-generated allocation sequence randomized patients to use either a NM + MAD or an ONM for 1 month. After a 1-week washout period (without CPAP), patients were then asked to use the other interfaces for 1 month. Neither clinicians nor investigators were blinded to allocation sequence. All patients used an auto-CPAP device (S9-Autoset RESMED, Sydney Australia) (pressure range 6–

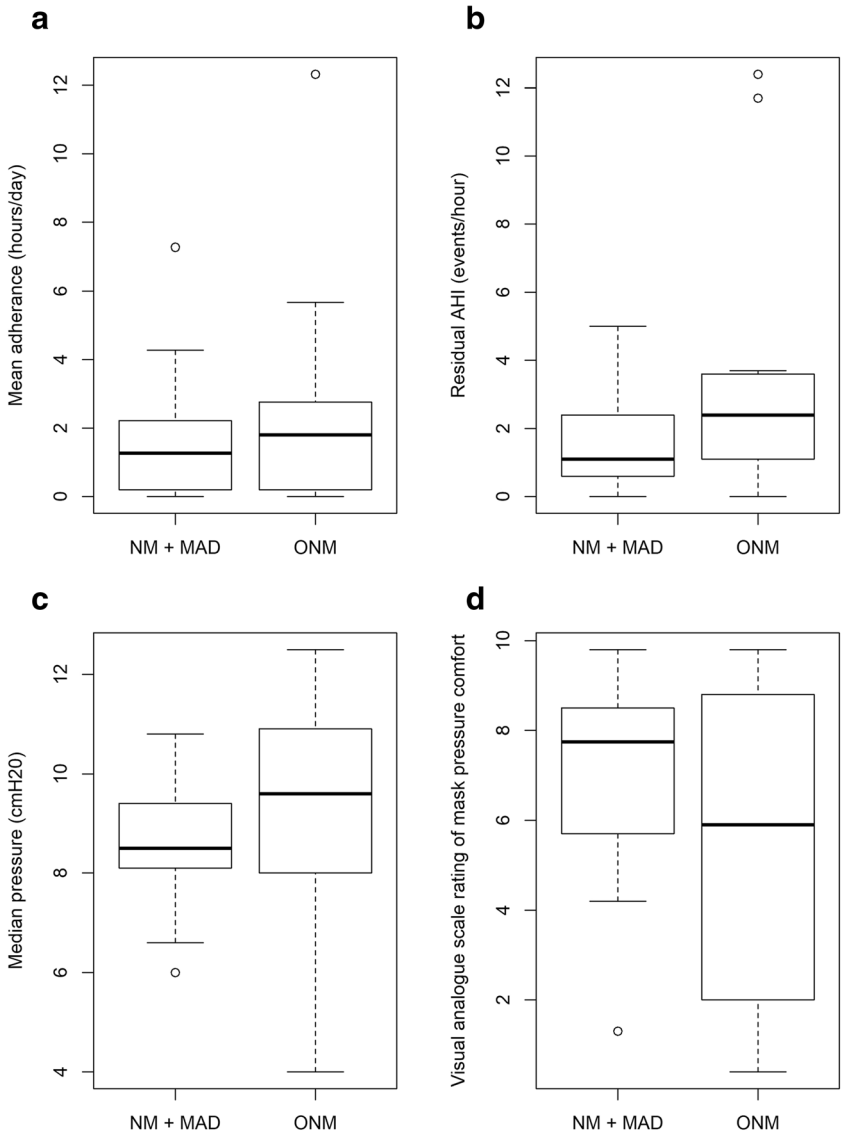

Fig. 2 Adherence, efficacy, and tolerance of combined therapy with a nasal mask and mandibular advancement device compared to an oronasal mask. **a** Mean CPAP adherence collected using CPAP built-in software (Rescan 5.5.0) during a 1-month period. **b** Mean residual AHI estimated by CPAP built-in software for each 1-month treatment modality. **c** Median delivered pressure for each 1-month treatment modality. **d** Mean pressure-related comfort (visual analogue scale). NM + MAD, nasal mask combined with mandibular advancement device; ONM, oronasal mask

14 cm H_2O). This protocol was approved by the IRB # 6705 and informed consent was obtained from all patients.

The primary outcome was CPAP adherence. Secondary outcomes included excessive daytime sleepiness (EDS), quality of life (QOL), residual events (r-AHI), level of unintentional leak, and CPAP pressures. The Epworth Sleepiness Scale and Quebec Sleep Questionnaire, respectively used to evaluate EDS and QOL, were assessed at baseline and at 1 month for each interface. Adherence, r-AHI, unintentional leaks, and pressure (mean and 95th percentile) were collected using built-in CPAP software (Rescan 5.5.0). Finally, interface comfort, pain, leaks, and satisfaction were evaluated by eight questions rated on a visual analogue scale (VAS).

Intention-to-treat analysis was used. Wilcoxon signed-rank tests were carried out first to evaluate any carryover effect between the two periods (none was found). Then, paired Student's *t* tests or Wilcoxon signed-rank tests were conducted to assess differences between ONM and NM + MAD for each outcome, depending on the distribution of the variables. A p value of < 0.05 was considered significant. SAS v9.4 (SAS Institute Inc., Cary, NC) was used for all analyses. Based on a difference in CPAP adherence of 1.5 (SD ± 2) hour/night between the two interfaces, the recruitment target was 35 patients.

Results

Of 584 patients screened, only 15 were included in a single center (Fig. 1). Table E1 shows patient characteristics at inclusion. Seven patients were randomized to use a NM + MAD first, and 7 to use an ONM first. One patient was wrongly included (adherent to CPAP with an ONM).

Mean CPAP adherence was not improved with NM + MAD compared to that with ONM ($p = 0.90$) (Fig. 2a). Adherence was very low in both groups: CPAP was used for ≥ 4 h in only 4.5% of nights with NM + MAD and 4% with ONM. Mean self-reported adherence to MAD was 1.2 h/night with a mean 19.6 days of non-use.

Table 1 reports effectiveness and tolerance outcomes for both interfaces. Median residual AHI and pressure tended to be lower ($p < 0.1$ for both) with NM + MAD compared to those with ONM, but the difference was not significant (Fig. 2b, c). NM + MAD did not reduce unintentional leaks measured by the CPAP devices ($p = 0.93$), but tended to reduce median pressure ($p = 0.09$) compared with ONM.

No differences were found for EDS, QOL, or tolerance. Comfort tended to be higher with ONM ($p = 0.06$) (Fig. 2d), and self-reported interface-related pain was significantly higher with NM + MAD ($p = 0.04$). Self-reported leaks (VAS) tended to be higher with NM + MAD ($p < 0.1$).

Table 1 Effectiveness and tolerance outcomes after 1 month with combined therapy (nasal mask and mandibular advancement device) compared to an oronasal mask

Variable	NM + MAD	ONM	*p*
Δ ESS*	0 [− 3; 2]	0 [− 2; 1]	1
Δ Total QSQ*	4 [− 5; 14]	8 [4; 17]	0.53
Median CPAP pressure (cm H_2O)	8.5 [8.1; 9.4]	9.6 [8; 10.9]	0.09
Residual AHI (events/h)	1.1 [0.6; 2.4]	2.4 [1.1; 3.6]	0.09
Median leaks (L/min)	3 [0; 5.4]	0 [0; 4.2]	0.93
Visual analogue scales†			
Mask setup and adjustment (cm)	7 [3.6; 8.9]	8.1 [7.2; 9.1]	0.39
Mask-related comfort (cm)	5.4 [1.3; 7]	7.2 [6.1; 8.7]	0.06
Mask-related pain (cm)	7.8 [4.9; 9]	9.1 [7.5; 9.6]	0.04
Mask-related leaks (cm)	6.2 [4.1; 9.1]	3.1 [1.6; 7.2]	0.09
Annoying mouth leaks (cm)	4.3 [1.6; 7]	7.7 [4; 9.6]	0.15
Nasal and/or oral dryness (cm)	5.8 [1.3; 8.6]	4.8 [2.7; 7.8]	0.63
Runny nose in the morning (cm)	9 [5.5; 9.6]	7.7 [3.2; 9.7]	0.32
Pressure-related comfort (cm)	7.8 [5.7; 8.5]	5.9 [2; 8.8]	0.48
Treatment satisfaction (cm)	5.4 [3; 8.4]	6.6 [2.1; 9]	0.48

AHI, apnea–hypopnea index; *CPAP*, continuous positive airway pressure; *ESS*, Epworth Sleepiness Scale; *NM + MAD*, nasal mask with associated mandibular advancement device; *ONM*, oronasal mask; *QSQ*, Quebec Sleep Questionnaire

*Results are presented as changes in score (Δ) (median [interquartile]) between baseline and evaluation for both interfaces

† A visual analogue scale (0–10) was used to measure the overall level of satisfaction with ONM or NM + MAD: 0 indicates very dissatisfied and 10 highly satisfied. For pain, 0 indicates worst pain and 10 no pain. For leaks: 0 indicates major leaks and 10 the absence of leaks

Discussion

This randomized controlled trial showed the combination of a nasal mask with a mandibular advancement device did not improve adherence to CPAP compared with an oronasal mask, although there was a trend towards a reduction in residual AHI and pressure requirements with the NM + MAD. Patients reported NM + MAD to be less comfortable and more painful than ONM.

Previous studies that found good adherence to CPAP with NM + MAD did not report the number of patients who did not tolerate the MAD at baseline or who discontinued treatment at follow-up [6, 7]. Although our results are consistent with previous findings that showed a trend towards lower pressures and residual events with NM + MAD [6, 7], the higher level of discomfort associated with NM + MAD could further discourage already non-adherent or poorly adherent patients. It could be suggested that residual bite opening with the MAD favored mouth leaks; however, there was no difference in leaks between NM + MAD and ONM (either self-reported or software-reported leaks; Table 1). Despite the fact the MAD were set at 50% of maximal voluntary protrusion to help

tolerance, self-reported adherence was very low. It is possible that the 1-month study duration may have been insufficient for patients to become sufficiently accustomed to the MAD to use it with CPAP. Also, the patients included did not have severe symptoms (no excessive daytime sleepiness) which could have contributed to the low level of adherence at baseline and follow-up [8].

One major limitation of this study was the failure to reach the target sample size ($n = 35$), limiting the power of the trial and increasing the risk of type II errors. We deliberately chose to recruit patients who reported annoying unintentional mouth leaks or who were non-adherent with oronasal masks in order to potentiate the benefits of NM + MAD. The results must be interpreted with caution since only two types of monobloc MAD were used; thus, the therapeutic strategy tested is not representative of all possible combinations of MAD + NM. The subjective criterion of "annoying mouth leaks" associated with inadequate dental status for the fitting of a MAD made the recruitment process difficult (Fig. 1).

Conclusion

Despite constant progress in the design of interfaces for CPAP, improving adherence in patients with mask-related lack of tolerance or mouth leaks remains challenging. Although the combination of MAD and nasal masks could reduce pressures by improving upper airway patency, this treatment may only be appropriate for a small number of patients (particularly with regard to the associated discomfort), and appropriate indications still need to be determined. We believe this study and its limitations will aid clinicians in decision-making and designing future studies.

Acknowledgments We would like to acknowledged Johanna Robertson (PT, PhD) for language editing.

Author contribution Conception: J-C Borel, F Series; acquisition: M Lesgoirres, A Verain; data analysis: N Daabek, S Bailly; data interpretation: J-C Borel, M Lebret, A Léotard; drafting the work or revising it: A Léotard, J-C Borel, JL Pépin, M Lebret, F Series; agreeing with manuscript results and conclusions: all authors

Compliance with ethical standards

Conflict of interest The authors M Lebret, M Lesgoirres, N Daabek, and J-C Borel are employees of AGIR à dom., a non-profit homecare provider. J-C Borel has received grants, personal fees, and non-financial support from Philips Healthcare and ResMed unrelated to the submitted work. M Lebret has received personal fees and non-financial support from Air liquid Medical System and Sefam unrelated to the submitted work. A Léotard, S Bailly, A Verain, F Series, and J-L Pépin declared that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

Glossary *AHI*, apnea–hypopnea index; *BMI*, body mass index; *CPAP*, continuous positive airway pressure; *EDS*, excessive daytime sleepiness; *MAD*, mandibular advancement device; *NM*, nasal mask; *NM+MAD*, nasal mask with associated mandibular advancement device; *ONM*, oronasal mask; *OSAS*, obstructive sleep apnea syndrome; *QOL*, quality of life.

References

1. Andrade RGS, Viana FM, Nascimento JA et al (2017) Nasal vs oronasal CPAP for OSA treatment: a meta-analysis. Chest 153: 665–674
2. Chai CL, Pathinathan A, Smith B (2006) Continuous positive airway pressure delivery interfaces for obstructive sleep apnoea. Cochrane Database Syst Rev (4):CD005308. https://doi.org/10.1002/14651858.CD005308.pub2
3. Borel JC, Tamisier R, Dias-Domingos S, Sapene M, Martin F, Stach B, Grillet Y, Muir JF, Levy P, Series F, Pepin JL, on behalf of the Scientific Council of The Sleep Registry of the French Federation of Pneumology (OSFP) (2013) Type of mask may impact on continuous positive airway pressure adherence in apneic patients. PLoS One 8:e64382. https://doi.org/10.1371/journal.pone.0064382
4. Schellhas V, Glatz C, Beecken I, Okegwo A, Heidbreder A, Young P, Boentert M (2018) Upper airway obstruction induced by non-invasive ventilation using an oronasal interface. Sleep Breath Published Online First 22:781–788
5. Borel J-C, Gakwaya S, Masse J-F, Melo-Silva CA, Sériès F (2012) Impact of CPAP interface and mandibular advancement device on upper airway mechanical properties assessed with phrenic nerve stimulation in sleep apnea patients. Respir Physiol Neurobiol 183: 170–176
6. Liu H-W, Chen Y-J, Lai Y-C, Huang CY, Huang YL, Lin MT, Han SY, Chen CL, Yu CJ, Lee PL (2017) Combining MAD and CPAP as an effective strategy for treating patients with severe sleep apnea intolerant to high-pressure PAP and unresponsive to MAD. PLoS One 12:e0187032
7. El-Solh AA, Moitheennazima B, Akinnusi ME et al (2011) Combined oral appliance and positive airway pressure therapy for obstructive sleep apnea: a pilot study. Sleep Breath 15:203–208
8. Jacobsen AR, Eriksen F, Hansen RW, Erlandsen M, Thorup L, Damgård MB, Kirkegaard MG, Hansen KW (2017) Determinants for adherence to continuous positive airway pressure therapy in obstructive sleep apnea. PLoS One 12:e0189614