ORIGINAL RESEARCH ARTICLE

Comparison of Sleep and Respiratory Parameters of Obstructive Sleep Apnea Patients during Diagnostic and 2 Hours Automatic Positive Airway Pressure Split-night Titration: A Descriptive Study

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Abstract

Aims and objectives: Obstructive sleep apnea (OSA) is a common disorder manifested with snoring, daytime sleepiness, fatigue, metabolic, and cardiovascular symptoms. Manual continuous positive airway pressure (CPAP) titration is the gold standard to determine the amount of positive pressure required to abolish the airflow limitations. The current American Academy of Sleep Medicine (AASM) criteria for manual titration are very stringent, elegant but difficult. The AASM protocol does not favor the use of automatic positive airway pressure (APAP) in a split-night study. This study was done to look into changes in sleep and respiratory parameters following diagnostic polysomnography (PSG) and subsequent APAP titration, as a split-night protocol.

Materials and method: Records of 80 patients were scrutinized who had done level 1 PSG in a sleep laboratory in Kolkata, India. The laboratory used APAP titration for all kinds of titrations. This is a descriptive study, where data were compared between diagnostic and therapeutic nights of the same patients, done as a split-night study.

Results: The diagnostic night was denoted by visit 1 and therapeutic night as visit 2; the study was done as a split-night study. The rapid eye movement (REM) sleep time was found to be significantly increased from 15.08 minutes in V1 (SD 16.26) to 29.69 minutes (24.45) in V2 with a p <0.001. The total respiratory events were found to be significantly reduced from baseline median value of 206–14 in the follow-up visit posttreatment, p <0.001 as computed by Wilcoxon's signed-rank test. The REM SpO_2 was found to be significantly increased from baseline value of 90.87 $\pm$ 7.105 to 93.29 $\pm$ 6.312 in the follow-up visit posttreatment, p <0.001 as computed by paired sample t-test.

Discussion and conclusion: The wake stages, N1 and N2 sleep, were reduced significantly in the therapeutic night than diagnostic night, but N3 sleep was increased in therapeutic night, though statistically not significant. The total arousals and arousal index were also decreased significantly, although there were wide interindividual variations. So overall, patients had an improved sleep architecture during therapeutic night and often with REM rebound. Overall respiratory parameters showed very significant improvement in terms of apnea and hypopnea index (AHI). Oximetry data showed very significant improvements in terms of oxygen saturation, nadir oxygen saturation, and REM time oxygen level. So we can formulate the hypothesis that even a 2 hours split-night APAP titration can perform a good titration and significant improvements in sleep and respiratory parameters.

Keywords: Automatic positive airway pressure titration, Continuous positive airway pressure titration, Obstructive sleep apnea, Polysomnography, Split-night study.

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Introduction

Obstructive sleep apnea (OSA) is a common disorder manifested with snoring, daytime sleepiness, fatigue, metabolic, and cardiovascular symptoms.[1] It is diagnosed with overnight polysomnography (PSG), either as a full-night or split-night study protocol.[2–6] The treatment of OSA is positive airway pressure (PAP) therapy, and PSG with manual continuous PAP (CPAP) titration is the gold standard to determine the amount of positive pressure required to abolish the airflow limitations.[2,7] The current American Academy of Sleep Medicine (AASM) criteria for manual titration are very stringent, elegant but difficult. It requires a competent technician, who should be competently conversed to scoring also. But there is a paucity of such trained technicians in various parts of the world. It often leads to automatic PAP titration, known as APAP titration.[8,9] The AASM protocol does not favor the use of APAP in the split-night study. Current APAP titration guideline recommends at least three nights titrations for getting an assessment of pressure required to abolish airflow limitations and thus obtaining optimal manual CPAP pressure to be prescribed thereafter.[10–14] This study was done to look into changes in sleep and respiratory parameters following diagnostic PSG and subsequent APAP titration done same night, like split-night protocol.

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Materials and Methods

Records of 80 patients were scrutinized who had done level 1 PSG in a sleep laboratory in Kolkata, India. All of these patients were referred for level 1 PSG with a request for split-night titration if required. The split-night study was done for moderate-

to-severe OSA patients or OSA patients with significant oxygen desaturations. The laboratory used APAP titration for all kinds of titrations. The patients first had undergone a diagnostic night for 4 hours with the following channels: electroencephalograms (EEG), electrooculograms (EOG), electromyograms (EMG), electrocardiograms (ECG), nasal pressure transducer, oral thermistor, thoracic and abdominal plethysmographic belts, pulse oximeter, and position and snore sensors. The APAP titration was carried out with similar channels except for the flow channels of nasal pressure transducers and oral thermistors. The titrations were done mainly with nasal interface mainly with full face masks in few patients. The choices of masks were done during preprocedure counseling. The data were manually validated by the trained doctor according to AASM protocol. Data of those patients were analyzed, who completed the study and for whom most of the channel data were available.

This is a descriptive study where data were compared between diagnostic and therapeutic nights of the same patients. Suitable statistical analysis was done for the paired data with statistical software.

Results

Statistical Methods

Descriptive statistical analysis has been carried out in the present study. Results on continuous measurements are presented on mean ± SD, and results on categorical measurements are presented in number (%). The significance is assessed at a level of 5%. The normality of data was tested by simultaneous Anderson–Darling test, Shapiro–Wilk test, and graphically by QQ plot. Analysis of variance (ANOVA) with post hoc Dunnett's test for adjustment method has been used to find the significance of study parameters between three or more groups of subjects. Paired *t*-test or Wilcoxon's signed-rank test was applied to detect any significant change of study parameters measured on two occasions for the same group of patients. A *p* value of <0.05 was considered statistically significant. The statistical software, namely statistical analysis system (SAS) version 9.2 for Windows, SAS Institute Inc. Cary, North Carolina, United States and statistical package for social sciences (SPSS Complex Samples) version 21.0 for Windows, SPSS, Inc., Chicago, Illinois, United States, were used for the analysis of the data. Microsoft word 2010 and Microsoft Excel 2010 (Microsoft Corp, Redmond, Washington, United States) have been used to generate graphs and Tables 1 to 4.

The paired data were obtained from a split-night study conducted on the same night, first as diagnostic night and followed by therapeutic night in a sample size of 80. The diagnostic night was denoted by visit 1 and therapeutic night as visit 2.

The total time in bed (TBD) was greater during diagnostic night than in therapeutic night, and it was 233.45 minutes (SD 43.66) during diagnostic night and 146.78 minutes (SD 35.62), with a *p* <0.001. The total sleep time (TST) was also significantly lower from diagnostic to therapeutic night from 205.71 minutes (SD 40.69) to 132.20 minutes (SD 28.21) with *p* <0.001, by paired *t*-test.

The non-REM (NREM) sleep time was found to be significantly reduced from 192.46 minutes (SD 39.86) to 112.76 minutes (SD 33.49) with a *p* <0.001 as computed by paired *t*-test. The REM sleep time was found to be significantly increased from 15.08 minutes (SD 16.26) to 29.69 minutes (24.45) with a *p* <0.001. The sleep time was found to be significantly increased from 8.44 minutes (SD 16.14) to 47.83 minutes (SD 40.68) with a *p* <0.001. The wake after sleep onset (WASO) was found to be significantly decreased from 30.90 minutes (SD 24.91) to 14.88 minutes (SD 17.57), with *p* <0.001. The wake stage was significantly reduced from 13.69% (SD 11.14) to 9.49% (SD 9.58), with *p* <0.002. Stage N1 was significantly decreased from 13.25% (SD 7.62) to 9.53% (SD 9.46), with *p* <0.002. The stage N2 was also significantly decreased from 69.70% (SD 11.75) to 62.51% (SD 20.15), with *p* <0.003. But though N3 sleep increased from 11.95% (SD 7.55) to 13.34% (SD 11.47), it was not statistically significant with *p* >0.307. REM stage significantly increased from 5.20% (SD 6.31) to 14.66% (SD 17.42), with *p* <0.001. The total number of arousals was decreased from mean 121.16 (SD 80.60) to 42.91 (SD 39.13), with *p* <0.001. So, arousal index was also decreased significantly from mean 35.58 (SD 21.64) to 19.25 (16.70) with *p* <0.001.

Inference

The total respiratory events were found to be significantly reduced from baseline median value of 206–14 in the follow-up visit posttreatment, *p* <0.001 as computed by Wilcoxon's signed-rank test. The events of apnea were found to be significantly reduced from baseline median value of 121–6 in the follow-up visit posttreatment, *p* <0.001 as computed by Wilcoxon's signed-rank test.

The events of hypopnea were found to be significantly reduced from baseline median value of 36.5–6 in the follow-up visit posttreatment, *p* <0.001 as computed by Wilcoxon's signed-rank test. The apnea and hypopnea index (AHI) was found to be significantly reduced from baseline median value of 60.5–6 in the follow-up visit posttreatment, *p* <0.001 as computed by Wilcoxon's signed-rank test.

Inference

The SpO_2 was found to be significantly increased from baseline value of 92.72 ± 5.103 to 94.77 ± 3.692 in the follow-up visit posttreatment, *p* <0.001 as computed by paired sample *t*-test. The nadir SpO_2 was found to be significantly increased from baseline value of 70.14 ± 16.172 to 83.44 ± 10.108 in the follow-up visit posttreatment, *p* <0.001 as computed by paired sample *t*-test.

The REM SpO_2 was found to be significantly increased from baseline value of 90.87 ± 7.105 to 93.29 ± 6.312 in the follow-up visit posttreatment, *p* <0.001 as computed by paired sample *t*-test.

Discussion

The TBD was more in diagnostic night than therapeutic night as patients were allowed almost 4 hours of diagnostic and 3 hours of therapeutic night time. TST also changed accordingly. NREM sleep time also changed in the same manner. But REM sleep time significantly increased during titration night, though there was a wide variation of REM sleep distribution between individuals. There may be two reasons for these—first, as therapeutic nights were mainly the early morning periods, the REM intensity was naturally high and secondly, correction of flow limitations resulted in REM rebound. The sleep time had very high interindividual variations but significantly increased on therapeutic night. The reason may be patient required an adjustment time with APAP before sleep. Interestingly, WASO significantly decreased in therapeutic night, although the data seem to vary widely among individuals. The wake stages, N1 and N2 sleep, were reduced significantly in therapeutic night than diagnostic night, but N3 sleep was increased in therapeutic night, though statistically not significant. The total arousals

Table 1: Change in study parameters—sleep stage summary—minutes

		Mean	*Std. deviation*	*Std. error mean*
Pair 1	Total time in bed—Visit 1	233.45	43.661	4.881
	Total time in bed—Visit 2	146.78	35.623	3.983
Pair 2	Total sleep—Visit 1	205.81	40.696	4.550
	Total sleep—Visit 2	132.20	28.213	3.154
Pair 3	NREM time—Visit 1	192.46	39.865	4.457
	NREM time—Visit 2	112.76	33.498	3.745
Pair 4	REM time—Visit 1	15.08	16.264	2.277
	REM time—Visit 2	29.69	24.453	3.424
Pair 5	Latency—Visit 1	8.44	16.148	2.197
	Latency—Visit 2	47.83	40.686	5.537
Pair 6	Awake after sleep—Visit 1	30.90	24.911	2.821
	Awake after sleep—Visit 2	14.88	17.574	1.990

Paired samples test

		Paired differences							
					95% confidence interval of the difference				
		Mean	*Std. deviation*	*Std. error mean*	*Lower*	*Upper*	*t*	*df*	*p value (two-tailed)*
Pair 1	Total time in bed—Visit 1—Total time in bed—Visit 2	86.675	63.102	7.055	72.632	100.718	12.286	79	<0.001
Pair 2	Total sleep—Visit 1—Total sleep—Visit 2	73.613	57.218	6.397	60.879	86.346	11.507	79	<0.001
Pair 3	NREM time—Visit 1—NREM time—Visit 2	79.700	57.599	6.440	66.882	92.518	12.376	79	<0.001
Pair 4	REM time—Visit 1—REM time—Visit 2	−14.608	28.464	3.986	−22.613	−6.602	−3.665	50	0.001
Pair 5	Latency—Visit 1—Latency—Visit 2	−39.389	46.129	6.277	−51.980	−26.798	−6.275	53	<0.001
Pair 6	Awake after sleep—Visit 1—Awake after sleep—Visit 2	16.013	22.103	2.503	11.029	20.996	6.398	77	<0.001

Table 2: Change in study parameters—sleep architecture—%

Paired samples statistics

		N	*Mean*	*Std. deviation*	*Std. error mean*
Pair 1	Awake—Visit 1	80	13.69	11.114	1.447
	Awake—Visit 2	80	9.49	9.580	1.247
Pair 2	N1—Visit 1	80	13.25	7.625	0.852
	N1—Visit 2	80	9.53	9.463	1.058
Pair 3	N2—Visit 1	80	69.70	11.753	1.314
	N2—Visit 2	80	62.51	20.158	2.254
Pair 4	N3—Visit 1	80	11.95	7.557	0.845
	N3—Visit 2	80	13.34	11.473	1.283
Pair 5	REM—Visit 1	80	5.20	6.319	0.707
	REM—Visit 2	80	14.66	17.421	1.948
Pair 6	Total arousals—Visit 1	80	121.16	80.602	9.012
	Total arousals—Visit 2	80	42.91	39.136	4.376
Pair 7	Arousal index—Visit 1	80	35.58	21.644	2.420
	Arousal index—Visit 2	80	19.25	16.706	1.868

(Contd...)

Table 2: *(Contd...)*

		Paired samples test							
		Paired differences							
					95% confidence interval of the difference				
		Mean	Std. deviation	Std. error mean	Lower	Upper	t	df	p (two-tailed)
Pair 1	Awake—Visit 1– Awake—Visit 2	4.203	10.177	1.325	1.551	6.856	3.172	58	0.002
Pair 2	N1—Visit 1– N1—Visit 2	3.725	10.460	1.169	1.397	6.053	3.185	79	0.002
Pair 3	N2—Visit 1–N2—Visit 2	7.188	20.604	2.304	2.602	11.773	3.120	79	0.003
Pair 4	N3—Visit 1–N3—Visit 2	−1.388	12.075	1.350	−4.075	1.300	−1.028	79	0.307
Pair 5	REM—Visit 1–REM—Visit 2	−9.462	16.528	1.848	−13.141	−5.784	−5.121	79	<0.001
Pair 6	Total arousals—Visit 1– Total arousals—Visit 2	78.250	77.201	8.631	61.070	95.430	9.066	79	<0.001
Pair 7	Arousal index—Visit 1– Arousal index—Visit 2	16.325	20.305	2.270	11.806	20.844	7.191	79	<0.001

Table 3: Changes in respiratory events

	N	Mean	Std.deviation	Minimum	Maximum	Median	Lower quartile	Upper quartile	Z value	p value
Total Resp events—Visit 1	80	197.89	116.926	9	443	206.00	85.25	295.75	−7.30	<0.001
Total Resp events—Visit 2	80	27.68	43.677	0	315	14.00	9.00	31.50		
Apneas—Visit 1	80	145.68	111.260	2	418	121.00	44.25	235.00	−7.11	<0.001
Apneas—Visit 2	80	17.66	38.379	0	283	6.00	2.00	18.00		
Hypopneas—Visit 1	80	51.81	41.892	5	223	36.50	22.50	68.75	−7.55	<0.001
Hypopneas—Visit 2	80	10.01	13.225	0	93	6.00	2.25	13.75		
AHI—Visit 1	80	55.80	30.773	4	129	60.50	26.00	80.00	−7.25	<0.001
AHI—Visit 2	80	12.23	15.414	0	85	6.00	3.25	13.75		
RDI—Visit 1	80	56.38	30.678	4	129	63.00	26.25	80.00	−7.26	<0.001
RDI—Visit 2	80	12.23	15.414	0	85	6.00	3.25	13.75		

and arousal index were also decreased significantly, although there were wide interindividual variations. So overall, patients had improved sleep architecture during therapeutic night and often with REM rebound.

Overall respiratory parameters showed very significant improvement in terms of AHI, apneas and hypopneas. Oximetry data showed very significant improvements in terms of oxygen saturation, nadir oxygen saturation, and REM time oxygen level. As per AASM, a good titration reduces respiratory disturbance index (RDI) ≤10 or by 50% if the baseline RDI <15 and should include supine REM sleep that is not continually interrupted by spontaneous arousals or awakenings at the selected pressure.[15] The current result is consistent with good titration, even during APAP split night.

Still now there is a paucity of data on head-to-head comparison between manual CPAP titration and APAP titration, especially done as a split-night protocol. One study done in this field from Egypt showed that the use of APAP was equal to manual titration in this group of patients and required lesser time to reach the therapeutic pressure.[16] Such a benefit may translate to earlier commencement of treatment for many patients.

The weakness of this study was a small sample size and no direct control group. The study also has not assessed whether this quick fixing translates to improved patient adherence to PAP devices. A large-scale multicenter randomized controlled trial (RCT) with proper control groups can probably answer this issue in a better fashion.

Conclusion and Hypothesis Formulation

So we can draw the following conclusion from the study:

- Even a 2 hours APAP titration results in a significant improvement of sleep architecture in OSA patients.
- Even a 2 hours APAP titration results in a very significant improvement of airflow limitations and oxygenation in OSA patients.

So we can formulate the hypothesis that even a 2 hours split-night APAP titration can perform a good titration and significant improvements in sleep and respiratory parameters. Whether it can be recommended as a split-night titration method will require a RCT and comparison with the gold standard CPAP titration.

Table 4: Changes in oxygen saturation

Paired samples statistics—oxygen saturation						
Oxygen saturation		*Mean*	*N*	*Std. deviation*	*Std. error mean*	*p*
Pair 1	Awake—Visit 1	92.72	74	5.103	0.593	<0.001
	Awake—Visit 2	94.77	74	3.692	0.429	
Pair 2	Nadir SpO_2—Visit 1	70.14	79	16.172	1.819	<0.001
	Nadir SpO_2—Visit 2	83.44	79	10.108	1.137	
Pair 3	REM—Visit 1	90.87	45	7.105	1.059	0.035
	REM—Visit 2	93.29	45	6.312	0.941	

Paired samples test									
		Paired differences							
					95% confidence interval of the difference				
		Mean	*Std. deviation*	*Std. error mean*	*Lower*	*Upper*	*t value*	*df*	*p (two-tailed)*
Pair 1	Awake SpO_2—Visit 1—Awake SpO_2—Visit 2	−2.054	4.037	0.469	−2.989	−1.119	−4.377	73	<0.001
Pair 2	Nadir SpO_2—Visit 1—nadir SpO_2—Visit 2	−13.304	13.325	1.499	−16.288	−10.319	−8.874	78	<0.001
Pair 3	REM SpO_2—Visit 1—REM SpO_2—Visit 2	−2.422	7.467	1.113	−4.665	−0.179	−2.176	44	0.035

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