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Higher prevalence and increased severity of sleep-disordered breathing in male patients with chronic tinnitus: Our experience with 173 cases

1 | INTRODUCTION

Tinnitus and sleep are closely related. One of the most important aspects of tinnitus is its association with sleep disturbance. According to the literature, up to 71% of patients with tinnitus report sleep problems[1]; furthermore, insomnia is also associated with more distressing tinnitus.[2] Conversely, sleep disturbance was proposed as one of the causes of chronic tinnitus.[3] The relationship of tinnitus with sleep-disordered breathing (SDB) and obstructive sleep apnoea (OSAS) has rarely been mentioned.[4] In a recent population-based case-control study, the risk of tinnitus was found to increase 1.36 times in patients with OSAS. However, no detailed grading or severity of SDB (or OSAS) and tinnitus was provided. The purpose of this study was to investigate the exact relationship between tinnitus and SDB and delineate the incidence and severity of SDB in patients with chronic tinnitus; moreover, our study reports the preliminary outcome of tinnitus after intervention with continuous positive airway pressure (CPAP) in selected patients with moderate-to-severe SDB.

2 | SUBJECTS AND METHODS

Because the prevalence and severity of SDB are different in men and women, the study targeted male patients only. A total of 249 consecutive male patients with chronic tinnitus visited our tinnitus special clinic from August 2015 to August 2016. Each patient underwent a detailed examination to identify any possible otological causes of tinnitus such as otitis media, sudden deafness and otosclerosis. Forty-five patients with such aetiologies were excluded. The remaining 204 patients were asked to participate in the research and undergo examination by polysomnography (PSG) to explore the possible relationship between SDB and tinnitus. One hundred seventy-three patients agreed and gave us their consensus. Therefore, the results were based on the examination of the selected 173 of 204 (84.8%) participants from our consecutive cases. The general demographics, such as age, tinnitus severity and weight, were not significantly different between the participants and the non-participants (31 cases). The ages of the 173 patients ranged from 25 to 82 years, with an average age of 52.9 years. All enrolled patients underwent PSG in addition to routine otological and audiological assessments.

Every patient stayed overnight at our sleep clinic for PSG examination, the PSG results were recorded with a Sandman system (Sandman, Tyco Healthcare, Kanata, Ontario, Canada) with electroencephalography (EEG) electrodes at a frequency of 128 Hz. The PSG files were scored by 2 certified PSG technologists, each with over 10 years' experience. The files were also scored by the automatic system to generate the ORP values for the 2 central (C3/A2, C4/A1) and 1 occipital (O2/A1) EEG signals, 2 electrooculograms, a chin electromyogram (EMG), an electrocardiogram, thermistor flow, end-tidal PCO_2, oxyhaemoglobin saturation (SpO_2) and a microphone. The files were re-scored for sleep, arousals, respiratory events and leg movements by an experienced PSG technologist (MO) who scored every 30-s epoch based on the 2007 American Academy of Sleep Medicine guidelines. We evaluated sleep apnoea based on the snoring index, severity of hypoxia during REM and NREM stage, and apnoea-hypopnoea index (AHI) to determine factor(s) which worsened tinnitus.

The body mass index (BMI) and dietary habits were also recorded, and the distribution was analysed. A BMI > 24 kg/m^2 was considered overweight. This standard was based on the "Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies" published by the WHO in 2004. The prevalence and severity of SDB were based on the AHI. Because daytime somnolence was not assessed in this study, the prevalence of OSAS could not be estimated. The distribution of prevalence and severity of SDB in our patients with tinnitus was compared with those from the Hong Kong and Korean communities.[5,6]

Fourteen of 114 patients with AHI >15 agreed to receive continuous positive airway pressure (CPAP) as the sole treatment for their sleep disorder and tinnitus. Their age ranged from 44 to 70 years old, with an average of 58.1 years. The Tinnitus Handicap Inventory (THI) and visual analogue scale (VAS) were used to assess their tinnitus handicap and severity before and after CPAP for 3 months. This study was approved by the Institutional Review Board of the hospital.

3 | RESULTS

3.1 | BMI distribution

Of the 173 men enrolled, the average BMI of our patients was 26.3 kg/m^2 (range: 20.2-49.6 kg/m^2). The averaged BMI of the

non-participating group (31 men) was 26.5 kg/m^2, and there is no statistically significant difference between groups of enrolment and non-enrolment. In our study, 28.9% (50/173) had normal BMIs (18-24) as opposed to the 47.3% in the general population of Taiwan. Moreover, in our study, the patients had higher BMIs (between 24.1 and 30) when compared to that of the general population of Taiwan (46.2% vs 28.6%). However, the percentages of obese patients (BMI > 30) were similar (24.7% vs 24.1%).

3.2 | SDB prevalence and severity

Of the 173 men enrolled, 16 (9.2%) were normal (AHI < 5), 43 (24.8%) had AHI between 5 and 15, 56 (32.3%) had moderate SDB with AHI between 15 and 30, and 58 (33.5%) had severe SDB (AHI > 30). The prevalence and distribution are shown in Table 1. The prevalence of SDB was compared with that reported in the community and population studies of two Asian countries (Table 1).[5,6] The prevalence of SDB in our study was 90.2%, which is significantly higher than that in Hong Kong (20.1%) and Korea (27%; $P < .01$ [Wilcoxon's signed rank test]). Furthermore, 65.8% of our cases had an AHI > 15, clearly indicating increased severity of SDB in tinnitus patients.

3.3 | Hearing and tinnitus

The average thresholds of 500 k, 1 k and 4 k were calculated as the pure tone average (PTA) to represent the patients' hearing. In our sample of 173 patients, the averaged PTA of the right ear was 26.2 dB HL, and of the left ear was 25.9 dB HL. There were 130 cases with symmetric hearing and 43 cases with asymmetric hearing. The PTA of the worse ear of each patient was used for further classification. Among the 173 patients, 88 (50.1%) had normal hearing (PTA ≤ 25 dB HL), 78 (45.1%) had mild hearing loss (PTA between 26 to 45 dB HL), 3 (2.6%) had moderate hearing loss (PTA between 46 and 70 dB HL), and 4 (2.3%) had severe hearing loss (PTA > 70 dB). As the PTA in divided groups based on the AHI, the averaged hearing of both ears increased significantly as the AHI severity increases (ANOVA, $P < .05$). The results are shown in Table 2.

One hundred thirty-four cases had bilateral tinnitus, while 39 had unilateral tinnitus (right side 15, left 24), with durations that ranged from 0.5 to 8 years (average duration = 3.2 years).

TABLE 1 Prevalence, distribution of SDB in our patients with tinnitus. The estimated prevalence in two Asian areas was also listed (from references 5 and 6)

AHI	Tinnitus patients	Hong Kong study[5]	Korean study[6]
<5	9.2% (16/173)	79.6%	73%
5-10	13.2% (23/173)	8.80%	27%
10-15	11.6% (20/173)	6.30%	
>15	65.8% (114/173)	5.30%	

Keypoints

- The prevalence of sleep-disordered breathing is higher in male patients with chronic tinnitus than in the general population.
- Tinnitus and SDB are either co-morbidities or aetiologically related.
- Treatment of SDB with CPAP may reduce the tinnitus handicap and loudness in certain patients.

3.4 | O_2 saturation

The averaged lowest oxygen saturation level based on AHI classification is also shown in Table 3. Similar to the averaged pure tone thresholds, the averaged saturation significantly decreased as the SDB severity increased.

3.5 | Tinnitus outcome after treatment

Basic demographic data including age, the laterality and duration of tinnitus, AHI, and BMI of the 14 patients who received CPAP are shown in Table 3. The averaged THI before treatment was 59 and dropped to 30 after 3 months of CPAP. The averaged VAS also decreased from 7.4 to 4.6. It seems that the treatment of SDB significantly reduced tinnitus and loudness in some patients. Seventy-nine percent of patients have improvement of THI and 71% have reduced VAS. The results are shown in Table 3 and Figure 1.

4 | DISCUSSION AND CONCLUSIONS

BMI is considered a risk factor for SDB. A prior study shows that the prevalence of chronic tinnitus is higher among obese patients when compared to individuals with normal BMI.[7] Our group had more overweight patients and less patients with normal BMI; however, the proportion of obese patients was comparable to that of the general population. Hence, BMI may not be considered a main reason for the increase in prevalence of SDB in this study. The reason for and relevance of SDB being more common and severe in patients with tinnitus are unclear. However, there are some plausible

TABLE 2 Averaged pure tone threshold and averaged SpO_2 nadir between groups with increasing AHI

	PTA (dB HL)		
AHI	R't	L't	SpO_2 Nadir
<5	22.9 ± 8.1	23.4 ± 8.8	90.0%
5-10	23.6 ± 7.7	24.5 ± 6.8	88.0%
10-15	27.1 ± 16.3	25.7 ± 11	85.0%
>15	28.3 ± 16.5	27.1 ± 12.6	80.2%

TABLE 3 Basic demographic data of the 14 patients who received CPAP as the treatment of their SDB and tinnitus

Case No.	Age	Sex	Laterally	Duration (yr)	HL	AHI	BMI	pre-CPAP THI	post-CPAP THI(3M)	pre-CPAP VAS	post-CPAP VAS (3M)
1	45	M	B	0.5	Mild	27	30.7	94	38	9	4
2	67	F	B	5	Mild	46.6	32.9	74	4	10	1
3	56	M	L	8	Moderate	44.2	26.4	98	18	9	5
4	64	M	B	2	Mild	36.2	26.9	30	20	8	6
5	57	M	L	5	Mild	30	22	52	64	8	8
6	44	F	B	1	N	66	30.8	40	36	6	6
7	62	M	L	1	N	35.6	39.4	48	22	5	2
8	70	M	B	2	Mild	36.4	21.7	42	28	5	3
9	63	M	B	3	Mild	44.5	27.9	52	64	6	8
10	55	M	B	2	Mild	53	22.8	82	44	7	4
11	56	M	B	5	Mild	43.7	21.6	24	30	5	7
12	54	M	R	0.5	Mild	61	27	60	16	9	5
13	55	M	B	4	Mild	53	26	40	12	8	2
14	66	M	R	1	Mild	61	24.6	90	26	8	4
Average								59 ± 23.5	30.1 ± 17.2	7.4 ± 1.6	4.6 ± 2.1

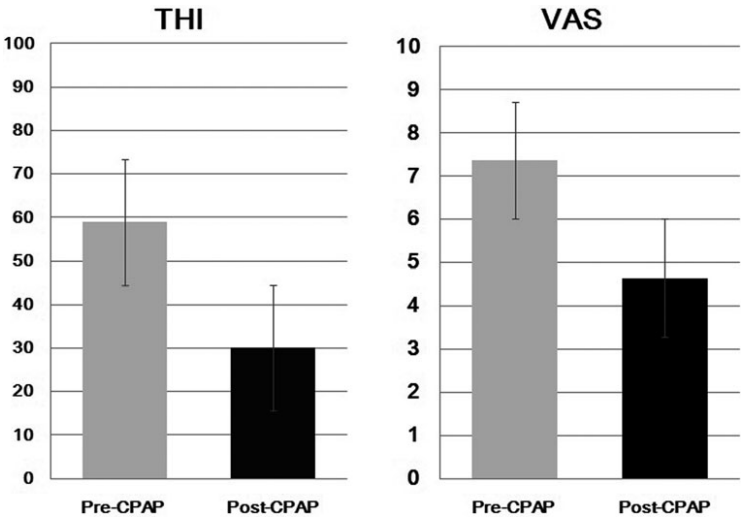

FIGURE 1 The averaged THI and VAS before and 3 months after SDB intervention with CPAP in the 14 cases

hypotheses and explanations. First, some studies have proposed that OSAS-induced hypoxaemia might have a negative impact on the auditory function, which may lead to chronic tinnitus.[8] This was supported by our results that hearing levels and oxygen saturation worsen as the SDB severity increases. Second, both tinnitus and SDB have been reported to be closely associated with anxiety, depression and short sleep duration; thus, they might be co-morbidities or aetiologically related.[9,10] Interestingly, patients with SDB and tinnitus experience arousal during sleep, which appears to be consistent with our results. We speculated that SDB was the reason for the arousal.

To our surprise, treating SDB had a remarkable effect on tinnitus in our 14 cases. However, this was not a randomised, well-controlled study. Patients with higher motivation and better compliance may tend to be more cooperative with the therapist. The cases number was also relatively small. The favourable results may be partially due to various biases. We think results that showed improvement was due to better sleep and higher nocturnal oxygen saturation. Although the definite effects of treating SDB require further larger-scaled studies, we believe it provides benefits to at least some tinnitus patients.

While the exact relationship between SDB and tinnitus and the underlying mechanisms warrant further investigation, our experiences showed that SDB is much more common and severe in men with tinnitus. In addition, CPAP helps some people by providing better sleep quality and higher oxygenation during sleep. Taking into account the prior finding that patients with SDB had a higher risk of developing chronic tinnitus,[5] tinnitus and SDB may be two sides of the same coin; that is, they are either co-morbidities or aetiologically related.

CONFLICT OF INTEREST

None to declare.

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An ENT smartphone handbook: Adopting new practice for induction

1 | BACKGROUND

Ear, nose and throat (ENT) remains a popular yet highly skilled hands-on specialty for junior doctors to rotate through. The majority of the junior tier doctors working in ENT tend to be a cohort of Foundation Doctors, Core Surgical Trainees and GP Trainees. However, ENT teaching at undergraduate level is limited, from as little as zero exposure to an average of 5 days.[1] The task therefore of expecting these doctors with little prior experience to manage complex ENT scenarios almost immediately can be considered an unrealistic expectation. Most departments, anecdotally, develop printed handbooks or "survival guides" to tackle this as a supplement to an orientation session.

With a national drive towards a paperless healthcare economy, there is a vast multitude of point-of-care healthcare software available being trialled in hospitals in different specialties.[2,3] Doctors, however, are still in the dark ages of carrying around printed handbook guides or flash cards, which are often obsolete, or rely on access to computer terminals for intranet-based guidelines. Ofcom figures report that 71% of UK adults own a smartphone,[4] and a recent survey shows more than 98% of doctors own a smartphone.[5] It is demonstrated that there are many positive uses for doctors incorporating modern smartphone technology to deliver health care.[6]

Therefore, the authors sought to migrate to modern practice and proposed the use of a mobile smartphone application as a quick reference handbook for junior doctors working in ENT.

2 | METHODS

A smartphone application with an accompanying online datafile creator was written by one of the authors (SL) using the AngularJS programming