The relation between chronic rhinosinusitis and sleep-disordered breathing

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Background
Chronic sinusitis is one of the most prevalent chronic illnesses affecting persons of all age groups. It is an inflammatory process that involves the paranasal sinuses and persists for 12 weeks or longer.
Purpose
The aim of this study was to investigate the effect of chronic rhinosinusitis (CRS) on sleep-disordered breathing.
Patients and methods
This study was conducted prospectively during the period spanning from June 2017 to June 2018 on 100 patients with CRS who attended to the ENT Departments of El-Maadi Armed Forces Medical Complex, Kobry El-Kobba Armed Forces Medical Complex, and El-Demerdash Hospitals. An additional 10 control patients were included in the study. All these patients gave informed consent to participate in this study.
Results
As regards apnea–hypopnea index, a comparative study between preoperative and postoperative measurements revealed a nonsignificant difference ($P>0.05$). As regards snore index and snore episodic measurements, the comparative study between preoperative and postoperative measurements revealed a highly significant decrease ($P<0.01$). As regards sleep efficiency and minimal and basal oxygen saturation measurements, the comparative study between preoperative and postoperative measurements revealed a highly significant increase ($P<0.05$).
Conclusion
Surgery decreased snoring and Epworth Sleepiness Scale scores, increased sleep efficiency and minimal and basal oxygen saturation measurements without changes in the apnea–hypopnea index, and improved sleep quality.

Keywords:
apnea–hypopnoea index, chronic rhinosinusitis, immunoglobulin A, multiple sleep latency test

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Introduction

Chronic sinusitis is almost always accompanied by concurrent nasal airway inflammation and is often preceded by rhinitis symptoms; thus, the term chronic rhinosinusitis (CRS) has evolved to more accurately describe this condition [1].

CRS may manifest as one of three major clinical syndromes: CRS without nasal polyps, CRS with nasal polyps, or allergic fungal rhinosinusitis. These classifications possess a great deal of therapeutic significance [2].

Patients with symptomatic CRS have a high prevalence of sleep pathology. The relationship between sleep dysfunction and quality of life (QOL) in CRS is likely bidirectional, whereby disability predicts worse sleep, which may influence QOL [2].

The pathophysiology of sleep impairment in CRS remains highly plausible and could be related to many factors including nasal obstruction, depression, sex, pain, and direct neural signaling or by systemic or local neural-immune signaling through proinflammatory somnogenic cytokines [3].

Consistent poor sleep can have staggering impacts on an individual's performance, overall QOL, and even mortality [3].

Patients and methods

Inclusion criteria

The inclusion criteria were as follows:

(1) Patients with chronic sinusitis with and without nasal polyposis.

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(2) Age: from 16 to 65 years old.
(3) Sex: male and female patients.

Exclusion criteria

The exclusion criteria were as follows:

(1) Obese patients: if BMI was more than 3.0.
(2) Other causes of sleep apnea such as hugely enlarged tonsils, severely redundant soft palate, enlarged uvula, huge tongue, and central causes.
(3) Any cause of nasal obstruction not related to CRS.

These patients were divided into three study groups:

(1) Study group A included 50 patients suffering from CRS with nasal polyposis±septal deviation.
(2) Study group B included 50 patients suffering from CRS without nasal polyposis.
(3) Study group C included 10 patients serving as a control group with no sinonasal disorders and no other cause of sleep apnea.

All of the study groups were subjected to the following measures preoperatively:

(1) Complete ENT history taking with a particular emphasis on Epworth Sleepiness Scale (ESS) questionnaires. The total ESS score is the sum of eight-item scores and can range between 0 and 24 as follows:
    (a) 0–9: normal.
    (b) 10–15: mild to moderate sleep apnea.
    (c) 16–24: severe sleep apnea.

Full ENT examination

The full ENT examination consisted of the following protocol:

(1) Endoscopic examination of the nose and paranasal sinuses.
(2) High-resolution Sinonasal computed tomograghy (CT) scan.
(3) Overnight polysomnography (PSG) using (Nicolet) electroencephalography, v32 device in the Neurology Department in the El-Maadi Armed Forces Medical Complex.

All these findings were recorded 1 month postoperatively for all patients for evaluation.

Statistical analysis

Data entry, processing, and statistical analysis were carried out using MedCalc, ver. 15.8 (MedCalc, Ostend, Belgium). Tests of significance (Kruskal–Wallis, χ^2, Wilcoxon's, factorial analysis of variance, and multiple regression analysis) were used. Data were presented and suitable analysis was carried out according to the type of data (parametric and nonparametric) obtained for each variable. *P* values less than 0.05 (5%) were considered to be statistically significant.

Results

Sociodemographic and clinical data

As regards sex of the patients, the majority (60%) of patients were male individuals in the control group, whereas in the CRS group, 54% were male individuals, and 46% were female individuals (Table 1).

As regards ESS categories, all control patients were normal; with respect to CRS patients, 48% were normal, 46% were mild to moderate, whereas only 6% were severe in ESS categories (Table 2).

Preoperative polysomnographic data

As regards apnea–hypopnea categories, all control patients were normal; with respect to CRS patients 46% were normal, 22% were mild, and 26% were moderate, whereas only (6%) were severe in apnea–hypopnea categories (Table 3).

Postoperative polysomnographic data

As regards apnea–hypopnea categories, 46% of CRS patients were normal, 22% were mild, and 26% were

Table 1 Sociodemographic data among 100 chronic rhinosinusitis patients

Variables	Control (*n*=10)	Chronic rhinosinusitis (*n*=100)
Age (mean±SD) (years)	35.1±9.76	37.69±10.03
Sex [*n* (%)]		
Female	4 (40)	46 (46)
Male	6 (60)	54 (54)

Table 2 Basic clinical data among 100 chronic rhinosinusitis patients

Variables	Control (*n*=10)	Chronic rhinosinusitis (*n*=100)
BMI (mean±SD)	27.27±1.46	27.24±1.54
ESS score (mean ±SD)	2.3±0.94	9.35±5.08
ESS category [*n* (%)]		
Normal	10 (100)	48 (48)
Mild and moderate	0 (0)	46 (46)
Severe	0 (0)	6 (6)

ESS, Epworth Sleepiness Scale.

moderate, whereas only 6% were severe in apnea–hypopnea categories (Table 4).

Sociodemographic and clinical data

A comparative study between the three groups revealed nonsignificant statistical difference as regards age and sex (P>0.05) (Table 5).

A comparative study between the three groups revealed a highly significant increase in ESS score in group A compared with group B then with group C (P<0.0001).

A comparative study between the three groups revealed a highly significant increase in moderate and severe ESS categories in the group A compared with other groups (P<0.0001).

A comparative study between the three groups revealed a nonsignificant statistical difference as regards BMI (P>0.05) (Table 6).

Preoperative polysomnographic data

A comparative study between the three groups revealed a highly significant decrease in preoperative sleep efficiency and basal oxygen saturation (SpO_2) in the group A compared with other groups (P<0.01, respectively).

A comparative study between the three groups revealed a highly significant increase in preoperative apnea–hypopnea index (AHI), snore index, and snore episodic in the group A compared with other groups (P<0.01, respectively).

A comparative study between the three groups revealed a nonsignificant statistical difference as regards preoperative minimal SpO_2 (P>0.05) (Table 7).

Table 3 Preoperative polysomnographic data among 100 chronic rhinosinusitis patients

Variables	Control (*n*=10) (mean±SD)	Chronic rhinosinusitis (*n*=100) (mean±SD)
Sleep efficiency (%)	88±1.26	80.51±9.45
AHI	2.6±1.07	11.43±15.09
Apnea–hypopnea category [*n* (%)]		
Normal	10 (100)	46 (46)
Mild	0 (0)	22 (22)
Moderate	0 (0)	26 (26)
Severe	0 (0)	6 (6)
Minimal SpO_2 (%)	87.4±1.5	85.3±3.4
Basal SpO_2 (%)	94.9±2.23	94.46±2.72
Snore index	95.4±29.78	351.85±274.85
Snore episodic (min)	2.97±1.02	18.75±18.32

AHI, apnea–hypopnea index; SpO_2, oxygen saturation.

Table 4 Postoperative polysomnographic data among 100 chronic rhinosinusitis patients

Variables	Chronic rhinosinusitis (*n*=100) (mean±SD)
Sleep efficiency (%)	83.62±8.54
AHI	11.43±15.09
Apnea–hypopnea category [*n* (%)]	
Normal	46 (46)
Mild	22 (22)
Moderate	26 (26)
Severe	6 (6)
Minimal SpO_2 (%)	85.94±2.78
Basal SpO_2 (%)	94.65±2.55
Snore index	240.7±195.72
Snore episodic (min)	14.04±12.79

Postoperative polysomnography was not assessed in controls.
AHI, apnea–hypopnea index; SpO_2, oxygen saturation.

Table 5 Comparison between the three groups as regards sociodemographic data using the Kruskal–Wallis and χ^2-tests

Variables	Group A (*n*=50)	Group B (*n*=50)	Group C (*n*=10)	*P* value (Kruskal–Wallis test)
Age [median (IQR)] (years)	39 (31–47)	37 (28–42)	36 (26–41)	0.206
Sex [*n* (%)]				
Female	23 (46)	23 (46)	4 (40)	0.936 (χ^2-test)
Male	27 (54)	27 (54)	6 (60)	

IQR, interquartile range.

Table 6 Comparison between the three groups as regards basic clinical data using Kruskal–Wallis and χ^2-tests

Variables	Group A (*n*=50)	Group B (*n*=50)	Group C (*n*=10)	*P* value (Kruskal–Wallis test)
BMI [median (IQR)]	27.5 (26–28.7)	27.2 (26.1–28.5)	26.9 (26.5–28.5)	0.935
ESS score [median (IQR)]	13 (11–15)	5 (3–7)	2 (2–3)	<0.0001**
ESS category [*n* (%)]				
Normal	4 (8)	44 (88)	10 (100)	<0.0001** (χ^2-test)
Mild and moderate	40 (80)	6 (12)	0 (0)	
Severe	6 (12)	0 (0)	0 (0)	

ESS, Epworth Sleepiness Scale; IQR, interquartile range. *P* value is highly significant.

Table 7 Comparison between the three groups as regards preoperative polysomnographic data using Kruskal–Wallis and χ^2-tests

Variables	Group A (n=50) [median (IQR)]	Group B (n=50) [median (IQR)]	Group C (n=10) [median (IQR)]	P value (Kruskal–Wallis test)
Sleep efficiency (%)	77.4 (69.1–84)	87 (82.1–88.8)	88 (87–89)	<0.0001**
AHI	17.5 (9–23)	3 (2–4)	3 (2–3)	<0.0001**
Minimal SpO_2 (%)	86 (83–88)	86 (82–88)	87.5 (86–88)	0.202
Basal SpO_2 (%)	92 (91–93)	96.5 (95–98)	94.5 (93–96)	<0.0001**
Snore index	396.5 (135–551)	217 (119–412)	85.5 (75–125)	0.000035**
Snore episodic (min)	21.4 (3.7–25.1)	14.5 (4.5–20.9)	2.8 (2.4–3.7)	0.000073**
Apnea–hypopnea category [n (%)]				
Normal	4 (8)	42 (84)	10 (100)	<0.0001** (χ^2-test)
Mild	14 (28)	8 (16)	0 (0)	
Moderate	26 (52)	0 (0)	0 (0)	
Severe	6 (12)	0 (0)	0 (0)	

AHI, apnea–hypopnea index; IQR, interquartile range; SpO_2, oxygen saturation. P value is highly significant.

Table 8 Comparison between the two groups as regards postoperative polysomnographic data using Mann–Whitney U and χ^2-tests

Variables	Group A (n=50) [median (IQR)]	Group B (n=50) [median (IQR)]	P value (Mann–Whitney U-test)
Sleep efficiency (%)	81 (74–87)	89 (85–91)	0.000005**
AHI	17.5 (9–23)	3 (2–4)	<0.0001**
Minimal SpO_2 (%)	86 (85–88)	86 (83–88)	0.291
Basal SpO_2 (%)	93 (91–94)	96.5 (95–98)	<0.0001**
Snore index	234.5 (95–364)	152.5 (88–264)	0.088
Snore episodic (min)	15.9 (3.3–21.2)	12.8 (3.6–15.2)	0.034*
Apnea–hypopnea category [n (%)]			
Normal	4 (8)	42 (84)	<0.0001** (χ^2-test)
Mild	14 (28)	8 (16)	
Moderate	26 (52)	0 (0)	
Severe	6 (12)	0 (0)	

AHI, apnea–hypopnea index; IQR, interquartile range; SpO_2, oxygen saturation. P value is highly significant.

Postoperative polysomnographic data

A comparative study between the two groups revealed a highly significant decrease in postoperative sleep efficiency and basal SpO_2 in group A; compared with group B (P<0.01, respectively).

A comparative study between the two groups revealed a highly significant increase in postoperative AHI and snore episodic in group A compared with group B (P<0.01, P=0.03, respectively).

A comparative study between the two groups revealed a marked increase in postoperative snore index in group A compared with group B without reaching a statistically significant difference (P=0.08).

A comparative study between the two groups revealed a nonsignificant statistical difference as regards postoperative minimal SpO_2 (P>0.05) (Table 8).

Combined paired and unpaired comparative studies

We further analyzed and compared all 100 (paired) patients according to the serial polysomnographic measurements (preoperative and postoperative) with entering a grouping factor (groups A or B).

Factorial analysis of variance table and multivariate graphs

Group A showed marked decrease in sleep efficiency compared with group B, but it also showed a significant postoperative increase in sleep efficiency level during the serial first and second measurements (Table 9 and Fig. 1).

Discussion

Chronic sinusitis is one of the more prevalent chronic illnesses affecting persons of all age groups. It is an inflammatory process that involves the paranasal sinuses and persists for 12 weeks or longer [4].

It is always accompanied by concurrent nasal airway inflammation and is often preceded by rhinitis symptoms; thus, the term CRS has evolved to more accurately describe this condition.

CRS may manifest as one of three major clinical syndromes: CRS without nasal polyps, CRS with nasal polyps, or allergic fungal rhinosinusitis. These classifications possess a great deal of therapeutic significance. Most cases of chronic sinusitis are continuations of unresolved acute sinusitis [1].

CRS may affect life quality in a number of ways, including disturbing sleep patterns. It may require treatment with the goal of clearing respiratory pathways and restoring normal breathing [5]. This may include surgery to remove polyps.

Table 9 Comparison between the two groups of patients as regards serial polysomnographic measurements using repeated measures analysis of variance test (two-factor study)

Variables	Repeated two-measures ANOVA (two-factor study: between the two groups)	
	F value	*P* value
Sleep efficiency (%)	31.25	<0.001**
AHI	0	1.000
Minimal SpO_2 (%)	0.25	0.619
Basal SpO_2 (%)	196.78	<0.001**
Snore index	9.50	0.003**
Snore episodic (min)	7.61	0.007**

AHI, apnea–hypopnea index; ANOVA, analysis of variance; SpO_2, oxygen saturation. Logarithmic transformation was performed for nonparametric data. *P* value is highly significant.

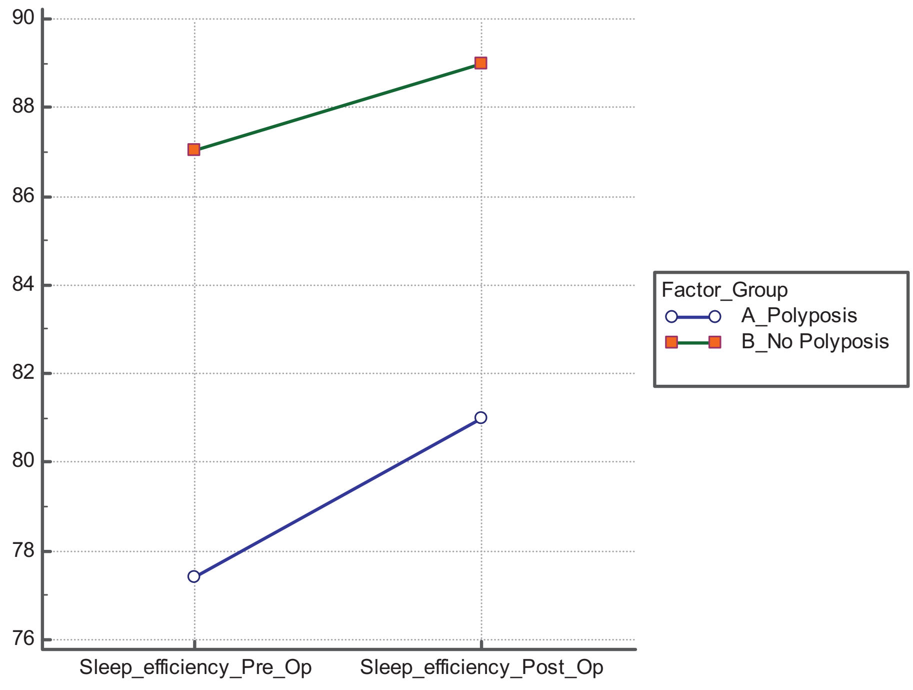
CRS may also be correlated with other conditions that are associated with sleep disruption and deprivation. This includes sleep apnea. People who suffer from sleep apnea may experience short, infrequent or even interrupted breathing during sleep, causing them to wake up to start normal respiration again. As a result, this condition is also associated with health deficits related to impaired sleep quality [3].

This study was conducted prospectively during the period spanning from June 2017 to June 2018 on 100 patients with CRS who attended to the ENT Departments of El-Maadi Armed Forces Medical Complex, Kobry El-Kobba Armed Forces Medical Complex, and El-Demerdash Hospitals. An additional 10 control patients were included in the study.

As regards the AHI, comparative study between preoperative and postoperative measurements revealed a nonsignificant difference in both groups A and B (*P*>0.05).

This was found to be similar to the study carried out by Tosun *et al.* [6], which stated that there was no significant difference between preoperative (6.85) and postoperative (5.53) mean values of AHI (*P*=0.55). This study was conducted on 27 patients with nasal polyposis, filling at least 50% of each nasal passage. All patients underwent endoscopic sinus

Figure 1



An example for multivariate graphs showing the comparison between the two groups of patients as regards serial sleep efficiency assessments.

surgery with polypectomy. Sleep quality was evaluated using visual analog scale, ESS, and PSG before and 3 months after the surgery. However, it differs from our study in the assessment of nasal patency postoperatively using acoustic rhinometry.

Moreover, the study by Nakata *et al.* [7] reported that there are no changes in the AHI (44.6±22.5 vs. 42.5 ±22.0). This study was conducted on 49 obstructive sleep apnea (OSA) syndrome patients suffering from symptomatic nasal obstruction/impaired nasal breathing and who underwent the standard PSG before and after surgery. PSG along with measures of nasal resistance and daytime sleepiness (the ESS scores) were also reviewed.

Another study was carried out by Kim *et al.* [8] and came in agreement with our study. It reported that AHI decreased from 19 to 16 (P=0.0209). This study reviewed 21 patients who presented with nasal obstruction and snoring. Septal surgery with or without inferior turbinectomy was performed. Each patient was assessed preoperatively and postoperatively using PSG. However, it differs from our study in the measurement of the respiratory distress index.

Furthermore, the study by Verse *et al.* [9] stated that the AHI decreased postoperatively from 31.6 to 28.9. However, daytime sleepiness improved significantly, and arousals decreased significantly in both apneic patients and simple snorers after nasal surgery. This study was conducted on 26 patients who snored and had impaired nasal breathing underwent attended PSG in the sleep laboratory and single treatment nasal surgery was performed.

This study concluded that nasal surgery has a limited efficacy in the treatment of adult patients with sleep apnea. Nevertheless, nasal surgery significantly improves sleep quality and daytime sleepiness independent of the severity of obstructive sleep-related breathing disorders, and this was found to be similar to our study [9].

As regards snore index and snore episodic measurements, comparative study between preoperative and postoperative measurements revealed a highly significant decrease in both groups A and B (P<0.01).

This was found to be similar to the study carried out by Wu *et al.* [10], which stated that there was a significant decrease in the ESS and Snore Outcomes Survey. This study concluded that nasal surgery can effectively improve the subjective symptoms of patients with simple snoring accompanied by nasal blockage and of patients with OSA–hypopnea syndrome, thus improving their QOL. It differs from our study in the measurement of the Sinonasal Outcome Test 20 scores for all patients at 6 months after surgery and in the visual analog scale score for subjective olfactory function.

Moreover, the study by Li *et al.* [11] reported that assessments showed significant improvement in the Snore Outcomes Survey (P<0.001), ESS (P<0.001) scores and in six of the eight short form-36 subscale scores (P<0.05). Remarkable improvements were observed in disease-specific Snore Outcomes Survey (by 43.1%), ESS (by 27.3%), and generic short form-36 role-emotional (by 30.4%).

This study was carried out on 51 consecutive patients with OSA [50 men and one woman; mean age, 39 years; mean (SD) AHI, 37.4 (28.9) events/h; and mean (SD) BMI (kg/m^2), 26.0 (3.5)] with symptoms of nasal obstruction due to a deviated nasal septum, and septomeatoplasty was performed for all patients.

It concluded that the correction of an obstructed nasal airway significantly improves disease-specific and generic QOL in adult patients with OSA who also have nasal obstruction symptoms. After nasal surgery, patients may experience greater improvement in snoring and daytime sleepiness than in other generic health status [11].

Furthermore, the study by Kim *et al.* [8] reported that nasal surgery had the following effects: the respiratory distress index decreased from 39 to 29 (P=0.0001), SpO_2 index decreased from 48 to 32 (P=0.0001) and the duration of snoring decreased from 44 to 39% (P=0.1595). Snoring and OSA were completely relieved in four (19%) patients who did not require any additional surgical therapy.

Another study carried out by Tosun *et al.* [6] stated that snoring scores were significantly improved postoperatively (P<0.01) and completely disappeared in nine of 27 patients. A significant improvement occurred in mean daytime sleepiness scores in the postoperative period (4.14) as compared with the preoperative values (9.44; P<0.01).

As regards sleep efficiency and minimal and basal SpO_2 measurements, comparative study between preoperative and postoperative measurements revealed a highly significant increase in both groups A and B (P<0.05).

The study of Nakata *et al.* [7] came in agreement with our study. It reported that surgery decreased the nasal resistance (0.55±0.37 vs. 0.17±0.19 Pa/cm^3/s; $P<0.001$) and ESS scores (11.7±4.1 vs. 3.3±1.3; $P<0.001$). Surgery increased nadir SpO_2 (76.2±10.9 vs. 78.8±8.1%; $P<0.01$), shortened apnea–hypopnea duration (averaged/maximum; 33.5±7.3/61.1±46.0 vs. 28.8±7.4/47.3±36.1 s; $P<0.05/P<0.01$), and improved sleep quality.

The Medline database (1999–2009) was searched for original articles published in peer-reviewed journals concerning nasal surgery for snoring/sleep apnea. Data extracted from these articles were reviewed and analyzed using meta-analysis technology [12].

Thirteen articles were critically appraised. Two studies provided control groups, and 11 (84.6%) articles consisted of prospective noncontrolled clinical trials (level II in evidence strength). The weighted mean AHI measured by PSG in nine studies decreased from 35.2±22.6 to 33.5±23.8 events/h after nasal surgery (overall, $P=0.69$). The pooled success rate of nasal surgery in treating OSA was 16.7%. ESS scores in eight studies decreased from 10.6±3.9 to 7.1±3.7 (overall, $P<0.001$). Nasal surgery for snoring assessed by individual questionnaires and visual analog scale reported significant improvement ($P<0.05$).

The critical literature appraisal and meta-analyses show that nasal surgery can effectively reduce daytime sleepiness and snoring. However, the efficacy of nasal surgery in treating OSA is limited, and this is the same conclusion of our study.

Conclusion

This study was carried out to investigate the effect of CRS on sleep-disordered breathing. Surgery decreased snoring and ESS scores, increased sleep efficiency, and minimal and basal SpO_2 measurements without changes in the AHI and improved sleep quality.

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Conflicts of interest

There are no conflicts of interest.

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