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Original Research Article

Pulmonary Function Test Abnormalities in Adolescent Patients of Allergic Rhinitis and Their Association with Hematological Parameters

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Abstract:

Background: Allergic rhinitis is an IgE-mediated inflammatory disorder of the upper airway; however, the unified airway concept indicates that lower airway involvement may occur even before clinically apparent asthma. Pulmonary function abnormalities and their relationship with inflammatory markers may help identify adolescents at risk.

Objective: To assess pulmonary function test abnormalities in adolescent patients of allergic rhinitis and evaluate their association with selected hematological and immunological parameters.

Methods: This observational cross-sectional study included 30 adolescents with allergic rhinitis aged 10-18 years. Baseline demographic variables were recorded. Spirometry was performed using a computerized spirometer. Among allergic rhinitis cases, pulmonary function abnormalities were classified using standard cut-offs: reduced FEV1 <80% predicted, obstructive pattern as FEV1/FVC <0.70, and reduced FEF25-75% <65% predicted. Hematological and immunological parameters including AEC, NLR, PLR and serum IgE were assessed. Pearson correlation was used to evaluate associations between pulmonary functions and inflammatory markers.

Results: Reduced FEV1 was observed in 13.6% of mild and 25.0% of moderate-severe allergic rhinitis cases. No subject showed FEV1/FVC <0.70. Reduced FEF25-75% was more frequent in moderate-severe allergic rhinitis (62.5%) than mild allergic rhinitis (13.6%). No significant changes were observed in pulmonary functions between Mild and Moderate-Severe Allergic rhinitis groups. Mild grade eosinophilia was observed in cases along with significant increase in Total IgE in Moderate- Severe group as compared to Mild group. Correlation analysis showed predominantly weak and statistically non-significant associations between IgE, AEC, NLR and pulmonary function parameters. PLR showed a moderate negative correlation with FVC ($r = -0.372$, $p = 0.043$).

Conclusion: Adolescent patients with allergic rhinitis showed pulmonary function abnormalities predominantly involving small airway function. Reduced FEF25-75% was more frequent in moderate-severe disease. Hematological parameters showed limited association with spirometric impairment, except for a significant negative correlation between PLR and FVC.

Keywords: Allergic rhinitis; Adolescents; Spirometry; Pulmonary function abnormalities; FEF25-75% (Forced expiratory flow 25-75%); FEV1 (Foeced expiratory volume 1), FVC (Forced vital capacity) Absolute eosinophil count; (AEC) Serum IgE; Neutrophil-lymphocyte ratio (NLR); Platelet-lymphocyte ratio (PLR).

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Introduction

Allergic rhinitis is a chronic IgE-mediated inflammatory disorder characterized by sneezing, rhinorrhoea, nasal obstruction and nasal itching. Although the dominant symptoms arise from the nasal mucosa, allergic rhinitis is now recognized as a component of systemic allergic airway disease rather than an isolated upper airway disorder. [1,2]

The unified airway concept explains the close anatomical, immunological and functional relationship between the upper and lower respiratory tract. Allergic inflammation in the nasal mucosa may influence bronchial function through circulating inflammatory mediators, neural reflexes and bronchial hyperresponsiveness. Therefore, lower airway involvement may exist in adolescents with allergic rhinitis even in the absence of clinically diagnosed asthma. [3-6]

Spirometry provides a non-invasive method for identifying functional airway impairment. Conventional parameters such as FEV1, FVC and FEV1/FVC are useful for detecting airflow limitation, while FEF25-75% is considered particularly relevant for small airway dysfunction. Small airway abnormalities may precede overt obstructive spirometric defects and may therefore serve as an early physiological marker. [7-10]

Allergic rhinitis is also associated with systemic inflammatory and immunological activation. Markers such as absolute eosinophil count, serum IgE, neutrophil-lymphocyte ratio and platelet-lymphocyte ratio may reflect the inflammatory burden [11-18]. The present study was undertaken to assess pulmonary function test abnormalities among adolescents with allergic rhinitis and to evaluate their association with selected hematological and immunological parameters.

Materials and Methods

Study Design and Setting: This was an observational, cross-sectional study conducted in the Upgraded Department of Physiology and the Allergy Clinic of Sawai Man Singh Hospital/SMS Medical College, Jaipur.

Study Participants: The study included 30 adolescents diagnosed with allergic rhinitis aged 10-18 years. Convenient sampling was used for recruitment of cases from the allergy clinic and were further divided into mild and moderate-severe groups as per ARIA guidelines 2008. [1]. Written informed consent from parents/guardians and assent from adolescent participants were obtained. The study was conducted after clearance from institutional Ethical and Scientific committee.

Eligibility Criteria: Cases were adolescents already diagnosed with allergic rhinitis and cooperative for spirometry. Subjects with acute or chronic systemic illness, smoking or tobacco exposure, alcohol use or intake of medicines affecting pulmonary function or hematological parameters were excluded.

Plan of Action: Before performing spirometry, Relevant history was taken and physical examination including measurement of anthropometric parameters were done as per standard procedure. Body mass index (BMI) was calculated as per the standard formulae-Weight (Kg)/Height ^{2} (m2).

Pulmonary function testing and abnormality classification: Spirometry was performed using a computerized Helios 401 spirometer with Spiro Excel software. Height and weight were entered for predicted values. After demonstration and practice, at least three acceptable and reproducible maneuvers were recorded in sitting position with a nose clip; the best technically acceptable reading was used for analysis. Reduced FEV1 (Forced expiratory volume 1) was defined as FEV1 <80% and >60% of predicted, Obstructive airway disease pattern as FEV1/FVC <0.70, and reduced FEF25-75% as <65% of predicted. [9,10]

Hematological and immunological assessment: Venous blood samples were collected under aseptic precautions. Complete blood count was used to derive hemoglobin, total leukocyte count, platelet count, eosinophil percentage and absolute eosinophil count. Based on the absolute eosinophil count, the subjects were categorized to No eosinophilia, Mild, moderate and severe eosionophilia groups. [19] Neutrophil-lymphocyte ratio and platelet-lymphocyte ratio were calculated from differential leukocyte and platelet counts. [14-16]. Total serum IgE was estimated using an immunoassay-based method in the central laboratory.

Statistical Analysis: Data were entered in Microsoft Excel and analyzed using SPSS version 27.0. Continuous variables were expressed as mean ± SD. Categorical variables were expressed as number and percentage. Between-group comparisons were performed using unpaired Student's t-test or Pearson chi-square/Fisher exact test, as appropriate. Pearson correlation coefficient was used to assess associations between inflammatory markers and pulmonary function parameters. A p value <0.05 was considered statistically significant.

Results

Out of total 30 cases of allergic rhinitis,22 cases (73.3 %) belong to mild grade and 8 (26.67%) cases belong to Moderate-severe group.

Table 1. Baseline characteristics of study participants

Variable	Mild AR (n=22) Mean ± SD	Moderate-severe AR (n=8) Mean ± SD	p value
Age (years)	15.95 ± 1.76	16.25 ± 1.49	0.676
Height (cm)	149.30 ± 7.90	154.70 ± 7.52	0.105
Weight (kg)	48.60 ± 8.21	52.94 ± 7.56	0.202
BMI (kg/m²)	21.86 ± 3.85	22.07 ± 2.22	0.888

Table 2: Distribution of Cases based on Symptoms of Allergic Rhinitis among cases

Symptom	Number of Cases	Percentage
H/O episodes of Breathlessness in past history	16	53.33
Sneezing in past history	30	100
Rhinorrhea in past history	30	100
Nasal obstruction in past history	19	63.33
Itching in past history	15	50.0
Eye symptoms in past history	8	26.67

Table 3: Distribution of pulmonary function abnormalities according to severity of allergic rhinitis

Pulmonary function abnormality	Mild AR (n=22)	Moderate-severe AR (n=8)	p value
Reduced FEV1 (<80%, >60% predicted)	3 (13.6%)	2 (25.0%)	0.589
FEV1/FVC <0.70	0 (0%)	0 (0%)	NA
Reduced FEF25-75% (<65% predicted)	3 (13.6%)	5 (62.5%)	0.02

Pulmonary function abnormalities were observed in both mild and moderate-severe allergic rhinitis. No patient demonstrated an FEV1/FVC ratio below 0.70. Reduced FEF25-75%, suggestive of small airway dysfunction, was more frequent in moderate-severe allergic rhinitis than mild allergic rhinitis.

Table 4: Comparison of PFT Parameters between Mild and Moderate- severe Allergic Rhinitis Patients

Parameter	Mild (Mean±SD)	Moderate-Severe (Mean±SD)	P value
FEV1 (L)	2.35 ± 0.28	2.55 ± 0.31	0.098
FVC (L)	2.83 ± 0.39	3.04 ± 0.40	0.212
FEV1/FVC (%)	83.31 ± 6.13	84.29 ± 5.85	0.699
FEF25-75 (L/s)	2.84 ± 0.58	2.60 ± 0.57	0.33
PEFR (L/min)	356.41 ± 72.40	356.00 ± 41.95	0.988

Table 5: Distribution of Eosinophilia Severity according to Clinical Severity of Allergic Rhinitis

Eosinophilia Category (AEC)	Mild AR Cases n (%)	Moderate–Severe AR Cases n (%)	Total n (%)
No eosinophilia (<500)	8 (26.7%)	0 (0%)	8 (26.7%)
Mild eosinophilia (500–1500)	14 (46.7%)	8 (26.7%)	22 (73.3%)
Moderate eosinophilia (1500–5000)	0 (0%)	0 (0%)	0 (0%)
Severe eosinophilia (>5000)	0 (0%)	0 (0%)	0 (0%)
Total	22 (73.3%)	8 (26.7%)	30 (100%)

Table 6: Serum IgE Levels according to Clinical Severity of Allergic Rhinitis

Group	Mean IgE (IU/mL)	Std. Deviation	P-value
Mild	566.9	176.5	0.048
Moderate–Severe	932.2	474.3	

Table 7: Correlation between hematological/immunological markers and pulmonary function parameters among allergic rhinitis cases

Marker	FEV1 (r, p)	FVC (r, p)	FEV1/FVC (r, p)	PEFR (r, p)	FEF25-75% (r, p)
IgE (IU/mL)	-0.006, 0.974	0.124, 0.513	-0.287, 0.125	0.041, 0.831	-0.185, 0.328
AEC (cells/µL)	0.093, 0.626	0.144, 0.448	-0.164, 0.388	0.032, 0.867	-0.176, 0.353
NLR	-0.199, 0.293	-0.288, 0.122	0.234, 0.213	0.184, 0.331	0.214, 0.257
PLR	-0.297, 0.112	-0.372, 0.043	0.229, 0.223	0.007, 0.971	0.209, 0.267

Discussion

The present study assessed pulmonary function test abnormalities among adolescents with allergic rhinitis and examined their association with selected hematological and immunological markers. The study groups were comparable for age, weight, height and BMI; (Table 1) therefore, demographic and anthropometric confounding was minimized.

Table 2 shows in addition to core symptoms of allergic rhinitis (Sneezing, Rhinorrhoea), 16 (53.33%) cases have past history of episodes of breathlessness ,15 (50%) have history of Itching and 8 (26.67%) have history of conjunctivitis. These findings suggest that subjects with allergic rhinitis presents with other systemic symptoms other than upper respiratory tract involvement.

The main physiological abnormality observed among allergic rhinitis cases was reduced FEF25-75%, (Table 3) particularly among moderate-severe cases. This finding is important because FEF25-75% reflects mid-expiratory flow and is considered a sensitive indicator of small airway dysfunction. The absence of FEV1/FVC <0.70 in all cases indicates that the abnormalities were not in the range of established spirometric obstruction but rather represented subclinical small airway involvement. [7-10]. Reduced FEV1 (<80% predicted) along with reduced FEF25-75%, suggest air trapping in small airways in their early involvement before overt obstructive airway pattern develops (FEV1/FVC <0.70). Similar findings of impaired FEF 25-75% and FEV1 <80% in patients of Allergic rhinitis were also reported by Abinayaah et al.2020 [20]

The findings are consistent with the unified airway concept. Allergic rhinitis and asthma are not completely separate disorders; rather, they represent related manifestations of allergic airway inflammation. Inflammation originating in the nasal mucosa may influence the lower airway through eosinophilic activation, circulating cytokines, inflammatory mediators and bronchial hyperresponsiveness. Thus, abnormal FEF25-75% in allergic rhinitis may represent early lower airway involvement before clinically overt asthma develops. [3-6] Pulmonary function abnormality was not limited to moderate-severe allergic rhinitis. A proportion of mild cases also showed reduced FEV1 and reduced FEF25-75%.

Table 4 shows that there was no significant difference between pulmonary function assessed by spirometry between Mild and Moderate-severe allergic rhinitis group. Ciprandi et al. 2004 in their study found that bronchial involvement in allergic rhinitis can occur irrespective of clinical severity, indicating that even subjects with mild symptoms can exhibit airway dysfunction [21]. Braunstahl and Hellings 2003 also found that allergic rhinitis and asthma share a systemic airway link,however, the factors determining progression from upper airway allergy to measurable lower airway dysfunction are complex and not uniform in all patients [3]. The grading of severity of Allergic rhinitis as per ARIA guidelines 2008 is predominantly symptom based and does not include any objective parameters [1]. This suggests that clinical severity based on nasal symptoms may not always parallel lower airway status.

Table 5 shows that no study subject have moderate or severe eosinophilia, whereas mild eosinophilia was found in majority of cases (22 cases -73.3%) suggesting that mild eosinophilic inflammation due to type 1 hypersensitivity was associated with allergic rhinitis. Gowthami M. R 2021 et al (22) and Chandana C.,et al [23] in their studies demonstrated increased eosinophil count in cases of allergic rhinitis with more eosinophil count in moderate-severe allergic rhinitis group**.**

There was a significant increase in Total IgE levels in subjects having mild allergic rhinitis as compared to moderate-severe allergic rhinitis group (Table 6) suggesting a role of type 1 hypersensitivity reaction with severity of allergic rhinitis. Sharma .M et al.(2018) found significantly increased total IgE levels in allergic rhinitis cases [18]. Awan et al. (2021) also found a significantly increased levels of mean serum IgE in moderate–severe group than mild group of allergic rhinitis subjects. [24]

The correlation analysis showed weak and inconsistent relationships between IgE, AEC, NLR, PLR and pulmonary function parameters. IgE and AEC showed weak negative trends with FEV1/FVC and FEF25-75%, but these correlations were not statistically significant. Mahesh et al.2026 in their study concluded that total IgE was only linked to allergen sensitization and total IgE and AEC are not linked to lung functions suggesting that systemic atopic or eosinophilic burden alone may not directly predict the magnitude of impairment in lung function tests in adolescent with allergic rhinitis. [11,17,18,25]

Among the evaluated hematological indices, PLR showed a statistically significant moderate negative correlation with FVC. Platelets can participate in inflammatory pathways through interaction with leukocytes and release of inflammatory mediators, while PLR has been described as a simple marker of systemic inflammation. However, because other correlations of PLR were weak and non-significant, this isolated association should be interpreted cautiously and requires confirmation in larger studies. [12-16]

Overall, the findings indicate that pulmonary function abnormalities in adolescent allergic rhinitis are mainly subclinical and small-airway predominant. Hematological markers reflect systemic inflammatory status, but their relationship with spirometric impairment appears limited in this sample. The progression of allergic rhinitis to lower airway obstructive airway disease is multi factorial and does not correlate with hematological and immunological parameters.

Conclusion

Adolescent patients with allergic rhinitis showed pulmonary function abnormalities predominantly involving small airway function. Reduced FEF25-75% was more frequent in moderate-severe allergic rhinitis than mild allergic rhinitis, while no case demonstrated FEV1/FVC <0.70. Correlations between hematological/immunological markers and pulmonary function parameters were mostly weak and non-significant, except for a significant negative correlation between PLR and FVC. These findings

support the role of spirometry, especially FEF25-75%, in detecting subclinical lower airway involvement in allergic rhinitis.

Limitations

The sample size was modest and derived from a single tertiary care setting.

The number of moderate-severe allergic rhinitis cases was small.

The cross-sectional design does not establish temporal progression to asthma.

Bronchial provocation testing and post-bronchodilator reversibility assessment were not included.

Allergen-specific IgE and longitudinal inflammatory marker follow-up were not evaluated.

Declarations

Ethics Approval: The study was conducted after approval from the Institutional Research Review Board and Institutional Ethics Committee, SMS Medical College, Jaipur. (1166/MC/EC/2024 dated 24/10/2024)

Consent to Participate: Written informed consent was obtained from parents/guardians, and assent was obtained from adolescent participants.

Funding: No external funding was received for this study.

Conflict of interest: The authors declare no conflict of interest.

Data availability: Data are available from the corresponding author on reasonable request, subject to institutional and ethical restrictions.

Author contributions: Dr. Manindra Singh: concept execution, data collection, analysis and manuscript drafting. Dr.Nidhi Gupta helped in devising research protocol. Dr. Hemant Tahilramani helped in clinical analysis of data. Dr. Kapil Gupta: supervision, conceptual guidance and critical revision. All authors approved the final manuscript draft.

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