Randomized Cross-Over Study Comparing Three Models of Auto-Titrating Positive Airway Pressure Therapy for Obstructive Sleep Apnea

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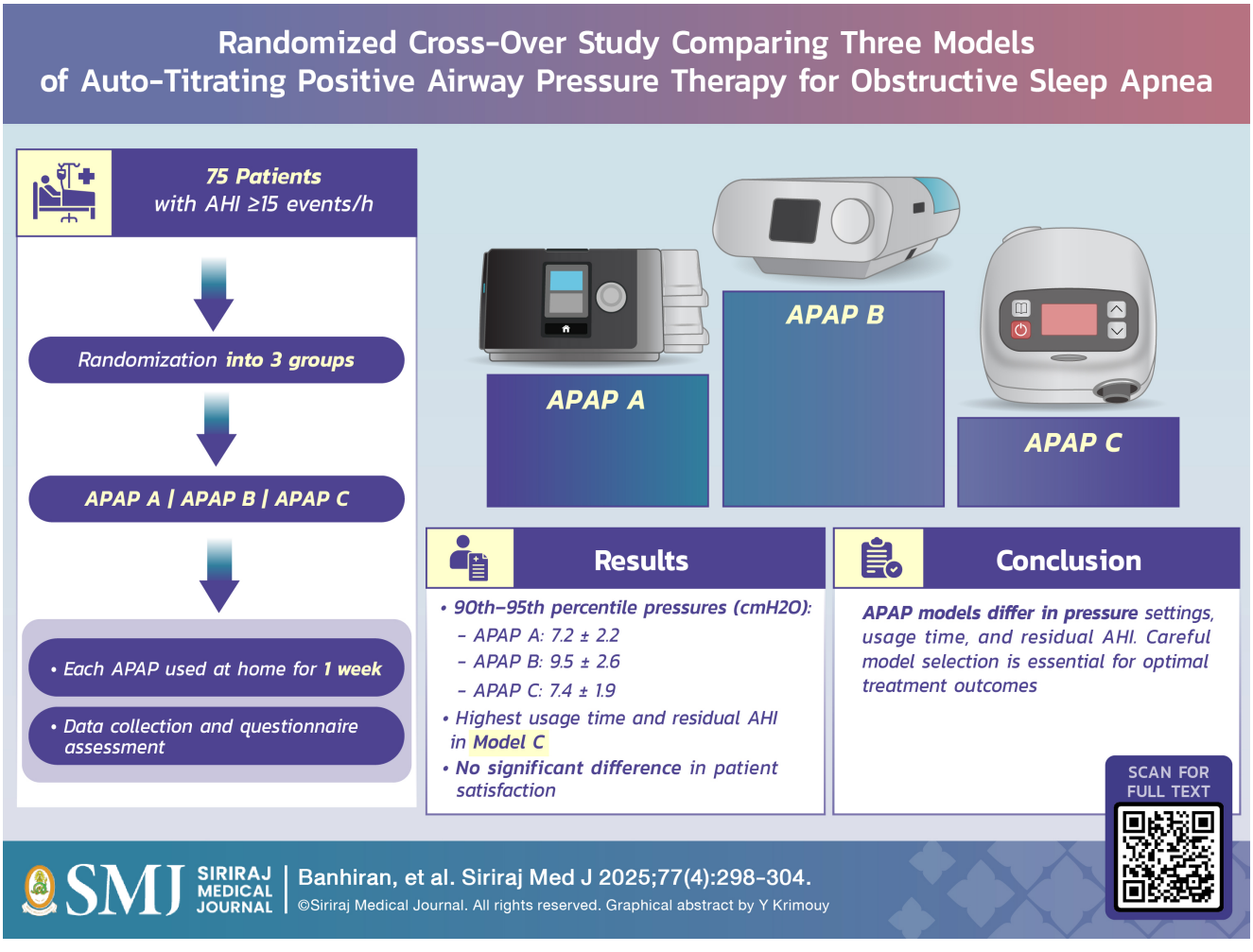

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ABSTRACT

Objective: To compare pressure, average usage time, residual apnea-hypopnea index (AHI), and patient satisfaction across three models of auto-titrating positive airway pressure (APAP) (A, B, and C refers to APAP devices — APEX, Philips, and Hoffrichter, respectively).

Materials and Methods: Seventy-five adult patients with an AHI of ≥15 events/h who were willing to use APAP were included and randomly assigned to three groups with different APAP sequences generated by computer randomization. After using each model at home for a week, patients returned to the clinic for data collection and switched to the next model. They completed questionnaires regarding their symptoms before and after the therapeutic session.

Results: Data from 62 patients (43 males, 19 females) who completed the research protocol were analyzed. The average 90th–95th percentile pressures for APAP models A, B and C were 7.2 ± 2.2, 9.5 ± 2.6 and 7.4 ± 1.9 cmH_2O, respectively ($p < 0.001$), with an intra-class correlation coefficient (ICC) of 0.52 (95% CI 0.22-0.70). In addition, average usage time and residual AHI differed significantly, with the highest values in model C. However, no significant differences were found in mean pressure or patient satisfaction across the three APAP models.

Conclusion: The 90th–95th percentile pressures, average time usage, and residual AHI varied among APAP models, showing only moderate consistency. These findings suggest that careful consideration is required when selecting an APAP model for home use, as it may affect pressure determination and treatment outcomes.

Keywords: Auto-titrating positive airway pressure; APAP; obstructive sleep apnea; pressure titration; continuous positive airway pressure; CPAP (Siriraj Med J 2025; 77: 298-304)

INTRODUCTION

Obstructive sleep apnea (OSA) is a common and potentially serious disease characterized by recurrent episodes of partial or complete upper-airway obstruction during sleep, leading to hypoxemia, hypercarbia, and interrupted sleep.[1-8] Patients with OSA often present with symptoms such as loud habitual snoring, excessive daytime sleepiness (EDS), irritability, reduced concentration, memory decline, diminished quality of life, an increased risk of motor vehicle or occupational accidents, and coexisting cardiovascular disease.[9-13]

The first-line treatments for OSA currently include sleep hygiene, weight reduction for overweight or obese patients, and continuous positive airway pressure (CPAP) therapy, particularly for those with moderate to severe OSA.[14-20] The primary mechanism of CPAP is to act as a pneumatic splint, keeping the upper airway open by applying positive pressure to the pharynx via the device's interface. When used regularly and with optimal airway pressure, CPAP can alleviate symptoms and improve patients' quality of life.[14,21,22]

There are several methods to determine the optimal airway pressure for OSA patients, including in-lab polysomnography (PSG) with CPAP titration, either full-night or split-night protocols;[14,23] auto-titrating positive airway pressure (APAP) at home;[20,24,25] and predictive calculated formulas. However, PSG is expensive and cumbersome, and predictive formulas are usually inaccurate. Home APAP titration allows patients to use APAP at home for a week, after which the 90th -95th percentile pressure that reduces the respiratory event index (REI) to 5 events/h or less is selected as the optimal fixed CPAP pressure. This method is currently considered the most practical.[20,24,25] However, there are various models of APAP available, and limited data exists comparing clinically relevant differences and the optimal pressure settings between them.[26,27] At Siriraj Hospital, three models of APAP are used for OSA patients, but no data regarding the differences in their effectiveness is available. Therefore, the primary objective of this study is to compare the 90th–95th percentile pressure recorded from the three models of APAP used at Siriraj Hospital.

The secondary objective is to compare the three APAP models in terms of mean pressure, maximum pressure, average usage time, residual AHI, and patient satisfaction.

MATERIALS AND METHODS

Study design

This randomized crossover study was conducted on three models of APAP at the snoring clinic in the Department of Otorhinolaryngology and the Siriraj Sleep Center, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand, between September 2018 and December 2019. The study was approved by the Siriraj Institutional Review Board (SIRB) (COA no.

Si 418/2018) and written consent was obtained from all participants before they enrolled.

Subjects

The inclusion criteria were patients aged ≥ 18 years with an apnea-hypopnea index (AHI) ≥15 events/h, as determined by diagnostic PSG. Exclusion criteria included patients with severe or unstable medical conditions, such as recent myocardial infarction or stroke, and those who declined CPAP therapy.

Intervention

During a routine follow-up visit after PSG, patients were randomly assigned to one of three groups according to APAP sequences generated by a randomization program by a statistician not involved in data collection, patients were then asked to use all three APAP models at home, each for one week. After using each model, the patients returned to the clinic for a follow-up, where their symptoms were reviewed, APAP data downloaded, and they switched to the next model (Fig 1). All patients completed questionnaires regarding their symptoms before treatment and after each therapeutic session. Treatment intolerance or failure was recorded if participants withdrew from the study due to adverse effects or if they failed to follow up for any reason.

Auto-titrating positive airway pressure

Three models of APAP were used in this study: (A) XT Auto (Apex Medical Corporation, New Taipei City, Taiwan), (B) REMstar Auto A-Flex System One 60 Series (Philips Respironics Murrysville, USA), and (C) Hoffrichter Point 2 AutoCPAP (Hoffrichter GmbH, Schwerin, Germany). The pressure for all devices was set between 5-15 cmH_2O. Each patient received education on APAP use before treatment and was instructed to use the devices with a properly selected nasal mask every night or as much as they could tolerate.

Sample size calculation

The sample size of this study was calculated by using data from a previous study by *Nolan, et al.*[26] The 90^{th}–95^{th} percentile pressure comparison among the three APAP models was reported as an intraclass correlation coefficient (ICC). Based on an ICC of 0.8 and an acceptable discrepancy within a 95% confidence interval of 0.15, the calculated sample size was 62. To account for an estimated dropout rate of about 20%, the total sample size for this study was set at 75 participants.

Randomization, allocation, and concealment

Patients were randomly assigned to one of three treatment groups using sequential numbers from a block-

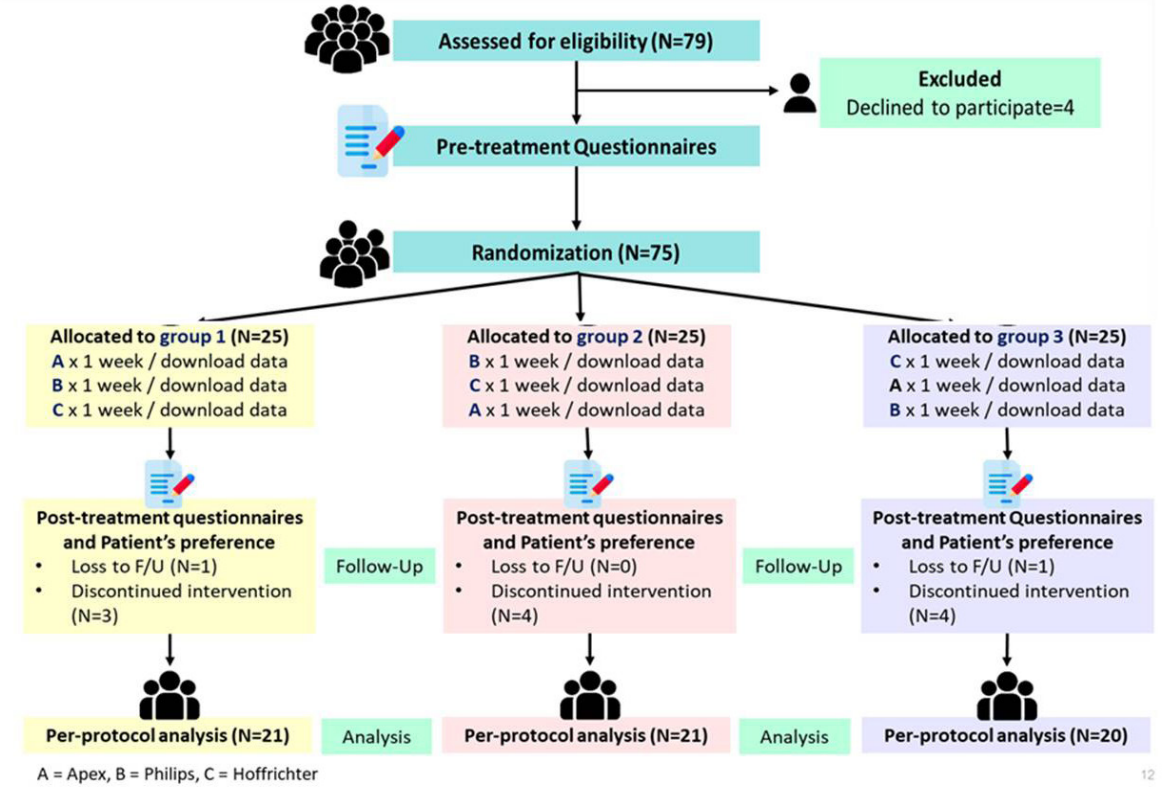

Fig 1. Consolidated Standards of Reporting Trials (CONSORT) flowchart of patients.
Abbreviations: APAP = auto- titrating positive airway pressure; A = APEX; B = Philips; C = Hoffrichte

computerized randomization program managed by a statistician not involved in data collection. The patients in each group were assigned to use the APAP models in the following order: group 1 (25 patients) — A, B, and C; group 2 (25 patients) — B, C, and A; and group 3 (25 patients) — C, A, and B (Fig 1). Patients and researchers were blinded to the sequential numbers prior to group assignment but not during the interventions.

Statistical analysis

Categorical data were presented as numbers and percentages, while continuous data were presented as means ± standard deviation (SD). The 90th–95th percentile pressure comparison among the three APAP models was reported using the intraclass correlation coefficient (ICC), which was interpreted as follows: ICC < 0.4 indicated a poor level of consistency; ICC 0.4-0.74 indicated a moderate level of consistency; and ICC ≥ 0.75 indicated an excellent level of consistency. Other variables were compared using one-way repeated measures analysis of variance (ANOVA) and the Bonferroni post hoc test, with results reported at a 95% confidence interval (CI). A *p* value of < 0.05 was considered statistically significant. All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) software, version 22.0.

RESULTS

Seventy-nine patients were initially enrolled, but four were excluded (patients declined PAP therapy), leaving 75 patients for randomized. During the follow-up period, 13 patients withdrew from the study (two were lost to follow-up and 11 discontinued the intervention due to intolerance of APAP therapy). As a result, data from 62 patients (43 males and 19 females) with a mean age of 50.2 ± 12.3 years (range 25-72) were analyzed. The mean body mass index (BMI) and mean AHI of all patients were 28.6 ± 5.0 kg/m^2 and 53.0 ± 27.7 events/h, respectively. There were no statistically significant differences in age, gender, body mass index (BMI), AHI, 90th–95th percentile pressure, or mean and minimum oxygen saturation among the three patient groups (Table 1).

Primary outcome

The average 90th–95th percentile pressures for APAP models A, B and C were 7.2 ± 2.2, 9.5 ± 2.6 and 7.4 ± 1.9 cmH_2O, respectively, with an ICC of 0.52 (95% CI 0.22-0.70), indicating a moderate level of consistency.

Secondary outcomes

There were no significant differences in the mean pressure or patient satisfaction among the three APAP models. However, the average usage time and residual AHI differed significantly, shown in Table 2.

TABLE 1. Demographics of the three groups of participants.

	Group 1 (ABC, N = 21)	Group 2 (BCA, N = 21)	Group 3 (CAB, N = 20)	*P*-value
Male, N (%)	14	14	15	0.44
Age (y)	51.8 ± 12.2	51.4 ± 13.6	47.5 ± 11.0	0.47
BMI (kg/m^2)	28.2 ± 4.1	27.9 ± 5.0	29.6 ± 6.1	0.55
AHI, events/h	49.9 ± 26.8	55.4 ± 31.6	53.7 ± 24.6	0.80
Mean O_2 saturation (%)	94.1 ±2.9	93.9 ± 2.9	93.6 ± 2.7	0.87
Lowest O_2 saturation (%)	80.1 ± 7.9	80.3 ± 10.5	79.1 ± 6.5	0.89
90th – 95th pressure of A (cmH_2O)	7.2 ± 1.9	6.9 ± 2.4	7.5 ± 2.5	0.84
90th – 95th pressure of B (cmH_2O)	9.0 ± 1.9	10.1 ± 3.2	9.6 ± 2.6	0.41
90th – 95th pressure of C (cmH_2O)	7.4 ± 2.0	7.5 ± 2.1	7.2 ± 1.8	0.82

Abbreviations: BMI = body mass index, AHI = apnea-hypopnea index, APAP = auto-titrating positive airway pressure, 90th – 95th pressure = 90th – 95th percentile pressure of APAP

TABLE 2. Recorded data of the three models of APAP.

	A	B	C	*P*- value
90th–95th pressure (cmH_2O)	7.2 ± 2.2	9.5 ± 2.6	7.4 ± 1.9	<0.001*
Mean pressure (cmH_2O)	6.6 ± 1.7	7.5 ± 1.8	5.6 ± 0.8	0.058
Average time usage (h/night)	5.5 ± 1.7	5.2 ± 1.9	5.7 ± 1.6	0.011*
Residual AHI (events/h)	2.8 ± 2.8	3.2 ± 2.2	7.7 ± 6.1	<0.001*

Abbreviations: AHI = apnea-hypopnea index, APAP = auto-titrating positive airway pressure, 90th – 95th pressure = 90th – 95th percentile pressure of APAP

*The statistical significant was accepted as *p*-value < 0.05.

Adverse side effects and treatment intolerance

The common side effects of APAP therapy were dry mouth, discomfort, burden, a feeling of burden, and nasal obstruction. However, these side effects were mild in most patients.

DISCUSSION

Although there are several methods to determine the effective airway pressure for OSA patients, home APAP titration currently appears to be the most practical method.[20,24,25] However, there is limited data comparing the optimal generated pressure across different APAP models. After randomization with no significant differences in baseline characteristics among the three APAP sequence groups, the results showed that the 90th–95th percentile pressure among the three APAP models were moderately consistent (ICC of 0.52, 95% CI 0.22-0.70), with the highest pressure in model B. A subsequent analysis comparing the 90th–95th percentile APAP pressure and the optimal pressure derived from split-night PSG in 30 patients demonstrated that model B had pressures closest to those obtained from split-night PSG (ICC of 0.76, 95% CI 0.50-0.89), which is consistent with previous studies.[27] Despite this, there were no significant differences in mean pressure or patient satisfaction among the three APAP models.

Although the average time of the APAP models was statistically different, the difference was slight (no more than 30 min/night), and likely not clinically significant. In terms of residual AHI, model C had the highest residual AHI compared to models A and B, which were nearly identical. This difference in residual AHI could have implications for follow-up in assessing treatment effectiveness.

This study had several limitations. First, the optimal pressure derived from APAP was not compared with the gold standard, i.e. PSG with CPAP titration, in all cases. Only 30 patients had data available from split-night PSG. Second, the three APAP models used in our hospital may not represent other models used elsewhere. Nevertheless, the results of this study suggest that using different APAP models to determine optimal pressure at home could result in varying treatment outcomes due to differences in the 90th-95th pressure and residual AHI recorded by each device. We recommend that future studies explore the long-term clinical impacts of different APAP models on treatment outcomes.

CONCLUSION

Although no significant differences were found in mean pressure or patient satisfaction, the 90th–95th percentile pressures differed among the three APAP models, with only moderate consistency. APAP model B had the highest 90th–95th percentile pressure, closely aligning with the optimal pressure derived from split-night PSG, compared to the other two models. Additionally, differences in average usage time and residual AHI were observed among APAP models, particularly with model C. These findings highlight the importance of carefully selecting an APAP model for home use to ensure optimal pressure determination, as different models may lead to varying treatment outcomes. Further studies are needed to explore these differences.

Data Availability Statement

The data that support the findings of this study are available upon request from the corresponding author, [P.K.]. The data are not publicly available due

to containing information that could compromise the privacy of research participants.

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DECLARATION

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Conflict of Interest

The authors declare they have no conflict of interest.

Registration Number of Clinical Trial

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Author Contributions

W.B., S.K.; Conceptualization W.B.; Writing - Original Draft. S.K., W.C., and S.R.; Data Curation, Methodology, Investigation. P.K; cWriting - Review & Editing. All authors have accepted responsibility for the entire content of this manuscript and have approved its submission.

Use of Artificial Intelligence

None

Compliance with Ethical Standards

Ethical approval: All procedures performed in studies involving human participants were conducted in accordance with the ethical standards of the institutional and/or national research committee and 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.

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