



Occurrence and impact of sinusitis in patients with asthma and/or allergic rhinitis

Sandeep Sahay MD, Kamal Gera MD, Satish K Bhargava MD & Ashok Shah MD

To cite this article: Sandeep Sahay MD, Kamal Gera MD, Satish K Bhargava MD & Ashok Shah MD (2016): Occurrence and impact of sinusitis in patients with asthma and/or allergic rhinitis, Journal of Asthma, DOI: [10.3109/02770903.2015.1091005](https://doi.org/10.3109/02770903.2015.1091005)

To link to this article: <http://dx.doi.org/10.3109/02770903.2015.1091005>



Accepted author version posted online: 07 Sep 2015.
Published online: 11 Apr 2016.



Submit your article to this journal [↗](#)



Article views: 28



View related articles [↗](#)



View Crossmark data [↗](#)

ORIGINAL ARTICLE

Occurrence and impact of sinusitis in patients with asthma and/or allergic rhinitis

Sandeep Sahay, MD^{1,*}, Kamal Gera, MD¹, Satish K Bhargava, MD², and Ashok Shah, MD¹¹Department of Respiratory Medicine, Vallabhbhai Patel Chest Institute, University of Delhi, Delhi, India and ²Department of Radiology, University College of Medical Sciences (University of Delhi) & G.T.B. Hospital, Delhi, India**Abstract**

Objective: The occurrence of radiological sinusitis in patients with asthma without any obvious nasal symptoms could possibly increase the severity of asthma. We investigated the occurrence and impact of sinusitis on computed tomography of the paranasal sinuses (CT-PNS) in patients with asthma and/or allergic rhinitis. Effect of sinusitis on the quality of life (QoL) was also assessed. **Methods:** All subjects underwent spirometry with reversibility, CT-PNS, intradermal test against common aeroallergens and responded to Symptom Severity Score and Rhinosinusitis Disability Index (RSDI). Of the 216 consecutive patients, 27 had asthma without nasal symptoms (Group 1), 58 had asthma with allergic rhinitis (Group 2) and 131 had allergic rhinitis (Group 3). Thirty normal healthy controls without atopy were also included (Group 4). **Results:** 20/27 (74%) patients in Group 1 had sinusitis on CT-PNS. 48/58 (82%) patients in Group 2 and 88/131 (67%) patients in Group 3 had chronic rhinosinusitis (CRS) as confirmed on CT-PNS. 6/30 (20%) healthy controls in Group 4 had mucosal thickening. Asthmatics with radiological sinusitis in Group 1 and with CRS in Group 2 had significantly lower FEV₁, FEV₁/FVC ratio, were more symptomatic and had a greater impairment of QoL. The mean sinus severity score was significantly higher in Group 2. In Group 3, sinusitis occurred significantly higher in “blockers” than “sneezers-runners” (41/79 versus 47/52, $p = 0.045$). **Conclusions:** Occurrence of radiological sinusitis on CT-PNS in asthmatics without nasal symptoms and CRS in allergic rhinitis with or without asthma increases the severity of the disease and affects the QoL.

Keywords

Allergic rhinitis, asthma, “blockers”, CT-PNS, imaging, quality of life, sinusitis, “sneezers-runners”

HistoryReceived 2 January 2015
Revised 12 August 2015
Accepted 31 August 2015
Published online xx Month xxxx**Introduction**

Although, the relationship between asthma, rhinitis and sinusitis has been known since antiquity, the importance of this association appears to have been diluted with the passage of time. Asthma and upper airway diseases like rhinitis and sinusitis were treated as distinct clinical entities. However, in recent times, the concept that these three diseases constitute a single overlapping syndrome occurring in a single airway has evolved [1–3]. In view of the frequent occurrence of rhinitis along with sinusitis, the European Position Paper on Rhinosinusitis and Nasal Polyps (EPOS) and the Practice Parameter Update by the American Academy of Allergy, Asthma and Immunology, the American College of Allergy, Asthma and Immunology and the Joint Council of Allergy, Asthma and Immunology strongly recommended the use of the term “rhinosinusitis” [4,5]. Allergic rhinitis (AR) often predisposes to chronic rhinosinusitis (CRS) as evidenced by the presence of AR in as high as 40–84% of patients with CRS in adults and 36–60% in children

[5]. This has been substantiated by the presence of elevated total IgE levels in 97% of patients with AR with chronic sinusitis while in those without sinusitis, increased total IgE levels were seen in 79% [6]. The co-existence of asthma and AR has been reinforced by a survey from Sweden in 18,087 respondents, where the prevalence of AR in patients with asthma was found to be as high as 64% while asthma was reported in 20% patients with AR [7].

Evidence is accumulating that there may be a cause-and-effect relationship between sinusitis and asthma [8]. Asthma is known to occur in 20–31.9% of patients with CRS [3] and the severity of sinonasal disease is thought to correlate with the severity of bronchial inflammation [3,8–14]. A cross-sectional study from USA documented the increased radiological severity of CRS with an increasing severity of asthma when the mean Lund–Mackay scores increased significantly from 11.6 in intermittent/mild asthma group to 15.6 in moderate/severe asthma group [14]. Histopathologically, heterogeneous eosinophilic inflammation and features of airway remodeling seen in asthma are also present in CRS [15]. Sinusitis is now thought to be an important trigger factor for asthma [16], and optimal control of sinusitis would help in preventing frequent exacerbations of asthma [8]. Furthermore, a questionnaire-based multi-centric international European survey conducted by the GA²LEN in over 52,000 adults has

Correspondence: Ashok Shah, Department of Respiratory Medicine, Vallabhbhai Patel Chest Institute, University of Delhi, Delhi - 110 007, India. Tel: +91-11-2543 3783. Fax: +91-11-2766 6549. E-mail: ashokshah99@yahoo.com

*Current address: Dr Sandeep Sahay, Division of Pulmonary, Critical Care and Sleep Medicine, Baylor College of Medicine, Houston, TX, USA.

shown the strong association of asthma with CRS (adjusted OR: 3.47; 95% CI: 3.20–3.76) [17]. The association was even stronger in patients with both CRS and AR (adjusted OR: 11.85; 95% CI: 10.57–13.17), while CRS without AR was associated with late-onset asthma [17].

The occurrence and impact of radiological sinusitis in patients with asthma without nasal symptoms is yet to receive the attention that it deserves [10–12]. In light of the above, we attempted to ascertain the occurrence and severity of radiological sinusitis in patients with asthma without nasal symptoms and also evaluated its impact in these patients. Furthermore, we also endeavored to determine the effects of CRS on the quality of life (QoL) in patients with AR with or without asthma.

Materials and methods

The study was conducted in newly referred, consecutive patients between 15 to 50 years of age, with respiratory symptoms suggestive of either asthma or allergic rhinitis or concomitant disease. The algorithm shown in Figure 1 highlights

the study design. The clinical diagnosis of asthma was based on symptoms and physical examination and confirmed as per Global Initiative for Asthma (GINA) guidelines [18], as an improvement of at least 12% and 200 ml in FEV1 after inhalation of 400 mcg of salbutamol. Allergic rhinitis was diagnosed, according to the Allergic Rhinitis and its Impact on Asthma (ARIA) workshop report [1], as presence of two or more of the following symptoms for more than an hour on most days, which included rhinorrhea, nasal blockage, sneezing and nasal itching. Patients with allergic rhinitis were symptomatic on recruitment. All patients had a positive intradermal test against at least three aeroallergens that were prevalent in the local environment as defined by Schwartz and Greenberger [19]. Intradermal testing was used in the study as antigens for skin prick test, the recommended standard for evaluation of atopic status, was not available with us. Patients with negative intradermal skin testing were excluded from the study, as were those who received oral corticosteroids and/or antihistaminic drugs within 1 month prior to enrollment. None of these patients had ever used inhaled medications and/or intranasal

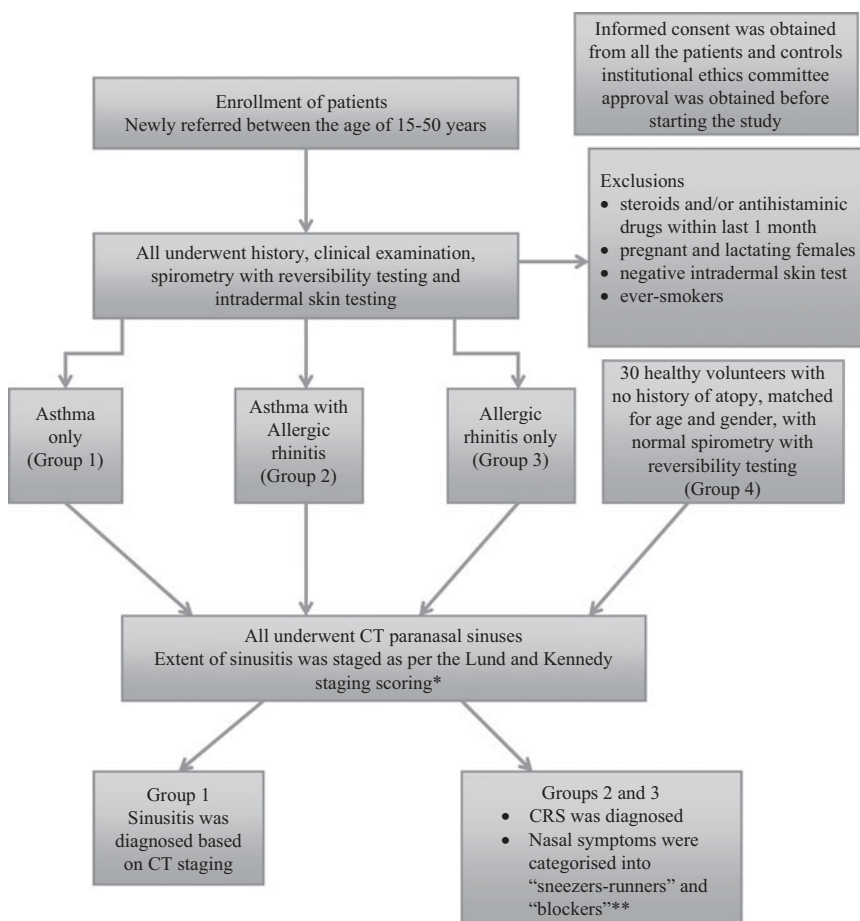


Figure 1. Study design algorithm.

- CRS was diagnosed in patients with nasal symptoms based on the EPOS document
- All patients and controls were subjected to questionnaire to assess severity of sinusitis and its effect on QoL
- Intradermal skin testing interpretation: negative (-), wheal and erythema different from those in control subjects; 1+, 3 to 6 mm wheal and 11 to 20 mm erythema; 2+, 6 to 9 mm wheal and 21 to 30 mm erythema; 3+, 9 to 13 mm wheal and 31 to 40 mm erythema; and 4+, > 15 mm wheal with pseudopods and > 40 mm erythema. Patients with > 2+ were considered to be positive for type I hypersensitivity.
- ***“Sneezers-runners” and “blockers” were identified based on their predominant symptoms.

corticosteroid sprays prior to inclusion in the study or had ever smoked.

Lund and Kennedy [20] scoring system was used to assess the severity of the sinusitis present on the computed tomography of the paranasal sinuses (CT-PNS). Each sinus group was graded as 0 (no abnormality), 1 (partial opacification) and 2 (total opacification). The ostiomeatal complex scored only as 0 (not occluded) or 2 (occluded). Anatomic variants did not contribute to the scoring. A total mean sinus score as well as the individual sinus scores were calculated in each group. To avoid bias, the radiologist was blinded to the clinical data.

Thirty age- and gender-matched healthy volunteers underwent similar evaluation as the study groups.

Grouping of the study subjects

Group 1 included patients with asthma, Group 2 included patients with asthma and allergic rhinitis, while Group 3 included patients with allergic rhinitis. Controls were categorized in Group 4. Group 1 patients had reversibility on spirometry, while Group 2 patients in addition had nasal symptoms. Group 3 patients had nasal symptoms with normal spirometry. In Groups 2 and 3, CRS was defined as per the EPOS [4] criteria as presence of nasal congestion or obstruction, nasal discharge, headache, facial pain or pressure, or hyposmia for more than 12 weeks with relevant clinical examination findings. Patients with allergic rhinitis in both Groups 2 and 3 were further categorized as “sneezers-runners” and “blockers” based on their predominant symptoms [21,22]. Written informed consent was obtained from all patients. The study had the approval of the institutional ethics committee.

Symptom severity and quality of life assessment

A questionnaire seeking detailed information about the nature, pattern and duration of symptoms of asthma, allergic rhinitis and sinusitis was filled in for all patients and controls by the same investigator. Information regarding itching of eyes, ears, throat and skin as well as aggravating factors like house dust, vehicular smoke, environmental tobacco smoke (ETS), etc was also sought for. Severity of sinusitis was assessed by the Symptom Severity Score [23], while Rhinosinusitis Disability Index (RSDI) [24] assessed the QoL.

Symptom Severity Score

A visual analog scale ranging from 1 to 7 to assess nasal obstruction, anterior purulent nasal discharge, posterior purulent nasal discharge, facial pain/fullness, headache, fatigue, hyposmia, ear pain, cough, halitosis, dental pain and fever was used. Score of “1” depicted “no symptoms”, while “7” reflected that the symptoms were “so bad that the patient could not function virtually all the time”. The mean score for each symptom was compared across four different groups.

Rhinosinusitis Disability Index

Rhinosinusitis Disability Index assessed the patients for the disability caused by sinusitis among the emotional, functional and physical scales. Patients were administered a set of 30 questions, which the patients filled in either “Yes” or “No”. The total

number of responses with “Yes” was compared among patients with or without sinusitis in all four groups.

Statistical analysis

SPSS for Windows was used for statistical analysis (version 11.5, SPSS, Inc., Chicago, IL). Differences in symptoms, CT-PNS scoring, symptom severity score and rhinosinusitis disability score between patients with and without sinusitis in different groups were analyzed for significance using the Chi-Square test. The Mann-Whitney U test was used to analyze non-parametric data. ANOVA was performed to compare group means wherever applicable.

Results

Of the 244 patients included, 216 (128 males, 88 females, mean age 30.3 years, range 15–50 years) and 30 controls (18 males, 12 females, mean age 29.5 years, range 15–50 years) completed the study protocol. Twenty-eight patients were excluded as 12 did not complete the questionnaire and 16 did not get the CT-PNS done. There were 27 (12.5%, 16 males, 11 females) patients in Group 1, 58 (26.5%, 33 males, 25 females) in Group 2 and 131 (61%, 79 males, 52 females) in Group 3. Of the 216 patients, 20/27 (74%) in Group 1 had radiological sinusitis, 48/58 (82%) patients in Group 2, 88/131 (67%) patients in Group 3 had CRS and 6/30 (20%) healthy controls in Group 4 had mucosal thickening. In Group 1, the subjects with radiological sinusitis were compared with those without them. In Groups 2 and 3 too, subjects with CRS were compared with those without. There were no significant age and gender differences in all four groups.

Spirometric data of all groups is shown in Table 1. Patients with concomitant radiological sinusitis in Group 1 (asthma only) and in Group 2 (CRS with asthma) had significantly lower FEV₁, FEV₁/FVC ratios than those without sinusitis. Table 2 displays the symptomatology and highlights that across all three patient groups, those with radiological sinusitis or CRS had a greater degree of morbidity.

Symptom Severity Score

In Group 1, patients with radiological sinusitis and in Groups 2 and 3, patients with CRS were significantly more symptomatic (Table 2). Analysis of the symptom severity score too showed that these patients had significantly more severe symptoms (Table 3).

Rhinosinusitis Disability Index

On comparing RSDI within Group 1, significantly more asthmatics with radiological sinusitis did not feel like socializing with people (19/20 versus 1/7, $p = 0.05$), were frequently irritable (20/20 versus 1/7, $p = 0.049$), were frequently tense (19/20 versus 0/7, $p = 0.015$) and had to frequently miss their daily activities (20/20 versus 0/7, $p = 0.013$). Straining increased or worsened their problem (19/20 versus 1/7, $p = 0.049$) and in addition, they found it difficult to sleep at night (20/20 versus 1/7, $p = 0.05$). Similarly, in Group 2, significantly more patients with CRS had to miss their work or social activities (46/48 versus 2/10, $p = 0.034$), while Group 3 patients with CRS were more confused (59/88 versus 7/10,

Table 1. Spirometry data of three study groups and control group.

	Group 1 (<i>n</i> = 27)		Group 2 (<i>n</i> = 58)		Group 3 (<i>n</i> = 131)		Group 4 (<i>n</i> = 30)	
	With radiological sinusitis (<i>n</i> = 20)	Without radiological sinusitis (<i>n</i> = 7)	With CRS (<i>n</i> = 48)	Without CRS (<i>n</i> = 10)	With CRS (<i>n</i> = 88)	Without CRS (<i>n</i> = 43)	With mucosal thickening (<i>n</i> = 6)	Without mucosal thickening (<i>n</i> = 24)
Mean FEV ₁ (L)	0.76 ± 0.86 <i>p</i> value = 0.007 (95% CI 0.32–1.8)	1.86 ± 0.85	0.46 ± 0.96 <i>p</i> value = 0.0002 (95% CI 0.89–2.22)	2.02 ± 0.9	2.96 ± 0.67	2.81 ± 0.87	3.43 ± 0.81	3.30 ± 0.61
Mean FVC (L)	1.2 ± 0.45 <i>p</i> value = 0.032 (95% CI 0.3–1.3)	2.02 ± 0.84	1.56 ± 0.34	1.90 ± 0.87	3.61 ± 0.85	3.56 ± 0.74	4.27 ± 0.54	3.96 ± 0.34
Mean FEV ₁ /FVC ratio	45 ± 20 <i>p</i> value = 0.009 (95% CI, 6.33–41.67)	69 ± 18	41 ± 20	70 ± 25	82 ± 20	77 ± 15	83 ± 8	81 ± 10
	<i>p</i> value = 0.0002 (95% CI, 14.46–43.54)		NS		NS		NS	

NS: Not significant.

$p = 0.0007$), frequently got angry (74/88 versus 13/43, $p = 0.003$), frequently missed work or activity (19/88 versus 2/10, $p = 0.029$), were more frequently fatigued (18/88 versus 1/10, $p = 0.013$) and they had more sleep disturbances (18/88 versus 2/10, $p = 0.037$).

Occurrence of sinusitis and mean CT scores

Maxillary sinuses were the most commonly involved in all three patient groups (116/156, 74.3%) followed by ethmoid sinuses (78/156, 50%). Isolated maxillary sinuses were involved in 69 (42.9%) patients, while isolated ethmoid sinus involvement was present in 52 (32.9%). In controls, all six subjects had isolated maxillary sinus mucosal thickening with a mean sinus score of only 1.1 ± 1.2 . On assessing the 78 patients with ethmoid sinusitis, 45 were asthmatics (45/78, 57.9%). Of the 68 asthmatics with radiological sinusitis or CRS (Groups 1 and 2), 45 (66.2%) had ethmoid sinus involvement, of whom 32 (71.1%) had isolated sinus involvement. The ethmoid sinuses involvement was significantly higher in asthmatics as compared to those with allergic rhinitis (45/68 versus 33/88, $p = 0.041$). The mean sinus scores for each sinus group showed that the mean score for ethmoid sinuses were significantly higher in Groups 1 and 2 when compared with Group 3 (Table 4). Similarly, the ratio of ethmoid sinus scores to the total sinus scores was significantly higher in Group 2 when compared with Group 3. Overall, mean sinus CT scores showed that radiologically, sinusitis was significantly more severe in Group 2 than those in Groups 1 and 3 (Table 4).

Categorization of patients with allergic rhinitis into “sneezers-runners” and “blockers”

Patients with allergic rhinitis in Groups 2 and 3 were further subdivided into “sneezers-runners” and “blockers” on the basis of their predominant symptoms (Table 5). Of the 131 patients with allergic rhinitis in Group 3, 88 had CRS. Of these patients, 79 were categorized as “sneezers-runners”, while 52 were “blockers”. Of the 79 “sneezers-runners”, 41 had CRS while 47 of “blockers” had CRS. Occurrence of CRS was significantly higher in “blockers” when compared with “sneezers-runners” (41/79 versus 47/52, $p = 0.045$).

Similarly in Group 2, 48 of the 58 patients had CRS, 31 of whom were “sneezers-runners” and 27 were “blockers”. Of the 31 “sneezers-runners”, 23 had CRS, while 25 of “blockers” had CRS. Occurrence of CRS was higher but not significant in “blockers” (23/31 versus 25/27, $p = 0.5$).

The mean sinus score was significantly higher in “blockers” (8.23 ± 1.75 in Group 2, 4.26 ± 0.32 in Group 3) as compared to “sneezers-runners” (6.5 ± 2.23 in Group 2, 3.9 ± 0.97 in Group 3) in both the groups ($p = 0.004$ in Group 2, $p = 0.027$ in Group 3). This suggests greater mucosal involvement and increased severity of sinusitis in “blockers” of both Groups 2 and 3.

Discussion

Although the association with asthma and/or allergic rhinitis with sinusitis have been highlighted in recent times, clinicians often overlook the added morbidity caused by this association. Our study showed that there was significant occurrence of sinusitis in all the three groups. Nearly three-fourth of the

Table 2. Symptomatology.

Symptoms	Group1 (n = 27)		Group 2 (n = 58)		Group 3 (n = 131)		Group 4 (n = 30)	
	With radiological sinusitis (n = 20)	Without radiological sinusitis (n = 7)	With CRS (n = 48)	Without CRS (n = 10)	With CRS (n = 88)	Without CRS (n = 43)	With mucosal thickening (n = 6)	Without mucosal thickening (n = 24)
Nocturnal awakening	20	1	47	2	35	7	1	4
	<i>p</i> = 0.05		<i>p</i> = 0.031		<i>p</i> = 0.04		NS	
Headache	20	1	46	2	70	15	2	6
	<i>p</i> = 0.05		<i>p</i> = 0.034		<i>p</i> = 0.013		NS	
Easy fatigability	19	1	35	7	50	7	3	4
	<i>p</i> = 0.05		NS		<i>p</i> = 0.003		NS	
Halitosis	20	0	46	2	58	14	0	1
	<i>p</i> = 0.013		<i>p</i> = 0.034		<i>p</i> = 0.042		NS	
Wheezing	19	5	46	2	12	10	0	0
	NS		<i>p</i> = 0.034		NS		—	
Post nasal drip	0	0	48	2	62	15	0	0
	—		<i>p</i> = 0.029		<i>p</i> = 0.039		—	
Breathlessness	20	6	48	8	54	12	0	0
	NS		NS		<i>p</i> = 0.03		—	
Nasal blockage	0	0	45	5	59	14	0	0
	—		NS		<i>p</i> = 0.037		—	
Purulent anterior nasal discharge	0	0	46	5	62	15	0	0
	—		NS		<i>p</i> = 0.039		—	
Hyposmia	12	2	44	6	44	4	0	0
	NS		NS		<i>p</i> = 0.0009		—	
Purulent posterior nasal discharge	0	0	39	6	65	9	0	0
	—		NS		<i>p</i> = 0.001		—	
Family history of allergic rhinitis	0	0	34	4	70	12	1	2
	—		NS		<i>p</i> = 0.03		NS	

NS: Not significant.

patients with asthma without any obvious nasal symptoms had radiological evidence of sinusitis. Studies done earlier also support this association. Ferrante et al. [10] documented sinusitis in 52 (43%) of the 120 young male asthmatics evaluated. Sixteen of these 52 patients never had any nasal symptoms. Since sinusitis was not confirmed by CT-PNS, the occurrence could possibly have been underestimated. In another study, where limited coronal sinus CT was performed in 65 patients with acute asthma and 62 controls, the authors found that asthmatics had significantly higher mucosal thickening in the nasal passages, ostiomeatal complexes, ethmoidal and sphenoidal sinuses but not in maxillary sinuses. CT scores differed significantly between asthmatic patients (7.7 +/– 0.8 points) and control subjects (4.1 +/– 0.4 points) [11]. In our study too, 20/27 patients with asthma had a mean sinus CT score of 6.45 ± 4.5. In contrast, the 6/30 (20%) control subjects had isolated maxillary sinus mucosal thickening with a mean sinus score of only 1.1 ± 1.2. In an earlier prospective study on asymptomatic healthy subjects, incidental sinus opacification on CT was observed in 27% subjects [25].

We also showed that the occurrence of sinusitis on CT in patients with asthma without obvious nasal symptoms had a significant impact on the severity of asthma as evidenced by significantly lower FEV1 and FEV1/FVC ratios. A study from France [12] has reported an increased prevalence of radiological sinusitis in patients with severe steroid-dependent asthma as compared to patients with mild-to-moderate asthma. Of the 35 patients with severe steroid-dependent asthma, 74% patients had symptoms of rhinosinusitis as compared to 70% of the patients with mild-to-moderate asthma. However, CT

scanning demonstrated sinusitis in all patients with severe steroid-dependent asthma as compared to 88% in those with mild-to-moderate asthma [12]. Similarly, in patients with asthma and allergic rhinitis, the occurrence of CRS too increased the severity of asthma. Our study highlighted the fact that even though patients with asthma alone did not have symptoms suggestive of sinusitis, their asthma was more severe and they also had a greater impairment in QoL. Although a relatively small number of patients with asthma alone (Group 1) appear to be a limitation in our study, our findings underscore the importance of regular examination of upper airways in asthmatics as co-existent radiological sinusitis or CRS could cause increased morbidity.

The American Lung Association-Asthma Clinical Research Centers while conducting two clinical trials in asthmatic subjects acquired information on self-reported allergic rhinitis, sinusitis and asthma symptoms [26]. They observed significantly higher scores for Asthma Symptom Utility Index and concluded that allergic rhinitis and sinusitis were associated with more severe asthma symptoms. This highlights the high prevalence of sinusitis in patients with bronchial asthma and the importance of sinus disease as an aggravating factor for chronic reactive airway disease. A retrospective review comprising 145 patients with CRS found that the asthma was present in 23.4% of patients with CRS. Coexistent asthma also increased the prevalence of nasal polyps, olfactory dysfunction and nasal congestion in these patients [27]. A more recent retrospective study highlighted that the coexistence of asthma in patients with allergic rhinitis was associated with faster development of CRS [28]. A recent prospective study evaluating the diagnostic

Table 3. Symptom Severity Score.

Symptom Severity Score	Group 1 (<i>n</i> = 27)		Group 2 (<i>n</i> = 58)		Group 3 (<i>n</i> = 131)		Group 4 (<i>n</i> = 30)	
	With radiological sinusitis (<i>n</i> = 20) mean ± SD	Without radiological sinusitis (<i>n</i> = 7) mean ± SD	With CRS (<i>n</i> = 48) mean ± SD	Without CRS (<i>n</i> = 10) mean ± SD	With CRS (<i>n</i> = 88) mean ± SD	Without CRS (<i>n</i> = 43) mean ± SD	With mucosal thickening (<i>n</i> = 6) mean ± SD	Without mucosal thickening (<i>n</i> = 24) mean ± SD
Nasal blockage	1.00 ± 0.00	1.00 ± 0.00	2.18 ± 0.36	1.87 ± 0.34	3.45 ± 0.33	3.30 ± 0.40	1.00 ± 0.00	1.00 ± 0.00
Anterior purulent nasal discharge	1.00 ± 0.00	1.00 ± 0.00	3.90 ± 0.29	3.45 ± 0.45	2.70 ± 0.43	2.50 ± 0.36	1.00 ± 0.00	1.00 ± 0.00
Posterior purulent nasal discharge	1.00 ± 0.00	1.00 ± 0.00	2.16 ± 0.34	2.00 ± 0.13	2.16 ± 0.27	2.00 ± 0.39	1.00 ± 0.00	1.00 ± 0.00
Facial pain / pressure / fullness	1.00 ± 0.00	1.27 ± 0.65	2.04 ± 0.86	1.30 ± 1.14	1.71 ± 0.44	1.41 ± 0.98	1.00 ± 0.00	1.00 ± 0.00
Headache	4.06 ± 0.45	3.56 ± 0.41	1.90 ± 0.96	2.70 ± 1.23	3.5 ± 3.46	2.50 ± 2.48	1.96 ± 0.50	1.67 ± 0.32
Fatigue	3.64 ± 0.26	2.96 ± 0.34	2.16 ± 0.61	2.00 ± 0.34	2.05 ± 0.46	1.93 ± 0.62	1.00 ± 0.00	1.89 ± 0.47
Decreased sense of smell	1.00 ± 0.00	1.00 ± 0.00	2.18 ± 1.98	1.00 ± 0.00	1.75 ± 0.32	1.90 ± 0.49	1.00 ± 0.00	1.00 ± 0.00
Ear pain / pressure / fullness	1.00 ± 0.00	1.00 ± 0.00	1.94 ± 1.86	1.00 ± 0.00	1.27 ± 0.62	1.16 ± 0.20	1.00 ± 0.00	1.00 ± 0.00
Cough	2.47 ± 0.36	1.90 ± 0.31	3.90 ± 1.89	3.50 ± 0.96	2.60 ± 1.45	2.44 ± 1.23	1.00 ± 0.00	1.20 ± 0.50
Halitosis	2.04 ± 0.45	1.30 ± 0.67	1.83 ± 0.65	1.90 ± 0.74	1.32 ± 0.45	1.30 ± 0.44	1.00 ± 0.00	1.19 ± 0.65
Dental pain	1.31 ± 0.25	1.18 ± 0.15	1.00 ± 0.00	1.00 ± 0.00	1.24 ± 0.51	1.18 ± 0.32	1.00 ± 0.00	1.00 ± 0.00
Fever	1.61 ± 0.098	1.18 ± 0.15	1.00 ± 0.00	1.00 ± 0.00	1.23 ± 0.45	1.18 ± 0.32	1.00 ± 0.00	1.00 ± 0.00

NS: Not significant.

Table 4. Scoring of sinusitis (Lund and Kennedy) on computed tomography of paranasal sinuses.

	Group 1	Group 2	Group 3	Group 4	<i>p</i> Value ANOVA (95% CI)	<i>Post-hoc</i> analysis between the groups
Sinusitis on CT-PNS	20/27 (74%)	48/58 (82%)	88/131 (67%)	6/30 (20%)		
Mean sinus score	6.45 ± 4.5	9.5 ± 8.1	5.77 ± 13.6	1.1 ± 1.2	0.0074	1 vs 2 0.02, 1 vs 4 0.0001, 2 vs 4 NS, 3 vs 4 0.003, 2 vs 3 0.047, 1 vs 3 NS
Mean number of sinuses involved	4.8 ± 0.43	5.8 ± 0.33	4.26 ± 0.37	1.00 ± 0.0	<0.001	NS
Mean maxillary sinuses score	1.23 ± 1.32	2.89 ± 1.25	2.5 ± 0.13	1.1 ± 1.2	<0.001	1 vs 2 0.001, 2 vs 3 NS, 1 vs 3, 0.007, 1 vs 4 NS, 2 vs 4 0.009, 3 vs 4 0.03
Mean ethmoid sinuses score	2.5 ± 1.02	3.05 ± 1.54	1.9 ± 0.67	—	<0.001	1 vs 2 NS, 2 vs 3 0.0006, 1 vs 3 0.04
Mean frontal sinuses score	1.0 ± 0.23	2.03 ± 1.84	3.60 ± 2.13	—	<0.001	1 vs 2 0.01, 2 vs 3 0.0041, 1 vs 3 NS
Mean sphenoid sinuses score	1.05 ± 0.5	1.68 ± 0.89	2.6 ± 1.45	—	<0.001	1 vs 2 NS, 2 vs 3 0.005, 1 vs 3 0.001
Mean OMC score	1.75 ± 0.25	1.54 ± 0.3	1.32 ± 0.6	—	<0.001	1 vs 2 NS, 2 vs 3 0.005, 1 vs 3 0.001
Ratio of maxillary sinus score to total score	0.19 ± 0.14	0.30 ± 0.24	0.24 ± 0.18	1.0 ± 1.2	<0.001	1 vs 2 0.02, 2 vs 3 NS, 1 vs 3 0.01, 1 vs 4 0.16, 2 vs 4 NS, 3 vs 4 NS
Ratio of ethmoid sinus score to total score	0.38 ± 0.25	0.64 ± 0.11	0.25 ± 0.9	—	0.002	1 vs 2 NS, 2 vs 3 0.001, 1 vs 3 NS
Ratio of frontal sinus score to total score	0.141 ± 0.01	0.44 ± 0.17	0.12 ± 0.11	—	<0.001	1 vs 2 0.01, 2 vs 3 0.001, 1 vs 3 NS
Ratio of sphenoid sinus score to total score	0.08 ± 0.04	0.23 ± 0.034	0.12 ± 0.012	—	<0.001	1 vs 2 0.001, 2 vs 3 0.003, 1 vs 3 0.05
Ratio of OMC score to total score	0.37 ± 0.55	0.20 ± 0.11	0.19 ± 0.24	—	<0.001	1 vs 2 0.0041, 2 vs 3 NS, 1 vs 3 0.001

NS: Not significant.

value of sinus CT for airway hyperresponsiveness (AHR) concluded that sinus CT was a useful tool for screening of AHR in patients with CRS [29]. In a cross-sectional retrospective study from USA, of the 187 patients with CRS meeting the inclusion criteria, 29 had intermittent/mild asthma, 18 had moderate/severe asthma while rest of them were non-asthmatics. The mean Lund Mackay Score was 9.7 in non-asthmatics, 11.6 in intermittent/mild asthmatics and 15.6 in moderate/severe asthmatics highlighting that with increasing severity of asthma, radiological severity of CRS also increases [14]. The GA²LEN surveyed in Europe to ascertain the prevalence of reported asthma in adults and its association with CRS. Over 52,000 adults in the age group of 18–75 years from 19 centers in 12 countries were included in the study. The authors observed a

strong association of asthma with CRS at all ages. It was also found that this association was stronger in those with both CRS and allergic rhinitis. Furthermore, it was also seen that CRS even alone, in the absence of nasal allergies, was positively associated with late onset asthma [17].

Berrettini and colleagues [30] performed CT-PNS in 40 patients with perennial allergic rhinitis and 30 controls. They observed that 67.5% of patients with allergic rhinitis had sinusitis as compared to 33.4% of controls ($p = 0.017$). Different studies documented the occurrence of CRS in 63–89% of adult patients and around 65% of the children [31] with allergic rhinitis. AR often results in restrictions on the physical, psychological and social aspects of the patients' life and can also impact their functions at work. Coexistent CRS

Table 5. Categorization of patients with allergic rhinitis into “sneezers-runners” and “blockers”.

	Group 2			Group 3		
	“Sneezers-runners”	“Blockers”	<i>p</i> Value	“Sneezers-runners”	“Blockers”	<i>p</i> Value
<i>n</i>	31	27		79	52	
With sinusitis	23	25		41	47	
Without sinusitis	8	2		38	5	
Occurrence of sinusitis in “Sneezers-runners” and “Blockers”	23/31 vs 8/31	25/27 vs 2/27	“Sneezers-runners” ($p = 0.028$) “Blockers” ($p = 0.0001$)	41/79 vs 38/79	47/52 vs 5/52	“Sneezers-runners” ($p = 0.78$) “Blockers” ($p = 0.000$)
“Sneezers-runners” vs “Blockers”	23/31	25/27	NS	41/79	47/52	0.045
Mean sinus score	6.5 ± 2.23	8.23 ± 1.75	0.004	3.9 ± 0.97	4.26 ± 0.32	0.027

NS: Not significant.

often leads to poorer quality of life as revealed by poorer subjective scores in these patients [32]. A recent study from South Korea documented that AR was significantly associated with asthma, CRS and nasal polyps [33]. Our study too highlights that in patients with AR, the occurrence of rhinosinusitis significantly increases nasal symptoms and adversely affects QoL.

CT-PNS has now emerged as the gold standard for the diagnosis of sinusitis [34] with the widespread acceptance of the CT-based quantification for staging sinusitis propounded by Lund and Kennedy [20]. In our study, mean score for severity of sinusitis was significantly higher in patients with asthma and allergic rhinitis (Group 2) with maxillary sinuses being the most commonly involved. However, in patients with asthma (Groups 1 and 2), the mean ethmoid sinuses scores were significantly higher. Dhong and colleagues [35] too found a significantly higher involvement of the ethmoid sinuses in patients with asthma on CT-PNS. They compared the extent of disease in each sinus group quantitatively by means of the ratio of individual sinus to the total sinus score. They then compared sinusitis in asthmatics to sinusitis in patients without asthma. The mean sinus score for ethmoid sinus was 0.421 in asthmatics, while it was 0.323 in non-asthmatic patients. They observed that ethmoid sinuses were more severely involved in those who had associated asthma and they felt that patients with ethmoid sinus involvement should be evaluated for asthma. We too found that the ratio of ethmoid sinus scores to the total sinus scores in Group 1 was 0.38 and in Group 2, it was 0.64, which was significantly higher when compared with Group 3 scores. The predominant involvement of the ethmoid sinus in patients with asthma was also confirmed recently by Adapinar and colleagues [36]. Dhong and colleagues [35] postulated that in the asthmatic subjects, the inhaled allergens trigger the hypersensitized mucosa in the ethmoid sinuses, which could possibly lead to edematous changes. These edematous changes may cause the obstruction of the natural ostium, resulting in secondary sinusitis.

We further categorized patients with allergic rhinitis of both Groups 2 and 3 into “sneezers- runners” and “blockers”. We had earlier shown that, these two groups had distinct clinical profiles and that “blockers” had more persistent symptoms and had significant history of breathlessness [22]. In patients with AR (Groups 2 and 3), CRS was significantly present in both “sneezers-runners” and “blockers” but in patients with AR alone (Group 3), it was significantly more frequent in “blockers” in comparison to “sneezers-runners”. The severity of sinusitis as assessed by the mean sinus CT-PNS score was higher in “blockers” in both groups. The significantly high association of CRS with patients of AR (Group 3), observed in our study, is not surprising.

Our study highlights the importance of recognizing concomitant sinusitis in patients with asthma and allergic rhinitis but it has its own limitations. Skin prick testing is more specific and is the gold standard for diagnosing atopy. Intradermal testing can result in a small number of false-positive reactions possibly due to an irritant effect. This can result in overestimating atopy and possibly higher testing related risks [37]. However, none of the participants in the study had any untoward reaction with intradermal testing. The small sample size in Group 1 also undermines the power of the study.

Conclusions

Our study highlights the significance of the occurrence and impact of radiological sinusitis without nasal symptoms in patients with asthma as well as CRS in those with asthma and/or AR. For a primary care pulmonologist, it is imperative to look for upper airway involvement including sinuses in patients with asthma as it may be responsible for the suboptimal control of the disease. Similarly, in patients with AR, it is essential to exclude CRS and asthma. This could possibly achieve better control of disease translating into reduction in morbidity.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article. The study was supported by Vallabhbhai Patel Chest Institute, University of Delhi, Delhi.

References

1. Brozek JL, Bousquet J, Baena-Cagnani CE, Bonini S, Canónica GW, Cásale TB, van Wijk RG, et al. Allergic Rhinitis and its Impact on Asthma (ARIA) guidelines: 2010 revision. *J Allergy Clin Immunol* 2010;126:466–476.
2. Licari A, Caimmi S, Bosa L, Marseglia A, Marseglia GL, Caimmi D [Editorial]. Rhinosinusitis and asthma: a very long engagement. *Int J Immunopathol Pharmacol* 2014;27:499–508.
3. Bachert C, Pawankar R, Zhang L, Bunnag C, Fokkens WJ, Hamilos DL, Jirapongsananurak O, et al. ICON: chronic rhinosinusitis. *World Allergy Organ J* 2014;7:25.
4. Fokkens WJ, Lund VJ, Mullol J, Bachert C, Alobid I, Baroody F, Cohen N, et al. European position paper on rhinosinusitis and nasal polyps 2012. *Rhinol Suppl* 2012; 23:3 p preceding table of contents; 1–298.
5. Peters AT, Spector S, Hsu J, Hamilos DL, Baroody FM, Chandra RK, Grammer LC, et al. Diagnosis and management of rhinosinusitis: a practice parameter update. *Ann Allergy Asthma Immunol* 2014;113:347–385.
6. Zhang T, Chen J, Zhu C, Li G, Xie C, Wang Y, He Z. [The clinical relationship between allergic rhinitis and allergic factors and chronic rhinosinusitis with or without nasal polyps]. *Lin Chung Er Bi Yan Hou Tou Jing Wai Ke Za Zhi* 2014;28:1278–1281 [Article in Chinese].
7. Eriksson J, Bjerg A, Lötvall J, Wennergren G, Rönmark E, Torén K, Lundbäck B. Rhinitis phenotypes correlate with different symptom presentation and risk factor patterns of asthma. *Respir Med* 2011; 105:1611–1621.
8. Rosenfeld RM, Piccirillo JF, Chandrasekhar SS, Brook I, Ashok Kumar K, Kramper M, Orlandi RR, et al. Clinical practice guideline (update): adult sinusitis. *Otolaryngol Head Neck Surg* 2015;152:S1–S39.
9. Newman LJ, Platts-Mills TA, Phillips CD, Hazen KC, Gross CW. Chronic sinusitis: relationship of computed tomographic findings to allergy, asthma, and eosinophilia. *JAMA* 1994;271:363–367.
10. Ferrante ME, Quatela MM, Corbo GM, Pistelli R, Fusco L, Valente S. Prevalence of sinusitis in young asthmatics and its relation to bronchial asthma. *Mil Med* 1998;163:180–183.
11. Crater SE, Peters EJ, Phillips CD, Platts-Mills TA. Prospective analysis of CT of the sinuses in acute asthma. *AJR Am J Roentgenol* 1999;173:127–131.
12. Bresciani M, Paradis L, Des Roches A, Vernhet H, Vachier I, Godard P, Bousquet J, et al. Rhinosinusitis in severe asthma. *J Allergy Clin Immunol* 2001;107:73–80.
13. ten Brinke A, Grootendorst DC, Schmidt JT, de Bruine FT, van Buchem MA, Sterk PJ, Rabe KF, et al. Chronic sinusitis in severe asthma is related to sputum eosinophilia. *J Allergy Clin Immunol* 2002;109:621–626.
14. Lin DC, Chandra RK, Tan BK, Zirkle W, Conley DB, Grammer LC, Kern RC, et al. Association between severity of asthma and degree of chronic rhinosinusitis. *Am J Rhinol Allergy* 2011;25: 205–208.

15. Ponikau JU, Sherris DA, Kephart GM, Kern EB, Gaffey TA, Tarara JE, Kita H. Features of airway remodeling and eosinophilic inflammation in chronic rhinosinusitis: is the histopathology similar to asthma? *J Allergy Clin Immunol* 2003;112:877–882.
16. Sumino K, O'Brian K, Bartle B, Au DH, Castro M, Lee TA. Coexisting chronic conditions associated with mortality and morbidity in adult patients with asthma. *J Asthma* 2014;51: 306–314.
17. Jarvis D, Newson R, Lotvall J, Hastan D, Tomassen P, Keil T, Gjomarkaj M, et al. Asthma in adults and its association with chronic rhinosinusitis: the GA²LEN survey in Europe. *Allergy* 2012;67:91–98.
18. From the Global Strategy for Asthma Management and Prevention, Global Initiative for Asthma (GINA) 2015. Available from: www.ginasthma.org/.
19. Schwartz HJ, Greenberger PA. The prevalence of allergic bronchopulmonary aspergillosis in patients with asthma, determined by serologic and radiologic criteria in patients at risk. *J Lab Clin Med* 1991;117:138–142.
20. Lund V, Kennedy D. Quantification for staging sinusitis. *Ann Otol Rhinol Laryngol* 1995;167:17–22.
21. Bachert C, van Cauwenberge P, Khaltaev N; World Health Organization. Allergic rhinitis and its impact on asthma. In collaboration with the World Health Organization. Executive summary of the workshop report; 7–10 December 1999; Geneva, Switzerland. *Allergy* 2002;57:841–855.
22. Khanna P, Shah A. Categorization of patients with allergic rhinitis: a comparative profile of “sneezers and runners” and “blockers”. *Ann Allergy Asthma Immunol* 2005;94:60–64.
23. Meltzer EO, Hamilos DL, Hadley JA, Lanza DC, Marple BF, Nicklas RA, Bachert C, et al. Rhinosinusitis: establishing definitions for clinical research and patient care. *J Allergy Clin Immunol* 2004;114:S155–S212.
24. Benninger MS, Senior BA. The development of the Rhinosinusitis Disability Index. *Arch Otolaryngol Head Neck Surg* 1997;123: 1175–1179.
25. Flinn J, Chapman ME, Wightman AJ, Maran AG. A prospective analysis of incidental paranasal sinus abnormalities on CT head scans. *Clin Otolaryngol Allied Sci* 1994;19:287–289.
26. Dixon AE, Kaminsky DA, Holbrook JT, Wise RA, Shade DM, Irvin CG. Allergic rhinitis and sinusitis in asthma: differential effects on symptoms and pulmonary function. *Chest* 2006;130:429–435.
27. Seybt MW, McMains KC, Kountakis SE. The prevalence and effect of asthma on adults with chronic rhinosinusitis. *Ear Nose Throat J* 2007;86:409–411.
28. Sedaghat AR, Gray ST, Chambers KJ, Wilke CO, Caradonna DS. Sinonasal anatomic variants and asthma are associated with faster development of chronic rhinosinusitis in patients with allergic rhinitis. *Int Forum Allergy Rhinol* 2013;3:755–761.
29. Chen F, Luo X, Xu R, Deng J, Zuo K, Li H, Shi J. Evaluation of airway hyperresponsiveness in chronic rhinosinusitis: values of sinus computed tomography. *Ann Allergy Asthma Immunol* 2014; 113:609–613.
30. Berrettini S, Carabelli A, Sellari-Franceschini S, Bruschini L, Abruzzese A, Quartieri F, Sconosciuto F. Perennial allergic rhinitis and chronic rhinosinusitis: correlation with rhinological risk factors. *Allergy* 1999;54:242–248.
31. Mir E, Panjabi C, Shah A. Impact of allergic rhinitis in school going children. *Asia Pac Allergy* 2012;2:93–100.
32. Shah A [Editorial]. Allergic rhinitis, chronic rhinosinusitis and nasal polyposis in Asia Pacific: impact on quality of life and sleep. *Asia Pac Allergy* 2014;4:131–133.
33. Rhee CS, Wee JH, Ahn JC, Lee WH, Tan KL, Ahn S, Lee JH, et al. Prevalence, risk factors and comorbidities of allergic rhinitis in South Korea: The Fifth Korea National Health and Nutrition Examination Survey. *Am J Rhinol Allergy* 2014;28:e107–e114.
34. Bhattacharyya N, Fried MP. The accuracy of computed tomography in the diagnosis of chronic rhinosinusitis. *Laryngoscope* 2003;113: 125–129.
35. Dhong HJ, Kim HY, Chung YJ, Kim TW, Kim JH, Chung SK, Kim MG. Computed tomographic assessment of chronic rhinosinusitis with asthma. *Am J Rhinol* 2006;20:450–452.
36. Adapinar B, Kurt E, Kebapci M, Erginel MS. Computed tomography evaluation of paranasal sinuses in asthma: is there a tendency of particular site involvement? *Allergy Asthma Proc* 2006;27: 504–509.
37. Bernstein IL, Li JT, Bernstein DI, Hamilton R, Spector SL, Tan R, Sicherer S, et al. American Academy of Allergy, Asthma and Immunology; American College of Allergy, Asthma and Immunology. Allergy diagnostic testing: an updated practice parameter. *Ann Allergy Asthma Immunol* 2008;100:S1–S148.