Pulmonary function tests in patients with chronic rhinosinusitis and the effect of surgery

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Objectives The aims of this study were to assess the pulmonary functions in patients with chronic rhinosinusitis (CRS) in comparison with normal individuals and also to assess whether surgical correction of these patients' condition through endoscopic sinus surgery (ESS) will result in any change in their pulmonary function tests (PFTs).

Patients and methods A prospective study of 50 patients (group I included 25 normal individuals and group II included 25 patients who fulfilled the clinical criteria for the CRS reference) was carried out. Demographic and clinical data were obtained; spirometry was performed for all the participants studied. Postoperative spirometry was carried out for patients with CRS after 1 month of the ESS operation.

Results The majority of patients had a computed tomography score of 14 (11 cases). The most affected group of sinuses was the maxillary sinuses and the least affected group of sinuses was the sphenoid. There were significantly lower values of mean forced vital capacity (FVC), FVC%, forced expiratory volume in the first second (FEV1), and FEV1% in the group of patients with chronic sinusitis compared with the control healthy group. In the group of patients undergoing ESS for CRS, the mean values of FVC, FVC%, FEV1, and FEV1% were significantly higher during the postoperative follow-up period than preoperative PFTs.

Conclusion PFT in patient with refractory chronic sinusitis is significantly lower than that in normal individuals and the improvement in their sinus condition can lead to an improvement in their PFT.

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Introduction

Chronic rhinosinusitis (CRS) is an inflammatory disease of the mucosa of the nasal cavity and paranasal sinuses with symptoms lasting longer than 12 weeks [1]. It is a commonly occurring, debilitating, and chronic disease [2–4]. The pathogenesis of CRS is poorly understood; however, genetic susceptibility, infection, anatomic abnormalities, and local immunologic imbalance have been postulated to play roles in its pathogenesis [5]. Treatment options for CRS include medical therapy, surgical intervention, or a combination of both. The most frequently used surgical technique is endoscopic sinus surgery (ESS) [6].

CRS is one of the most common chronic upper respiratory tract conditions associated with chronic lower respiratory tract diseases such as prolonged and chronic cough, chronic bronchitis, cystic fibrosis, bronchiectasis, and asthma [7–13].

The present study focuses on the difference in lung functions in patients with resistant CRS compared with normal individuals and also focuses on the benefits of ESS on lung functions in these patients.

Patients and methods

Our case–control study was carried out at the Department of Otolaryngology, Head and Neck Surgery, Minia University Hospital (Minia, Egypt) between January 2014 and January 2015. The study was approved by the Institutional Review Board at Minia University. Fifty adult participants were enrolled in the study and were divided into two groups: group I included 25 control normal individuals and group II included 25 patients with CRS.

We included in the study 25 adult normal individuals (group I) and 25 adult patients with medically resistant CRS (group II) diagnosed according to the definition of the consensus report of the Rhinosinusitis Task Force 12 as the presence of symptoms and classic physical examination findings of CRS confirmed by soft tissue involvement of the paranasal sinuses on a computed tomography (CT) scan lasting for at least 3 months after maximal medical therapy [1].

Patients with any of the following conditions were excluded: nasal polyps, nasal allergy, bronchial asthma, allergic fungal sinusitis, chronic obstructive pulmonary disease, cystic fibrosis, primary ciliary dyskinesia, immunodeficiency, pregnant women, coexistent systemic diseases such as diabetes, hypertension, neoplasia, patients who had undergone previous paranasal sinus surgery, and patients who were lost to follow-up.

A subjective CRS assessment was performed for all patients reporting the following symptoms: nasal congestion, facial pain or pressure, headache, nasal discharge, olfactory disturbance, and overall discomfort [1].

Endoscopy of both nasal cavities was performed to exclude patients with nasal polyposis [14].

Computed tomography assessment

The Lund–Mackay staging system assigns a value of 0, 1, or 2 to each of the following sinuses: maxillary, anterior ethmoid, posterior ethmoid, frontal, and sphenoid. Score assignments are 0 if the sinus is totally patent, 1 if the sinus is partially opacified, and 2 if the sinus is completely opacified. The osteomeatal complex (a novel two-dimensional computerized analysis of a single coronal slice) is scored as either 0 if not occluded or as 2 if occluded. The maximum score for each side is thus 12, with a total score determined out of 24 [15].

Clinical assessment

Symptoms of the lower airway including cough, sputum, dyspnea, chest pain, wheezes, and hemoptysis were reported. We excluded patients with a diagnosis of asthma according to GINA guidelines for the diagnosis and management of asthma [16].

Chest radiographs (posterior–anterior and lateral views) were obtained for each patient to identify any concomitant disease in the lungs.

Spirometry was performed using a spirometer (Lab Digital Spirometer 762600; Sensormedics, ZAN, Germany). In a normal case, forced vital capacity (FVC) and forced expiratory volume in the first second (FEV1) should be greater than or equal to 80% of the predicted value for a patient's age, height, and weight. An obstructive ventilatory defect was defined as a decrease in FEV1 out of proportion to any decrease in FVC, that is, a decrease in the FEV1/FVC ratio. The severity of lower airway obstruction was assessed as follows: FEV1% from 70 to 79% was considered to indicate mild obstruction, an FEV1 ratio from 60 to 69% was considered to indicate moderate obstruction, 50–59% was considered to indicate moderately severe obstruction, 35–49% was considered to indicate severe obstruction, and FEV1 less than or equal to 35% was considered to indicate very severe obstruction [17]. Pulmonary function test (PFTs) were performed for the patients in group II at 1 week before and 1 month after ESS.

Surgical steps

A written and informed consent was obtained from the patients with CRS before ESS and patients were provided with all information including the details of their disease, the procedure, the risks of the procedure, and possible outcomes. ESS was performed under general anesthesia using the Messerklinger technique [18]. Patients with marked septal deviation obstructing one nasal cavity were subjected to septoplasty. Merocel (Medtronic, USA) packs were left in the nasal cavities and the patient was kept in the hospital overnight and discharged in the morning.

Follow-up

Packs were removed after 48 h and the patients were prescribed antibiotics for 7–10 days with alkaline nasal douching and an intranasal corticosteroid spray for 1 month postoperatively [19].

Statistical analysis

Statistical analysis was carried out using SPSS software version (12.0; SPSS Inc., Chicago, Illinois, USA). Results are expressed as the mean and SD for continuous variables and as percentages for categorical variables. Data were compared using the *t*-test or a Mann–Whitney and a χ^2 test as appropriate. *P* value of 0.05 or less was considered statistically significant.

Results

Our study included two groups: group I included 25 normal control participants and group II included 25 patients with CRS and had undergone ESS.

Table 1 shows the demographic data of the participants in groups I and II. The age of all the participants involved in the study ranged from 18 to 50 years, with a mean of 27.1±6.86 years; 60% of the patients in group I

Table 1 Demographic data in group I versus group II

Demographic data	Group I (*n*=25)	Group II (*n*=25)	*P* value
Age (years)	28.95±9.83	27.1±6.86	0.494
Sex			
Male	15 (60)	12 (48)	0.525
Female	10 (40)	13 (52)	
Weight (kg)	67.45±6.3	69.7±9.72	0.391
Height (cm)	166.2±8.55	164±3.68	0.449
Smoking history	5 (20)	6 (24)	0.874

Data are presented as mean±SD or *n* (%).

and 48% of the patients in group II were men. Both groups were matched in terms of age, weight, height, and smoking history (no significant difference between them).

Table 2 presents the involvement of different sinus groups on the CT scan for the patients of group II. The majority of patients had a score of 14 (nine cases). The most affected group of sinuses was the maxillary sinuses and the least affected group of sinuses was the sphenoid. Osteomeatal complex was affected in 80% of patients.

Table 3 presents the PFT assessment of the patients studied. There were significantly lower values of mean FVC, FVC%, FEV1, and FEV1% in the group of patients with chronic sinusitis compared with the control healthy group (P=0.02, 0.001, 0.05, and 0.001, respectively).

In the group of patients undergoing ESS for chronic sinusitis, the postoperative values of mean FVC, FVC %, FEV1, and FEV1% were significantly higher during the postoperative follow-up period (P=0.03, 0.001, 0.03, and 0.001, respectively) (Table 4 and Fig. 1).

Discussion

Rhinosinusitis significantly impacts quality-of-life measures, with decrements in general health perception, vitality, and social functioning comparable with those observed in patients who have angina or chronic obstructive pulmonary disease. This disease is also one of the main reasons for which antibiotics are prescribed and for lost productivity in the work force [20].

The relationship between CRS and asthma has been considered in medical references for centuries [21–23]. Epidemiological studies have reported the prevalence of CRS accompanied by asthma in epidemiological studies to be between 30 and 80% [24–26]. Appropriate medical treatment for CRS has been reported to have a beneficial effect on asthma symptoms [27–29]. There is some controversy on the effects of surgical therapy in the concurrent treatment of these two disorders [17,18,20,29–32].

Our prospective study was carried out in a tertiary referral institution to compare the PFTs of normal individuals and PFTs of patients with medically resistant CRS and to assess the impact of ESS on PFTs of these patients comparing the preoperative and postoperative values. The study included patients of varied age groups, varied socioeconomic status, and of both sexes. The results were compared with the available literature.

Table 2 Computed tomography sinus score in the patients in group II

	Right side (%)			Left side (%)		
	0	1	2	0	1	2
Frontal	80	15	5	90	5	5
Maxillary	5	80	15	10	80	10
Anterior ethmoidal	15	70	15	15	70	15
Posterior ethmoidal	25	65	10	20	70	10
Sphenoid	80	10	10	80	10	10
OMC	20	–	80	20	–	80

OMC, osteomeatal complex.

Table 3 Comparison between the patients in group I and group II in terms of pulmonary function tests values

	Group I (n=25)	Group II (n=25)	P value
FVC (l)	3.94±0.88	3.45±0.78	0.02*
FVC%	99.95±9.27	84.80±11.51	<0.001*
FEV1 (l)	3.35±0.87	3.00±0.54	0.05*
FEV1 (%)	103.15±9.84	89.90±9.91	<0.001*
FEV1/FVC (%)	84.00±0.07	88.00±0.7	0.145

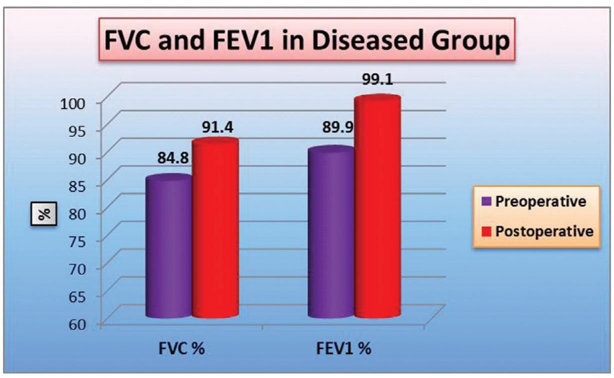
Data are presented as mean±SD. FEV1, forced expiratory volume in the first second; FVC, forced vital capacity.

Table 4 Comparison between preoperative and postoperative pulmonary function tests among patients undergoing endoscopic sinus surgery

	Preoperative PFTs	Postoperative PFTs	P value
FVC (l)	3.45±0.78	3.57±0.81	0.03*
FVC%	84.8±11.51	91.4±11.09	<0.001*
FEV1 (l)	3±0.54	3.09±0.53	0.03*
FEV1 (%)	89.9±9.91	99.1±13.17	0.001*
FEV1/FVC (%)	88±0.7	88±0.6	0.536

Data are presented as mean±SD. FEV1, forced expiratory volume in the first second; FVC, forced vital capacity; PFT, pulmonary function test.

Figure 1



Comparison between preoperative and postoperative pulmonary function tests in patients undergoing endoscopic sinus surgery. FEV1, forced expiratory volume in the first second; FVC, forced vital capacity

In our study, 11 (45%) patients had a CT score in the range of 14. These findings suggest that the majority of our CRS patients presented to our hospital at a relatively late stage of the disease. The most common group of sinuses involved in our patients was the maxillary sinus, which was involved in all patients; this finding is in agreement with most of the published data [33].

In the present study, there were significantly lower values of mean FVC, FVC%, FEV1, and FEV1% in the group of patients with chronic sinusitis compared with the control healthy group (*P*=0.02, 0.001, 0.05, and 0.001, respectively) (Table 3). In agreement with our study, Matsumoto *et al.* [34] (in their study of never-smoker Japanese CRS patients without asthma) reported that CRS is an independent risk factor for the development of airflow obstruction and that the severity of CRS is significantly associated with airflow obstruction in never-smokers. Also, Lee *et al.* [35] found that CRS is associated with a subclinical airflow limitation in patients without lower respiratory disease. Ragab *et al.* [29], in their study, found different kinds of lower airway involvement in 60% of adult CRS patients who failed medical treatment; some are manifest such as asthma and some are hidden such as bronchial hyper-reactivity. They also reported that the presence of nasal polyps was a risk factor for the involvement of the lower airways.

This nonsymptomatic lower airway involvement in patients with CRS can be explained by the small lower airway dysfunction, which involves the terminal and respiratory bronchioles less than 2–3 mm in diameter; when the disease mainly involves the conducting airways it is called small airway disease. Another indication of lower airway functional involvement is the inflammation of the lower airways resulting in bronchial hyper-reactivity. These findings also draw attention to the role of nasal obstruction in the development of lower airway disease, in which the nasal function is bypassed with loss of its function of cleaning, warming, and humidifying the inhaled air and loss of its protective mechanisms [36]. Nasal obstruction can induce a blockage of the sinus ostia with a reduction in the availability of nitric oxide in the upper and lower airways, which was reported in patients with chronic sinus disease. Shturman-Ellstein *et al.* [37] examined the effect of nasal breathing versus mouth breathing in patients with asthma during exercise or hyperventilation, resulting in worsened pulmonary function with mouth breathing versus nasal breathing.

In our present study, there was a significant increase in the mean values and percentages of postoperative follow-up FVC, FVC%, FEV1, and FEV1% compared with the preoperative values (*P*=0.03, 0.001, 0.03, and 0.001, respectively). This improvement can be attributed mainly to the surgical interference combined with continued postoperative intranasal steroid therapy, together with the possible effect of antibiotics, which may also play a role. Only a few reports have used lung functions to evaluate the impact of sinus surgery in CRS patients without lung diseases. Karuthedath *et al.* [38] evaluated the impact of ESS on the PFTs of patients with CRS; on the whole, patients benefited from ESS with better PFTs. However, their study did not have a control group of normal individuals. In a study carried out by Ragab *et al.* [29], it was found that the 6- and 12-month postoperative FEV1 (% of predicted) showed a significant increase compared with their patients' preoperative results. However, Dhong *et al.* [31] found that there was a nonsignificant change in the pulmonary function outcome after surgical interference.

The exact mechanism of improvement in PFTs that occurred in patients with CRS after ESS is unclear. It is likely that part of the improvement after ESS occurs because of removal of trigger areas in the nose and sinuses that can induce the release of leukotrienes, prostaglandins, and other inflammatory mediators that may affect the lower airways. Importantly, there was also a significant improvement in the FEV1/FVC value at 1 month postoperatively in our patients; these results reflect the effect of ESS in relieving the nonsymptomatic lower airway obstruction. These results may also be attributed to the postoperative use of intranasal corticosteroid sprays, which may lead to significant reductions in both upper and lower airway responses to intense triggers [39].

Although our study was limited by a relatively small number of patients, we believe that this prospective study, with its well-defined outcome measures and criteria included for patients selection, would help to clarify the actual value of ESS for these difficult-to-treat patients and to emphasize that the underuse of objective testing such as spirometry in patients with CRS may lead to underdiagnosed lower airway problems. Early diagnosis and good CRS control are important to reduce morbidity and healthcare costs as well as to minimize the development of chronic illnesses.

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Conflicts of interest

There are no conflicts of interest.

References

1. Fokkens WJ, Lund VJ, Mullol J, Bachert C, Alobid I, Baroody F, *et al.* AEPOS 2012: European position paper on rhinosinusitis and nasal polyps 2012. *Rhinology* 2012; **50**:1–12.
2. Halawi AM, Smith SS, Chandra RK. Chronic rhinosinusitis: epidemiology and cost. *Allergy Asthma Proc* 2013; **34**:328–334.
3. Rudmik L, Smith TL, Schlosser RJ, Hwang PH, Mace JC, Soler ZM. Productivity costs in patients with refractory chronic rhinosinusitis. *Laryngoscope* 2014; **124**:2007–2012.
4. Smith KA, Orlandi RR, Rudmik L. Cost of adult chronic rhinosinusitis: a systematic review. *Laryngoscope* 2015; **125**:1547–1556.
5. Fokkens W, Lund V, Mullol J. On behalf of the European Position Paper on Rhinosinusitis and Nasal Polyps Group. European position paper on rhinosinusitis and nasal polyps 2007. *Rhinol Suppl* 2007; 201–136.
6. Strong EB, Senders CW. Surgery for severe rhinosinusitis. *Clin Rev Allergy Immunol* 2003; **25**:165–176.
7. Marple BF, Stankiewicz JA, Baroody FM, Chow JM, Conley DB, Corey JP, *et al.* Diagnosis and management of chronic rhinosinusitis in adults. *Postgrad Med* 2009; **121**:121–139.
8. Rosenfeld RM. Clinical practice guideline on adult sinusitis. *Otolaryngol Head Neck Surg* 2007; **137**:365–377.
9. Morice AH, Fontana GA, Sovijarvi AR, Pistolesi M, Chung KF, Widdicombe J, *et al.* The diagnosis and management of chronic cough. *Eur Respir J* 2004; **24**:481–492.
10. Guilemany JM, Angrill J, Alobid I, Centellas S, Pujols L, Bartra J, *et al.* United airways again: high prevalence of rhinosinusitis and nasal polyps in bronchiectasis. *Allergy* 2009; **64**:790–797.
11. Hayden FG. Rhinovirus and the lower respiratory tract. *Rev Med Virol* 2004; **14**:17–31.
12. Vinuya RZ. Upper airway disorders and asthma: a syndrome of airway inflammation. *Ann Allergy Asthma Immunol* 2002; **88**:8–15.
13. Kariya S, Okano M, Higaki T, Noyama Y, Haruna T, Ishihara H, *et al.* Chronic rhinosinusitis patients have decreased lung function. *Int Forum Allergy Rhinol* 2014; **4**:828–833.
14. Annamalai S, Davis J, Kubba H. How subjective is nasal endoscopy? A study of interrater agreement using the Lund and Mackay scoring system.*Am J Rhinol* 2004; **18**:301–303.
15. Lund VJ, Mackay IS. Staging in rhinosinusitis. *Rhinology* 1993; **31**:183–184.
16. Global Initiative for Asthma. *Global strategy for asthma management and prevention*. Baltimore, MD: Global Initiative for Asthma; 2013. http://www.ginasthma.org.
17. Miller MR, Hankinson J, Brusasco V, Burgos F, Casaburi R, Coates A, *et al.* Standardization of spirometry. *Eur Respir J* 2005; **26**:319–338.
18. Stammberger H, Posawetz W. Functional endoscopic sinus surgery. Concept, indications and results of the Messerklinger technique. *Eur Arch Otorhinolaryngol* 1990; **247**:63–76.
19. Steinke JW, Payne SC, Tessier ME, Borish LO, Han JK, Borish LC. Pilot study of budesonide inhalant suspension irrigations for chronic eosinophilic sinusitis. *J Allergy Clin Immunol* 2009; **124**:4–1.
20. Batra PS, Kern RC, Tripathi A, Conley DB, Ditto AM, Haines GK, *et al.* Outcome analysis of endoscopic sinus surgery in patients with nasal polyps and asthma. *Laryngoscope 2003*; 2003; **13**:1703–1706.
21. Jarvis D, Newson R, Lotvall J, Hastan D, Tomassen P, Keil T, *et al.* Asthma in adults and its association with chronic rhinosinusitis: The GA(2) LEN survey in Europe. *Allergy* 2012; **67**:91–98.
22. Stelmach R, Junior SA, Figueiredo CM, Uezumi K, Genu AM, Carvalho-Pinto RM, *et al.* Chronic rhinosinusitis in allergic asthmatic patients: radiography versus low-dose computed tomography evaluation. *J Asthma* 2010; **47**:599–603.
23. Kim HY, So YK, Dhong H, Chung SK, Choi DC, Kwon NH, Oh MJ. Prevalence of lower airway diseases in patients with chronic rhinosinusitis. *Acta Otolaryngol Suppl* 2007; **127**:110–114.
24. Vashishta R, Soler ZM, Nguyen S, Scholsser RJ. A systematic review and meta-analysis of asthma outcomes following endoscopic sinus surgery for chronic rhinosinusitis. *Int Forum Allergy Rhinol* 2013; 788–794.
25. Chen FH, Zuo KJ, Guo YB, Li ZP, Xu G, Xu R, *et al.* Long-term results of endoscopic sinus surgery-oriented treatment for chronic rhinosinusitis with asthma. *Laryngoscope* 2014; **124**:24–28.
26. Gulati SP, Chaudhry D, Kalra V, Wadhera R, Garget A, *et al.* The role of functional endoscopic sinus surgery (FESS) in patients with asthma with chronic sinusitis. *Indian J Otolaryngol Head Neck Surg* 2008; **60**:152–155.
27. Ikeda K, Tanno N, Tamura G, Suzuki H, Oshima T, Shimomura A, *et al.* Endoscopic sinus surgery improves pulmonary function in patients with asthma associated with chronic sinusitis. *Ann Otol Rhinol Laryngol* 1999; **108**:355–359.
28. Palmer JN, Conley DB, Dong RG, Ditto AM, Yarnold PR, Kern RC. Efficacy of endoscopic sinus surgery in the management of patients with asthma and chronic sinusitis. *Am J Rhinol* 2001; **15**:49–53.
29. Ragab S, Scadding GK, Lund VJ, Saleh H. Treatment of chronic rhinosinusitis and its effects on asthma. *Eur Respir J* 2006; **28**:68–74.
30. Mohamed A, Hesham R, Sonya E. The of functional endoscopic sinus surgery on pulmonary functions of patients with asthma and chronic sinusitis. *AAMJ* 2013; **11**:1–5.
31. Dhong HJ, Jung YS, Chung SK, Choi DC. Effect of endoscopic sinus surgery on asthmatic patients with chronic rhinosinusitis. *Otolaryngol Head Neck Surg* 2001; **124**:99–104.
32. Razmpa E, Saedi B, Safavi A. The effect of functional endoscopic sinus surgery on pulmonary improvement of controlled asthmatic patients with chronic sinusitis. *Iran J Allergy Asthma Immunol* 2010; **9**:231–236.
33. Ogunleye AO, Fasunla AJ. Radiological changes and complications associated with nasal polyposis. *West Afr J Med* 2004; **23**:111–113.
34. Matsumoto K, Kawayama T, Kinoshita T, Minami S, Matsunaga K, Nagafuchi M, *et al.* Chronic rhinosinusitis is associated with airflow obstruction in Japanese never-smokers without asthma. *Int J Respir Pulm Med* **2**:0–23.
35. Lee SY, Yoon SH, Song WJ, Lee SH, Kang HR, Kim SS, *et al.* Influence of chronic sinusitis and nasal polyp on the lower airway of subjects without lower airway diseases. *Allergy Asthma Immunol Res* 2014; **6**:310–315.
36. Togias A. Mechanisms of nose-lung interaction. *Allergy* 1999; **57**:S94–S105.
37. Shturman-Ellstein R, Zeballos R, Buckley J, Souhrada JF. The beneficial effect of nasal breathing on exercise induced bronchoconstriction. *Am Rev Respir Dis* 1978; **118**:65–73.
38. Karuthedath S, Singh I, Chadha S. Impact of functional endoscopic sinus surgery on the pulmonary function of patients with chronic rhinosinusitis: a prospective study. *Indian J Otolaryngol Head Neck Surg* 2014; **66**:441–448.
39. Wood RA, Eggleston PA. The effect of intranasal steroids on nasal and pulmonary responses to cat exposure. *Am J Respir Crit Care Med* 1995; **151**:315–320.