Relative accuracy of algorithm-based prescription of nasal CPAP in OSA

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Summary Background: Patients with OSA on nasal continuous positive airway pressure (CPAP) have considerable night-to-night variation in their pressure requirements, suggesting that a one-night titration might not be very precise. This study investigates the likely error incurred using a one-night titration, and explores whether an algorithm-based approach to determine the pressure is as accurate.

Methods: Thirty patients with OSA used an autotitrating CPAP device for 28 nights and the average was regarded as the ‘reference’ pressure for that patient. Using estimates of precision and bias, this ‘reference’ pressure was compared with (1) an algorithm-derived pressure (based on neck circumference and OSA severity), (2) a one-night titration (using four alternative nights), and (3) a fixed pressure of 10 cmH2O.

Results: The mean ‘reference’ pressure for the group was 9.83 (± 2.12) cmH2O. There was little bias from any of the alternatives. However, the precision varied between 1.65 and 2.45 cmH2O for the four one-night titrations, was 2.00 for the algorithm, and was 2.12 using a fixed pressure of 10 cmH2O.

Conclusions: Considerable night-to-night variation means that a one-night titration is not very precise and is subject to random variation. A one-night titration has a similar inaccuracy to that resulting from using an algorithm, based on OSA severity and neck circumference. Setting all patients with OSA at 10 cmH2O is little worse.

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Introduction

A one-night, attended, sleep study with manual titration of the nasal continuous positive airway pressure (CPAP) to control OSA and snoring, is regarded by many as the gold standard for assessing the pressure requirements for subsequent home use. However, this is assumed rather than being evidence-based. Various studies have shown that unattended studies, using automatic titrating CPAP machines, give similar pressures and outcomes. However, there are also data suggesting that there is considerable night-to-night variation in CPAP titration pressures, implying that a one-night titration, manual or automatic, may not be as precise as assumed. This current study was performed to assess the night-to-night variability of CPAP pressure requirements, and to assess the theoretical bias and precision of both an algorithm-based pressure prescription, and a simple strategy of placing everyone on a fixed pressure of 10 cmH2O.

Methods

The presence of OSA was established by a one-night sleep study, recording body movement and heart
rate as markers of sleep disturbance, with arterial oxygen saturation measurements (SaO\textsubscript{2}) and snoring as markers of respiratory impairment, and measurements of pulse transit time to differentiate obstructive from central apnoeas\textsuperscript{6} (Visi-Lab monitoring system, Stowwood Scientific Systems, Oxford, UK).\textsuperscript{7} In addition, a video recording of the whole night is available to confirm that abnormalities seen on the tracings are due to OSA. The severity of OSA was quantified from the number of >4\% falls in SaO\textsubscript{2} per hour of study. This predicts the severity of OSA symptoms and its response to treatment at least as well as any other index.\textsuperscript{7} Thirty such patients, newly diagnosed at the Oxford Sleep Unit and going onto nasal CPAP, were given an auto-titrating CPAP machine (Autoset-T, ResMed) to take home following our standard intensive CPAP induction programme. They were instructed to use it all night and every night for a minimum of 28 nights, and after this period the devices were returned and downloaded to give the 95th centile for pressure, for each of the individual nights. The average of these individual night data values was assumed to provide the best estimate for the fixed pressure the patient should receive thereafter, the ‘reference’ pressure. Only nights with CPAP usage (‘mask on’ times) over 3 h were included in the data sets. We then compared how close a one-night titration would have been to this ‘reference’ pressure (using the Autoset data from nights 1, 8, 15, and 22), how close an algorithm-derived pressure would have been, and finally how close a standard pressure of 10 cmH\textsubscript{2}O would have been.

The algorithm we used to predict nasal CPAP pressure was derived using data from an earlier study\textsuperscript{8} on 101 patients with OSA (Epworth Sleepiness Scale, ESS, ≥10, >4\% SaO\textsubscript{2} dips/h overnight ≥10/h), similar to the approach used by Hoffstein and Mateika.\textsuperscript{9}

Multiple linear regression techniques identified only neck circumference and OSA severity (>4\% SaO\textsubscript{2} dips/h) as independent predictors of nasal CPAP titration pressures (derived from an overnight unattended titration using DeVilbiss Horizon auto-titrating devices): the model also included age, body mass index and ESS which all proved not to be independent predictors. The final model was

\[
\text{CPAP pressure in cmH}_2\text{O} = (0.048 \times 4\% \text{ SaO}_2 \text{ dips/h}) + (0.128 \times \text{neck size in cm}) + 2.1.
\]

The data are presented in terms of bias and precision, where bias is the mean of the differences for the 30 patients between their ‘reference’ pressure and the value from the various alternatives, and the precision is the standard deviation of these differences, i.e. how variable was the error between the ‘reference’ pressure and the alternatives across the 30 patients. In addition, the maximum errors, either above or below the ‘reference’ pressure, are also given. For the one-night titration comparisons, data from not only the first night on the Autoset were chosen, but also from the night after 1, 2 or 3 weeks (nights 8, 15, 22, respectively), to investigate if there was any improvement in accuracy after different periods on nasal CPAP.

**Results**

The 30 patients had mean (SD) values for age, BMI, OSA severity, ESS, and neck circumference of 49.0 (10.5, years), 36.5 (6.5, wt/kg\textsuperscript{2}), 48.6 (28.2, >4\% dips/h), 15.3 (4.3, out of 24), and 45.7 (3.7, cm), respectively. The mean (SD) number of nights available per patient, with more than 3 h of data, was 24.9 (5.8), and the mean (SD) ‘mask on’ time was 5.1 (1.7) hours per night. The mean (SD) CPAP pressure was 9.83 (2.12, cmH\textsubscript{2}O) for all the patients.

Table 1 compares the bias, precision, and largest errors for the six alternatives. Note that the four individual titration nights performed similarly with little bias, but considerable imprecision. For example, if the first night had been used to decide on the fixed pressure for subsequent use, then 40\% of the patients (>1SD) would have been more than 1.65 cmH\textsubscript{2}O from the ‘reference’ pressure, and if the eighth night had been used then 40\% would have been more than 2.45 cmH\textsubscript{2}O from the ‘reference’ pressure: the maximum errors varied between 2 and 8 cmH\textsubscript{2}O.

The algorithm gave a small bias of +0.43 cmH\textsubscript{2}O and a precision of 2.00 cmH\textsubscript{2}O, very similar to the precision from any of the one-night titration values. In addition, the largest errors tended to be smaller than those from one-night titration figures. Finally, the use of a ‘one pressure for all’ showed a bias of +0.17 cmH\textsubscript{2}O (since the average ‘reference’ pressure across all 30 patients was 9.83 cmH\textsubscript{2}O) and a precision of 2.12, slightly worse than the algorithm, but again similar to the precision of any of the one-night titration values.

**Discussion**

This study has shown that there is considerable night-to-night variation in the required nasal CPAP
pressure, when measured as the 95th centile of pressure using an Autoseat-T, autotitrating CPAP machine. One-night titrations, often using autotitrating machines, are used extensively in clinical practice to define the fixed pressure that a patient subsequently needs for home use. The idea that a one-night titration is precise, and would remain the same on subsequent nights, is clearly not correct. It also appears that an algorithm, based on neck size and OSA severity, is as precise as a one-night titration, and surprisingly a 'one pressure for all' (10 cmH2O) is little worse. In addition, the algorithm and single pressure approaches limited the size of the largest errors.

The source of this night-to-night variation is unclear, but it seems unlikely to be a true variation in requirement, given the success of fixed pressure machines over the last 20 years, and the lack of evidence of any advantage from using autotitrating systems on a long-term basis. Similar night-to-night variation has been found by other authors and a recent report suggests this may be due to variations in sleep quality.

### Conclusions

An algorithm-based approach to prescribing nCPAP is theoretically as good as a one-night titration in estimating the pressure requirements. Whether this translates into similar long-term outcomes for patients going onto CPAP for OSA is the subject of a companion paper.

### References

1. Indications and standards for use of nasal continuous positive airway pressure (CPAP) in sleep apnea syndromes.


### Table 1

<table>
<thead>
<tr>
<th>Differences from patient’s ‘reference’ pressure, n = 30 patients</th>
<th>1st titration night</th>
<th>8th titration night</th>
<th>15th titration night</th>
<th>22nd titration night</th>
<th>Algorithm</th>
<th>Fixed 10 cmH2O</th>
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<tr>
<td>Mean (bias) (cmH2O)</td>
<td>+0.15</td>
<td>−0.41</td>
<td>−0.26</td>
<td>−0.24</td>
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<td>SD (precision) (cmH2O)</td>
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<td>Maximum (cmH2O)</td>
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<td>+3.59</td>
<td>+3.31</td>
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<td>Minimum (cmH2O)</td>
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