The impact of chronic rhinosinusitis on sleep-disordered breathing*

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Abstract

Background: The nose plays an important role in sleep quality. Very little is known about sleep problems in patients with chronic rhinosinusitis (CRS). The aim of this study was to investigate the impact of CRS on sleep-disordered breathing.

Methodology: CRS patients who underwent functional endoscopic sinus surgery were collected between July 2010 and May 2015. Before surgery, they filled 20-item Sino-Nasal Outcome Test and Epworth Sleepiness Scale questionnaires, were asked about the severity of nasal obstruction, and received acoustic rhinometry, smell test, an endoscopic examination, sinus computed tomography, and a one-night polysomnography. Sleep quality was evaluated in these patients and was correlated with the severity of rhinosinusitis.

Results: One hundred and thirty-nine CRS patients were enrolled in the study. Among them, 38.1% complained of daytime sleepiness, and this sleep problem was correlated with the symptom of nasal obstruction. Obstructive sleep apnea syndrome (OSAS) was diagnosed in 64.7% of the patients, but there was no correlation with the severity of rhinosinusitis. Nasal polyps did not worsen sleep problems in the CRS patients.

Conclusions: This study showed that CRS patients had a high prevalence of OSAS, and worse OSAS in CRS patients was not correlated with the severity of rhinosinusitis.

Key words: nasal obstruction, nasal polyps, obstructive sleep apnea syndrome, polysomnography, sinusitis, sleep

Introduction

Sleep-disordered breathing is a spectrum of breathing abnormalities related to increased airway resistance. It includes snoring, upper airway resistance syndrome, and obstructive sleep apnea syndrome (OSAS) [(1)]. The nose has been shown to play an important role in the pathophysiology of sleep-disordered breathing [(2)]. Allergic rhinitis was shown to be an independent risk factor for obstructive sleep apnea syndrome (OSAS) [(3)]. It is thought that nasal obstruction causes increased airway resistance resulting in the development of OSAS in these patients. Chronic rhinosinusitis (CRS) is a very common sinonasal disorder, with up to 13% of American adults affected [(4)]. Sleep impairment has been reported to be a common problem in CRS patients [(5)]. They also often complain of nasal obstruction which may play a role in sleep impairment in these patients. Moreover, it has been suggested that CRS is associated with the release of pro-inflammatory cytokines such as IL-1β and THF-α which might be involved in the development of sleep problems [(6)]. Recently, Alt et al. reported a high prevalence of poor quality of sleep in CRS patients, as measured by the Pittsburg Sleep Quality Index instrument [(7)]. However, whether sleep impairment in CRS patients is related to increased airway resistance is not well studied. The impact of allergic rhinitis, CRS, and nasal polyposis on sleep has been evaluated by subjective and objective measures [(5)]. CRS

disease-specific questionnaires such as the Sino-Nasal Outcome Test-20 (SNOT-20), which includes sleep-specific survey items, have been used to evaluate sleep and its role in CRS [6]. General sleep questionnaires such as the Epworth Sleepiness Scale (ESS) have not been widely used to evaluate sleep problems in CRS patients [6]. Moreover, relatively few studies have used objective measures such as polysomnography (PSG) to evaluate sleep problems in CRS patients [8]. The aims of this study were to explore the relationship of CRS and sleep-disordered breathing by using the SNOT-20, ESS, and PSG.

Materials and methods

Subjects

CRS patients who responded poorly to medical treatment and subsequently underwent functional endoscopic sinus surgery (FESS) were collected in this study between July 2010 and May 2015. The diagnosis of CRS was based on guidelines of the SAHP task force in 2002, which included a history of rhinosinusitis for more than 12 weeks, the findings of nasal endoscopy, and a radiological examination [9]. Any patient whose age was below 20 years old or who had a history of immunodeficiency or a previous sinus surgery was not enrolled. This study was approved by the Ethics Committee of Taichung Veterans General Hospital.

Assessment of rhinosinusitis severity

Before the FESS procedure, all patients completed the Taiwanese version of the 20-item Sino-Nasal Outcome Test (SNOT-20) questionnaire [10], and were asked about the severity of nasal obstruction. Patients also received an acoustic rhinometry assessment, two smell tests, an endoscopic examination, and sinus computed tomography (CT).

SNOT-20 is a 20-item questionnaire which is used to assess the degree and effect of treating patients with rhinitis and rhinosinusitis. Based on the frequency and severity of symptoms, the patient scores each question from zero to five (0 for no problem, 5 for the problem as bad as it can be). The total score is the sum of the scores of all the items (range 0-100). The severity of nasal obstruction was also graded from zero to five, as in the SNOT-20. Acoustic rhinometry was performed to measure the second minimal cross-sectional area (MCA2) of the nasal cavity. The MCA2 of the right and left nasal cavity was averaged to give a mean MCA2 (cm^2). The smell function was evaluated by Smell Threshold Test (Sensonics, Inc., Hadden Heights, NJ) and a traditional Chinese version of the University of Pennsylvania Smell Identification Test (UPSIT-TC) (Sensonics, Inc., Hadden Heights, NJ) [11]. The endoscopic appearances were quantified on a 0 to 2-point scale according to the staging system devised by Lund and Mackay [12]. Endoscopic appearances included the presence of polyps, discharge, and edema. The total score is the sum of the all the scores of the bilateral endoscopic findings (range 0-12). Based on the endoscopic findings, patients were divided into those with and without nasal polyps. The sinus CT scan findings were quantified according to the staging method described by Lund and Mackay [12]. The CT findings of maxillary, anterior ethmoid, posterior ethmoid, sphenoid, and frontal sinus were graded as 0, 1, or 2. The total score is the sum of all the scores of the bilateral sinuses (range 0-24).

Table 1. Clinical characteristics when classified by ESS score.

ESS score	Below 10	10 or more	p value
Gender			0.045
Male	51	41	
Female	35	12	
Age (years)	46.0±14.4	42.8±12.2	0.241
BMI	25.01±4.22	25.57±4.06	0.41
ESS score	5.6±2.8	13.4±3.1	<0.001
AHI	14.44±17.67	16.16±19.69	0.609
Lowest SaO_2 (%)	86.62±7.14	85.38±7.59	0.205
Snoring index	248.90±165.02	276.72±160.87	0.34
SNOT-20	33.8±19.7	43.8±17.3	0.003
Sleep-related score	13.3±9.6	16.6±8.1	0.016
Nasal obstruction	2.9±1.6	3.6±1.4	0.009
MCA_2	0.43±0.22	0.41±0.19	0.885
Smell threshold	-3.86±3.27	-3.52±3.04	1
UPSIT-TC	20.6±9.3	21.1±9.2	0.715
Endoscopy	5.2±2.5	5.2±2.2	0.969
CT	11.2±5.2	12.3±5.0	0.854

BMI: body mass index; ESS: Epworth Sleepiness Scale; AHI: apnea-hypopnea index; SaO_2: oxygen saturation; SNOT-20: 20-item Sino-Nasal Outcome Test; MCA_2: the second minimal cross-sectional area; UPSIT-TC: traditional Chinese version of the University of Pennsylvania Smell Identification Test; CT: computed tomography.

Assessment of sleep quality

Before the FESS procedure, all patients also completed a Chinese version of the ESS questionnaire [13], and received a one-night PSG. Sleep quality was also evaluated using the 7 sleep-related items of the SNOT-20. The 7 sleep-related items were item 11: difficulty falling asleep, item 12: waking up at night, item 13: lack of a good night's sleep, item 14: waking up tired, item 15: fatigue, item 16: reduced productivity, and item 17: reduced concentration.

ESS is an 8-item questionnaire which is a useful tool for evaluating daytime sleepiness in adults [13]. Each of the 8-item scores ranges from 0 to 3, and the total ESS score is from 0 to 24. A score of 10 or more is considered to indicate that the patient

Table 2. Clinical characteristics when classified by AHI.

ESS score	Without OSAS	Mild OSAS	Moderate OSAS	Severe OSAS	p value
Gender					0.585
Male	34	25	24	12	
Female	18	16	8	5	
Age (years)	39.4±11.9	43.7±12.5	51.6±15.0	49.5±11.8	0.068
BMI	23.88±4.16	25.49±3.15	24.66±3.39	29.52±4.87	0.003
ESS score	8.2±4.9	9.0±4.6	8.6±4.6	8.3±5.3	0.758
AHI	1.96±1.30	9.01±2.76	20.35±4.31	57.74±15.97	<0.001
Lowest SaO_2 (%)	89.96±3.69	87.02±4.88	84.83±6.31	75.48±10.63	<0.001
Snoring index	128.27±118.36	271.84±107.83	323.55±114.93	487.46±130.89	<0.001
SNOT-20	42.1±19.6	39.7±18.3	31.0±19.8	32.0±17.3	0.094
Sleep-related score	16.6±9.5	15.4±8.9	11.2±8.3	13.2±9.0	0.13
Nasal obstruction	3.1±1.5	3.6±1.3	2.9±1.7	2.9±1.6	0.104
MCA_2	0.39±0.2	0.43±0.2	0.40±0.2	0.53±0.27	0.165
Smell threshold	-4.60±3.44	-3.33±2.82	-3.86±3.42	-1.96±1.68	0.151
UPSIT-TC	22.8±9.8	19.7±8.3	21.0±9.5	17.3±8.3	0.543
Endoscopy	4.8±2.0	5.5±2.5	5.4±2.5	5.5±2.9	0.992
CT	10.9±4.6	12.0±5.1	12.3±5.7	11.3±6.0	0.848

AHI: apnea-hypopnea index; OSAS: obstructive sleep apnea syndrome; BMI: body mass index; ESS: Epworth Sleepiness Scale; SaO_2: oxygen saturation; SNOT-20: 20-item Sino-Nasal Outcome Test; MCA_2: the second minimal cross-sectional area; UPSIT-TC: traditional Chinese version of the University of Pennsylvania Smell Identification Test; CT: computed tomography.

suffers from daytime sleepiness [14]. Therefore, patients were divided into those whose ESS scores were below 10 and whose ESS scores were 10 or more. PSG has been used as a reference standard for the diagnosis of OSAS [15]. It measures several sleep variables, including body mass index (BMI), apnea-hypopnea index (AHI) or respiratory disturbance index, and minimum oxygen saturation. The AHI is defined as the sum of apneas and hypopneas per hour of sleep. Apnea is defined as a 90% decrease in airflow for 10 seconds relative to the baseline value. Hypopnea is defined as a 50% decrease in the airflow amplitude for 10 seconds relative to the baseline value with the presence of arousal or oxygen desaturation of 4%. Patients with AHIs of ≥5 and <15 were considered to have mild OSAS, those with AHIs of ≥15 and <30 were considered to have moderate OSAS, and those with AHIs of ≥30 were considered to have severe OSAS [8]. According to the severity of OSAS, patients were divided into those without OSAS (AHI <5), those with mild OSAS, those with moderate OSAS, and those with severe OSAS.

Statistical analysis

All data are presented as mean ± standard deviation. Patients were divided into 2 ESS groups based on ESS score (below 10 and 10 or more), into 4 AHI groups based on AHI value (<5, ≥5 and <15, ≥15 and <30, and ≥30), and into 2 polyp groups based on the existence of nasal polyps (with and without polyps). The severity of sinusitis was compared between the 2 ESS groups and among the 4 AHI groups, and sleep quality was compared between the 2 polyp groups. The sex of patients was compared between the 2 ESS groups, among the 4 AHI groups, and between the 2 polyp groups by Pearson's Chi-Square test. The age of patients, SNOT-20 score, total score of 7 sleep-related items, nasal obstruction score, mean MCA_2, smell threshold, UPSIT-TC score, endoscopic score, and CT score were compared between the 2 ESS groups and between the 2 polyp groups by Mann-Whitney U test and were compared among the 4 AHI groups by Kruskal-Wallis test. The correlations between ESS score and SNOT-20 score, nasal obstruction score, UPSIT-TC score, endoscopic score, and CT score and the correlations between AHI value and SNOT-20 score, nasal obstruction score, UPSIT-TC score, endoscopic score, and CT score were evaluated by Spearman's correlation coefficient. All computations were performed using SPSS version 17.0 (SPSS, Inc., Chicago, IL, USA). Two-tailed p-values < 0.05 were considered statistically significant.

Results

Patients

One hundred and thirty-nine CRS patients were enrolled in the study. Among them, there were 92 males and 47 females. The ages ranged from 20 to 84 years old with a mean of 44.7 years. Patients' characteristics among the different groups are shown in Tables 1-3. The ESS score was below 10 in 86 patients and was 10 or more in 53. Therefore, 38.1% of patients were considered to suffer from daytime sleepiness. Forty-nine patients were without OSAS, 41 had mild OSAS, 32 had moderate OSAS, and 17 had severe OSAS. In total, 64.7% of patients were diagnosed with OSAS. Seventy patients were with nasal polyps and 69 were without polyps.

Comparison of rhinosinusitis severity between ESS groups

The comparison of rhinosinusitis severity and sleep quality between the 2 ESS Groups is shown in Table 1. Patients with poor sleep quality (ESS≥10) had significantly higher SNOT-20 and nasal obstruction scores, but the endoscopic score, CT score and smell function were not significantly different between the 2 ESS groups. The correlation analysis also showed a positive correlation between ESS score and SNOT-20 score ($r = 0.306$; $p<0.001$) as well as nasal obstruction score ($r = 0.297$; $p<0.001$), but there was no correlation between ESS score and UPSIT-TC score, endoscopic score, and CT score.

Comparison of rhinosinusitis severity among AHI groups

The comparison of rhinosinusitis severity and sleep quality among the 4 AHI groups is shown in Table 2. The SNOT-20 score, nasal obstruction score, endoscopic score, CT score, and smell function were not significantly different among the 4 AHI groups. The correlation analysis also showed there was no correlation between ESS score and SNOT-20 score, nasal obstruction score, UPSIT-TC score, endoscopic score, and CT score.

Comparison of sleep quality between polyp groups

The comparison of sleep quality and rhinosinusitis severity between the 2 polyp groups is shown in Table 3. Rhinosinusitis was more severe in patients with nasal polyps than in those without polyp when assessed by nasal obstruction score, mean MCA2, smell threshold, UPSIT-TC score, endoscopic score, and CT score. However, sleep quality was similar between patients with and without nasal polyps.

Table 3. Weighted percentages by city, age and gender of children/adolescents characteristics and OR of the association between possible related factors and AR.

Nasal polyps	Without polyps	With polyps	p value
Gender			0.952
Male	45	47	
Female	24	23	
Age (years)	44.8±13.1	44.6±14.2	0.889
BMI	25.10±3.95	25.35±4.36	0.588
ESS score	8.9±4.6	8.3±4.9	0.499
AHI	14.17±18.98	16.02±17.93	0.26
Lowest SaO_2 (%)	86.23±7.92	86.05±6.71	0.412
Snoring index	241.80±172.49	276.96±153.21	0.153
SNOT-20	40.6±19.4	34.7±19.0	0.066
Sleep-related score	16.0±9.4	13.1±8.7	0.067
Nasal obstruction	2.8±1.5	3.5±1.5	0.006
MCA_2	0.46±0.23	0.38±0.19	0.024
Smell threshold	-4.98±3.26	-2.50±2.58	<0.001
UPSIT-TC	25.1±8.3	16.6±8.0	<0.001
Endoscopy	3.8±1.6	6.6±2.2	<0.001
CT	8.4±4.1	14.7±4.1	<0.001

BMI: body mass index; ESS: Epworth Sleepiness Scale; AHI: apnea-hypopnea index; SaO_2: oxygen saturation; SNOT-20: 20-item Sino-Nasal Outcome Test; MCA_2: the second minimal cross-sectional area; UPSIT-TC: traditional Chinese version of the University of Pennsylvania Smell Identification Test; CT: computed tomography.

Discussion

Sleep problems have not been well studied in CRS patients [5]. Alt et al. reported that 75% of CRS patients have PSQI scores above the traditional cutoff, indicating poor sleep quality [7]. Among our patients, 38.1 % reported ESS scores above 9, indicating daytime sleepiness. The patients with poor sleep quality in the study by Alt et al. had significantly higher SNOT-22 scores compared with those of patients with good sleep quality, but there were no significant differences in endoscopic, CT, or smell function scores between the two groups [7]. The patients with poor sleep quality (ESS≥10) in our study also had significantly higher SNOT-20 scores than those of patients with good sleep quality, but there were no differences in endoscopic, CT, or smell function scores between the two groups. Among the patients in the study by Alt et al. women had a higher prevalence of poor sleep quality than men [7], but in the present study men had a higher prevalence of poor sleep quality than women. The etiology of poor sleep quality in CRS patients is likely multifactorial. Our patients with poor sleep quality had significantly higher nasal obstruction scores, and ESS score was positively correlated with nasal obstruction scores. This indicates that nasal obstruction plays an important role in the pathophysiology of sleep impairment in CRS patients. However, other factors might also play a

role such as cytokines [6].

OSAS is a very common disorder, afflicting 40 million Americans [4]. Its prevalence is increasing, and approximately 24% of men and 9% of women are affected. In this study, 66.3% of male patients and 61.7% of female patients were diagnosed with OSAS (AHI≥ 5). Our CRS patients were unresponsive to medical treatment, which suggests that symptomatic CRS patients, regardless of gender, had a higher prevalence of OSAS than that in the general population. Nasal obstruction and inflammation of nasal airway mucosa have been suggested to be possible etiologies in the pathogenesis of OSAS in CRS patients [8]. The high prevalence of OSAS in CRS patients was unrelated to BMI. Although BMI of patients with severe OSAS was higher than that of patients without OSAS, BMI of patients without OSAS was not significantly different from those of patients with mild or moderate OSAS (p=0.266, 0.846, respectively). The worsening of OSAS in CRS patients was also not correlated with the severity of rhinosinusitis. The SNOT-20 score, nasal obstruction score, endoscopic score, CT score, and smell function were not significantly different among the 4 AHI groups.

It has been reported that patients with nasal polyps had a higher risk of sleep impairment and a greater prevalence of snoring than controls without nasal polyps [16]. When our CRS patients were classified into those with and without nasal polyps, the severity of rhinosinusitis was found to be significantly higher in CRS patients with nasal polyps than in those without nasal polyps, and sleep quality whether evaluated by ESS or PSG was not significantly different between CRS patients with and without nasal polyps. This result indicates that nasal polyps did not worsen sleep problem in CRS patients, and the severity of rhinosinusitis also did not have a deleterious effect on sleep quality in CRS patients.

Conclusion

The results of this study showed that 38% of CRS patients suffered from daytime sleepiness, and this sleep problem was related to the symptom of nasal obstruction, which was very common in CRS patients. CRS patents had a higher prevalence of OSAS. The worsening of OSAS in CRS patients was not correlated with the severity of rhinosinusitis, and presence of nasal polyps did not appear to be associated with worse sleep problems in CRS patients.

Authorship contribution

RSJ: study design, data collection, manuscript; KLL: study design, data analysis; HCH: manuscript edits; SMC: study design, manuscript edits.

Conflict of interest

The authors declare no conflict of interest.

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