Paranasal computed tomography results in asthma patients: Association between sinus sites and allergen types

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ABSTRACT

Chronic rhinosinusitis (CRS) is a common comorbidity of asthma. The aim of this study was to investigate the relationships between the presence of rhinosinusitis, sinus site involvement, and total computed tomography (CT) sinus scores and the presence of allergy, allergen type, and severity of disease. Asthma patients (128 subjects), consisting of 57 allergic and 71 nonallergic patients, were included in the study. Presence of rhinosinusitis and sinus scores were evaluated by CT. CRS was determined in 45 (78.9%) allergic asthma patients and 44 (62.0%) nonallergic asthma patients ($p < 0.05$). Ethmoid sinus involvement was higher among allergic asthma patients compared with nonallergic patients (68.4% versus 43.7%; $p = 0.005$). House-dust mite allergy (71.4% versus 46.5%; $p = 0.008$) and pollen allergy (73.5% versus 47.9%; $p = 0.01$) showed positive correlations with ethmoid sinus involvement. No correlation was found between severity of disease and mean total CT sinus scores ($p > 0.05$). The present study has shown the prevalence of chronic sinusitis to be higher in patients with allergic asthma, particularly in patients allergic to house-dust mites and pollens, with no correlation between severity of disease and presence of CRS. Investigating chronic sinusitis together with allergen sensitivity early in asthma diagnosis may contribute positively to patient treatment.

(Allergy Asthma Proc 29:475–479, 2008; doi: 10.2500/aap.2008.29.3157)

Key words: Allergen, allergy, asthma, chronic, computed tomography, ethmoid sinus, sinusitis

Asthma is a chronic inflammatory disorder of the airways in which many cells and cellular elements play a role.[1] Rhinosinusitis is replacing the term sinusitis because sinusitis is often preceded by rhinitis and rarely occurs without concurrent nasal airway inflammation. Asthma and rhinosinusitis have been reported to be diseases that may frequently be seen together.[2] Significant correlations among blood and induced sputum eosinophil rates and paranasal sinus computed tomography (PNS CT) scores were reported in patients with severe asthma.[2] Histopathology of airway and sinus epitheliums in asthma patients has shown similarities with the disease process of rhinosinusitis.[3]

PNS CT perfectly reveals the bony anatomy and extent of sinus disease. PNS CT, therefore, is regarded as the "gold standard" in PNS imaging.[4] The presence of rhinosinusitis in asthma patients may complicate asthma treatment or require additional treatment. Therefore, investigation of chronic rhinosinusitis (CRS) may be important when a patient is diagnosed with asthma. Thus, the aim of this study was to ascertain the relationship between total CT sinus scores, CT stages, and sinus site involvement and severity of disease; patient age and gender; presence of allergy; and allergen type in skin-prick tests with the help of PNS CT imaging.

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METHODS

Study Population

The study included 128 consecutive asthma patients (57 allergic and 71 nonallergic patients) entering the Chest Diseases Polyclinic. The mean age and standard deviation (SD) for the study population was 47.2 (±15.3) years. Of the 128 patients, 96 were women and 32 were men. There were 12 current smokers. The mean total IgE level in allergic asthma patients was higher than that of nonallergic asthma patients ($p = 0.01$; Table 1). Diagnosis and severity of disease in asthmatic patients were made according to the Global Initiative for Asthma guidelines.[1] Patients presenting with asthma attacks, changes in PNS anatomy due to previous trauma, presence of paranasal malignity, or previous surgery were excluded from the study. Nonallergic rhinitis (NAR) was defined as recurring or perennial inflammatory symptoms (typical of inciting allergens such as pollens and animal dander), together with negative allergy test results. Gastroesophageal reflux was defined as heartburn and/or acid regurgitation occurring at least weekly. CRS was defined by symptoms and associated inflammation of the PNS mucosa persisting for >12 weeks without reaching normal levels even in intervals free of acute episodes. Written informed consent was obtained from all par-

Table 1 **Demographic characteristics and severity of disease of allergic and nonallergic asthmatic patients**

	Allergic Asthmatic Patients (*n* [%])	Nonallergic Asthmatic Patients (*n* [%])	Total (*n*)
Mean age + SD	43.3 ± 15.1	50.5 ± 14.8	47.2 ± 15.3
Mean duration of asthma (moh)	89.5 ± 98.9	82.7 ± 103.8	85.9 ± 101.2
Mean total IgE (U/mL)	268 ± 349	117 ± 219	192 ± 299
Gender			
Male	22 (61.4)	10 (14.1)	32
Female	35 (38.6)	61 (85.9)	96
Smoking			
Nonsmoker	38 (66.7)	54 (76.1)	92
Former smoker	14 (24.6)	10 (14.1)	24
Smoker	5 (8.8)	7 (9.9)	12
Total	57 (44.5)	71 (55.5)	128

Table 2 **Sinus computed tomography scan scores**

Nasal passages	3	(0–3)		
Osteomeatal complex	6	(0–3 each)		
Sinuses	21 points			
Points for mucosal thickening	0	1	2	3
Frontal	0–1 mm	2–5 mm	6–9 mm	>10 mm
Maxillary	0–1 mm	2–5 mm	6–9 mm	>10 mm
Sphenoid	0–1 mm	2–5 mm	6–9 mm	>10 mm
Ethmoid	0 mm	1 mm	2–3 mm	>4 mm

ticipants. This study was approved by our Local Ethical Committee.

Skin-Prick Tests

None of the subjects had received antihistamines orally for 3 days preceding the study. Skin-prick tests were performed using a panel of common inhalant allergens, including house-dust mites, cockroaches, molds, cats, dogs, and pollens (Allergopharma, Reinbek, Germany). Saline and histamine solutions were used as negative and positive controls, respectively. A positive result to a specific allergen was indicated if a mean wheal diameter measuring 3 mm or greater than the negative control was recorded 15 minutes post–skin prick. Atopy was recorded if one or more positive allergy prick tests occurred. Allergic asthma was defined as having asthma in combination with atopy; nonallergic asthma was defined as having asthma without atopy.

PNS CT Scan

Subjects underwent PNS CT examination in a supine position. The CT examination collected 1.5-mm axial images, which were off-line reconstructed and reformatted to 3-mm coronal images for analysis (Siemens Emotion Duo, Germany). Contrast material was not administered. All PNS CT exams were evaluated by the same radiologist. CT scoring was done according to the scoring defined by Hoover *et al.*[5] A total of 30 points was allowed (21 from the sinus, 6 from the osteomeatal complexes, and 3 from the nasal passages; Table 2). CT staging was done according to the criteria of Metson and Gliklich.[6]

Statistical Analyses

Statistical analyses was done using SPSS statistical software program Version 10.0 (SPSS, Inc., Chicago, IL). Mann-Whitney and *t*-tests were used when comparing two groups, and Kruskal-Wallis H and ANOVA tests were used when comparing more than two groups. Pearson's chi-square was used to compare categorical variables, with significance set at $p < 0.05$.

RESULTS

There was no difference between the allergic and nonallergic asthma patients in terms of forced expiratory volume in 1 second values and severity of disease ($p > 0.05$). PNS CT stages and mean total CT sinus scores were not correlated with severity of asthma, allergen type in skin-prick test, age, asthma duration, or smoking ($p > 0.05$). Positive correlations were found between CT sinus score and serum eosinophil rate and

Table 3 **Sinus computed tomography scores according to gender, severity of disease, and presence of allergy**

	Total Score ± SD	*p* Value
Gender		
Male	7.3 ± 5.8	0.022
Female	4.7 ± 5.3	
Severity of disease		
Mild	4.8 ± 5.3	>0.05
Moderate	6.1 ± 6.5	
Severe	5.6 ± 5.6	
Presence of allergy		
Allergic	6.1 ± 6.2	>0.05
Nonallergic	4.7 ± 5.3	
Mean serum eosinophil rate		
≤3%	4.4 ± 4.7	0.026
>3%	7.8 ± 7.0	
Mean total serum IgE level (U/mL)		
IgE <200	4.4 ± 5.3	0.002
IgE ≥200	8.3 ± 6.0	
Total	5.3 ± 5.7	

total IgE level ($p < 0.05$). Mean total CT sinus scores were higher in men compared with those of women (7.3 points versus 4.7 points; $p < 0.05$; Table 3). Mean total CT sinus scores of asthma patients exhibiting ≥200 u/mL of total IgE level were higher compared with those of patients with <200 u/mL of total IgE level (8.3 points versus 4.4 points; $p = 0.002$; Table 3).

CRS was determined in 45 (78.9%) allergic asthma patients and 44 (62.0%) nonallergic asthma patients ($p < 0.05$). Ethmoid sinus involvement was higher among allergic asthma patients compared with nonallergic patients (68.4% versus 43.7%; $p = 0.005$). There was no correlation between allergic and nonallergic asthma patients regarding mucosal thickening in other sinuses ($p > 0.05$; Table 4). Other parameters were compared within each of the sinus areas exhibiting mucosal thickening. Sinus areas exhibiting mucosal thickening were not correlated with age, smoking, and presence of cockroaches, animal epithelium, and fungi allergy ($p > 0.05$). There were no correlations between mucosal thickening of maxillary, sphenoid and frontal sinuses, and house-dust mite and pollen allergy ($p > 0.05$). Positive allergen tests correlated with mucosal thickening in ethmoid sinus ($p < 0.05$). There was a correlation between house-dust mite allergy and involvement of at least one sinus. House-dust mite allergy was also correlated with the involvement of ethmoid sinus ($p < 0.05$; Table 5). Mucosal thickening of frontal and sphenoid sinuses showed no correlation with house-dust mite allergy ($p > 0.05$). Ethmoid sinus mucosal thickening was present in 25 (73.5%) asthma patients with pollen allergy and in 45 (47.9%) asthma patients without pollen allergy ($p = 0.01$). Other sinuses exhibiting mucosal thickening did not show a correlation with pollen allergy ($p > 0.05$).

Gastroesophageal reflux was present in 26 patients. No correlations were observed between gastroesophageal reflux and presence of CRS, involvement of sinus site, and atopy. NAR was present in 32 of 72 patients. There were no correlations between NAR and presence of CRS, involvement of sinus site, and mean total CT score.

DISCUSSION

In the present study, the prevalence of CRS was higher in patients with allergic asthma and in patients with house-dust mite allergy than in patients with nonallergic asthma and patients without house-dust mite allergy, respectively. Higher CT sinus scores in allergic patients compared with nonallergic patients were reported.[7] The prevalence of house-dust mite allergy in CRS patients with nasal polyps was also reported to be higher.[8] Emanuel and Shah[9] applied allergic tests before endoscopic sinus surgery. They reported multiple inhalants and, particularly, house-dust mite allergy as contributing to the development of CRS. Gutman *et al.*[10] reported a correlation between perennial allergies, such as house-dust mites and mold, and chronic and recurrent acute sinusitis. Occlusion of paranasal ostia plays an important role in development

Table 4 **The association between mucosal abnormalities of the paranasal sinuses and allergy in asthmatic patients**

Mucosal Abnormality	Allergic ($n = 57$)	Nonallergic ($n = 71$)	*p* Value
Maxillary sinus mucosal thickening	41 (71.9%)	43 (60.6%)	>0.05
Ethmoid sinus mucosal thickening	39 (68.4%)	31 (43.7%)	0.005
Frontal sinus mucosal thickening	19 (33.3%)	20 (28.2%)	>0.05
Sphenoid sinus mucosal thickening	19 (33.3%)	16 (22.5%)	>0.05
Osteomeatal complex	25 (43.9%)	21 (29.6%)	>0.05
Each sinus abnormality	45 (78.9%)	44 (62.0%)	0.038

Table 5 **The association between mucosal abnormalities of the paranasal sinuses and house-dust mite allergy**

Mucosal Abnormality	House-Dust Mite Allergy (+; $n = 42$)	House-Dust Mite Allergy (−; $n = 86$)	p Value
Maxillary sinus mucosal thickening	32 (76.2%)	52 (60.5%)	>0.05
Ethmoid sinus mucosal thickening	30 (71.4%)	40 (46.5%)	0.008
Frontal sinus mucosal thickening	14 (33.3%)	25 (29.1%)	>0.05
Sphenoid sinus mucosal thickening	15 (35.7%)	20 (23.3%)	>0.05
Osteomeatal complex	18 (42.9%)	28 (32.6%)	>0.05
Each sinus abnormality	36 (83.7%)	52 (61.2%)	0.009

of CRS. This occlusion may occur due to various anatomic variations or as a result of a mucosal disease process, such as allergic rhinitis.[10] Nasal allergy may occlude ostia directly because of inflammation or indirectly because of increased secretion and delayed mucociliary clearance. Furthermore, allergens may directly penetrate to sinus cavities.[10] The prevalence of CRS was higher in our allergic asthma patients (78.9%) compared with nonallergic asthma patients (62.0%). However, our nonallergic asthma patients displayed a high prevalence as well. Sixty-five percent of our nonallergic patients with CRS exhibited nasal occlusion complaint. In asthma patients, anatomic variation or NAR may lead to rhinitis just as well as allergic rhinitis. Because we did not perform endoscopic examinations on our patients, we could not determine the causes of CRS in nonallergic asthma patients.

In the present study, a positive correlation was found between ethmoid sinus involvement and house-dust mite allergy and pollen allergy. Tezer *et al.*[11] reported a high rate of maxillary sinus mucosal thickening in allergic individuals compared with that of nonallergic people. They reported no difference for mucosal thickening of ethmoid and other sinuses between allergic and nonallergic individuals. Dhong *et al.*[12] found a significantly higher rate of ethmoid sinus involvement in patients with asthma than in nonasthma patients and showed the ethmoid sinus as the proper place to be examined to evaluate sinusitis in CRS patients associated with asthma. Another study showed a higher level of inflammatory response in the ethmoid sinus than in the maxillary sinus during CRS.[13] Drainage of the ethmoid sinus may often be inefficient for asthma patients with house-dust mite or pollen allergy.

In the present study, male patients, high serum total IgE level patients, and high serum eosinophil rate patients had higher mean total CT sinus scores. There was no correlation between severity of disease and mean total CT sinus scores. In the study of Adapinar *et al.*, mean total sinus mucosal CT scores and single sinus site scores were reported higher in patients with high blood eosinophil level compared with patients with normal scores.[14] There was no correlation between total IgE level and CT scores in that study.[14] They reported a significant correlation between total sinus mucosal scores and asthma severity.[14] Dursun *et al.*[15] determined no correlations among asthma severity, CT stages, total opacification scores, anatomic variation, and sinonasal symptom scores. Although Bresciani *et al.*[16] reported no difference in terms of prevalence of rhinosinusitis in patients with mild to moderate asthma compared with patients with severe asthma dependent on steroid therapy, total sinus scores were reported to be significantly higher in steroid-dependent severe asthma patients than in mild to moderate asthma patients. The aforementioned studies report conflicting results, particularly, for the correlation between asthma severity and CRS. These differences may be arising because of high heterogeneity of asthma patients. Investigating this issue further within a wider study population and considering various factors such as allergy, aspirin sensitivity, and nasal anatomic differences may help in obtaining more concrete information.

In conclusion, this study has shown the prevalence of chronic ethmoid sinusitis to be higher in patients with allergic asthma, particularly in patients with house-dust mite and pollen allergy. There was no correlation between severity of disease and CRS. Investigating CRS together with allergen sensitivity at an early period of asthma diagnosis may contribute positively to patient treatment.

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