British Journal of Hospital Medicine

Br. J. Hosp. Med. (Lond) **2026**; 87(1): 50388
https://doi.org/10.31083/BJHM50388

Article

Impacts of the Severity of Allergic Rhinitis on Inflammatory Characteristics, Nasal Function, Anxiety and Depression

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Academic Editor: John Alcolado
Submitted: 19 August 2025 Revised: 13 October 2025 Accepted: 30 October 2025 Published: 26 January 2026

Abstract

Aims/Background: Allergic rhinitis (AR) is an upper respiratory disease that affects inflammation levels, nasal function, and mental health in patients. However, the effect of AR severity on these indicators remains obscure. This study aimed to explore the impacts of AR severity on levels of inflammatory factors, nasal function, anxiety and depression. **Methods**: The clinical data of 188 patients with AR from January 2022 to January 2025 were collected and retrospectively analyzed. The patients were divided into mild group (n = 90) and moderate/severe group (n = 98) based on the severity of AR. Meanwhile, 79 healthy individuals matched in age, gender, and body mass index (BMI) with the AR patients were included in the control group. Nasal airway resistance (NAR) and nasal mucociliary clearance time (NMCT) were detected. Hospital Anxiety and Depression (HAD) scale was applied for the assessment of anxiety and depression. Serum level of C-reactive protein (CRP) was measured using an automatic biochemical analyzer. Serum procalcitonin (PCT) and nasal lavage fluid levels of interleukin-1β (IL-1β) and tumor necrosis factor-α (TNF-α) were measured using commercial assay kits. **Results**: Compared with the control group, the CRP, PCT, IL-1β, TNF-α, NAR, NMCT, and HAD anxiety and depression scores in AR patients were significantly increased (both $p < 0.05$). Compared with the mild group, the moderate/severe group exhibited increased levels of inflammatory biomarkers, NAR, NMCT, and HAD anxiety and depression scores ($p < 0.05$). In the mild group, anxiety and depression were correlated with the NAR, CRP, PCT, IL-1β, and TNF-α ($p < 0.05$); NMCT was correlated with the depression ($p < 0.05$). In moderate/severe group, anxiety and depression were correlated with the NAR, NMCT, CRP, PCT, IL-1β, and TNF-α ($p < 0.05$). The correlation between anxiety and depression and nasal function and inflammatory factors in moderate/severe group were stronger than those in mild group. **Conclusion**: The anxiety/depression and inflammation levels in AR patients increase, while the nasal function decreases, with the deteriorating severity of the disease. Anxiety and depression are correlated with nasal function and inflammation levels, with a more prominent correlation detected in patients with moderate/severe AR than those with mild disease.

Keywords: allergic rhinitis; inflammatory; nasal function; anxiety; depression

1. Introduction

Allergic rhinitis (AR) is a common chronic upper respiratory disease characterized by chronic inflammation of the nasal mucosa [1]. In China, approximately 250 million people suffer from AR, with an incidence rate in adults of approximately 18.6%–52.9% in northern China [2]. The clinical features of AR include sneezing, watery nasal discharge, nasal congestion, and nasal itching. The diagnosis of AR is based on the clinical symptoms, medical history, and results of allergen testing (such as serum-specific immunoglobulin E [sIgE] measurements and skin prick tests) [1]. The existing diagnostic methods for AR are limited by their invasiveness, relatively high false-positive rates in the outcomes, and high costs, especially in sIgE detection. The clinical managements of AR mainly lie in preventive (e.g., blocking exposure to allergens) and pharmacological approaches [3,4].

Inflammation is a key mechanism underlying the pathogenesis of AR. Allergens stimulate the nasal mucosa, activate inflammatory cells, inducing the generation and release of inflammatory mediators, such as histamine and leukotrienes. These inflammatory mediators act on the blood vessels of the nasal mucosa, causing vasodilation and increased permeability, which lead to congestion and swelling of the nasal mucosa. They also stimulate sensory nerve endings in the nasal mucosa, causing nasal discomfort [5–7]. Previous study reported that the serum level of interleukin-17A (IL-17A) was significantly correlated with severity of AR [8]. In addition, the neutrophil-to-lymphocyte ratio in patients with moderate/severe AR was higher compared to those with mild AR [9]. However, these studies examined a limited number of inflammatory markers, leaving the changes in other inflammatory indicators across different severities of AR insufficiently delineated.

The nasal cavity is a key part of the respiratory tract. Patients with AR face impaired nasal function and experience complete or partial nasal obstruction, which reduces airflow through the nasal passages. This obstruction neces-

sitates compensatory mouth breathing, either partially or completely, which may further augment the risk of bronchospasm [10]. In addition, the nasal cilia play an important role in dust and pathogen clearance, serving as a critical defense mechanism for maintaining respiratory health. In AR patients, however, nasal ciliary clearance function is reduced due to a decrease in ciliary number, structural defects, among other reasons [11]. It has been reported that children with moderate/severe AR had much lower nasal mucociliary clearance compared with their mild disease counterparts [12]. Nevertheless, it is still unclear how nasal function changes across varying levels of AR severity in adult patients.

The clinical manifestations of AR include sneezing, watery nasal discharge, nasal congestion, and nasal itching. These symptoms have a profound impact on the patients' daily functioning, social interactions, and sleep, markedly diminishing their quality of life and influencing their psychological emotions [13]. A study has reported that the severity and duration of AR could affect mental health and were positively correlated with anxiety and depression occurring in the patients [14]. While previous studies have assessed alterations in anxiety, depression, inflammation levels, and nasal function in AR of varying severity, most studies focused on investigating each of the aforementioned aspects in isolation, without attempting to explore the relationship between physiological abnormalities and psychological health. Interestingly, the association of anxiety and depression with inflammation is well-recognized [15,16]. Inflammation has been shown to influence anxiety and depression in patients with asthma [17]. However, it remains unclear whether anxiety and depression are affected by inflammation and nasal function in AR patients, and whether these effects vary with disease severity.

Thus, addressing these knowledge gaps may help enhance clinical screening and enable early mental health intervention for AR patients. This study aimed to explore the effects of varying AR severity levels on inflammatory markers, nasal function, anxiety and depression. In this retrospective study, changes in inflammatory markers, nasal function, anxiety and depression in both mild and moderate/severe AR patients were investigated. In addition, the correlation of anxiety and depression with inflammatory markers and nasal function in AR patients was explored. The findings of the current study will facilitate the development of personalized treatment and enhance the diagnosis and treatment of psychological conditions in AR.

2. Methods

2.1 Patients and Grouping

The information of patients with AR who visited The Second Affiliated Hospital of Heilongjiang University of Chinese Medicine from January 2022 to January 2025 was collected for retrospective analysis. A total of 188 patients were included. The inclusion criteria are as follows: (1) patients meeting the diagnostic criteria for AR [18], including presentation of clinical symptoms (sneezing, watery nasal discharge, nasal congestion, and nasal itching), and positive skin prick test or positive sIgE result; (2) patients with persistent AR, marked by presentation of clinical symptoms lasting for $>$4 days per week and $>$4 weeks per year; (3) patients aged $>$18 years old; and (4) patients with complete clinical data. The exclusion criteria are as follows: (1) individuals suffering from other chronic inflammatory airway conditions, including chronic obstructive pulmonary disease, asthma, bronchitis; (2) patients with abnormal heart and lung function; (3) pregnant women; (4) patients suffering from psychiatric disorders, such as schizophrenia, hallucination, and cognitive impairment; (5) patients diagnosed with other comorbid systemic immune diseases; (6) patients with a history of nasal surgery; (7) patients with other nasal diseases, including nasal septum deviation, nasal turbinate hypertrophy, and sinus malformation; and (8) patients receiving treatment with immunosuppressants or glucocorticoids, or taking psychiatric medications within the past 6 months.

The severity of AR was assessed according to the total nasal symptom score (TNSS). Specifically, the nasal symptoms (sneezing, watery nasal discharge, nasal congestion, and nasal itching) were scored using a 4-point Likert scale: 0 (no symptoms); 1 (mild symptoms, easy to tolerate); 2 (obvious symptoms, but still tolerable); 3 (unbearable symptoms, affecting daily activities or sleep). The total scores of four nasal symptoms were calculated. A total TNSS score $\geq$6 points was regarded as moderate/severe, whereas a score $<$6 points was considered mild [12,19]. All AR patients were divided into two groups according to the AR severity: mild group (n = 90) and moderate/severe group (n = 98).

In addition, healthy individuals who attended the same hospital for routine physical examination were included in the control group (n = 79). The age, gender and body mass index (BMI) of these healthy individuals were matched with those of the AR patients. All subjects in the control groups were confirmed negative for AR based on their medical history and clinical examination findings. A set of exclusion criteria were applied in the selection of subjects assigned to the control group: (1) presence of other allergic diseases and immunodeficiency diseases; (2) presence of diabetes and thyroid disease; (3) presence of other respiratory inflammatory diseases, such as asthma and tracheitis; and (4) a history of upper and lower respiratory tract surgery. Fig. 1 shows the flowchart of patient selection.

2.2 Nasal Function

A nasal resistance measurement device (zk-nr-100c, Anhui Zhongke Medical Devices Co., Ltd., Hefei, China) was applied to detect nasal airway resistance (NAR). Nasal mucociliary clearance time (NMCT) was assessed using saccharin test. Specifically, after clearing the nasal se-

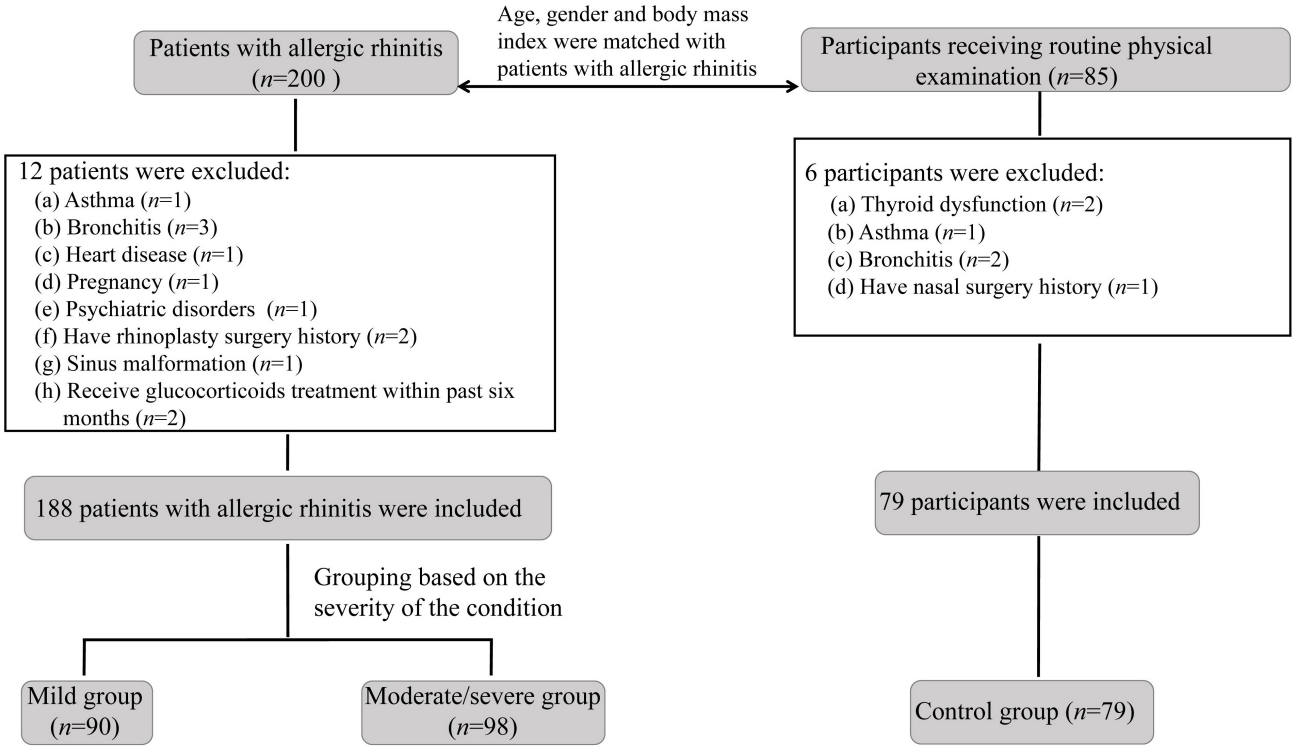

Fig. 1. Flowchart of patient selection for this study.

cretions, a saccharin particle was placed on the posterior surface of the nasal turbinates of each subject. The subjects were instructed to swallow once every 30 s. The time needed for the subject to perceive a sweet taste was recorded. NAR and NMCT measurements were obtained from routine clinical records and were performed by trained physicians according to a standardized protocol at our hospital.

2.3 Assessment of Anxiety and Depression

Hospital Anxiety and Depression (HAD) scale was applied for the assessment of anxiety and depression [20]. The HAD scale contains 14 items. Each item has a score range from 0 (no symptomatic) to 3 (severe symptoms). Seven items of the scale are used to measure anxiety severity (0–21 points), whereas the remaining seven items are oriented for measurement of depression severity (0–21 points). The total scores for anxiety and depression were calculated, with 0–7 indicating normal, 8–10 possible anxiety or depression, and 11–21 clinical levels of anxiety and depression.

2.4 Detection of Inflammatory Indicators

Fasting venous blood was collected from every patient in the morning after having fasted for 12 hours. The serum C-reactive protein (CRP) level was detected using an automatic biochemical analyzer (BC-5390CRP, Mindray Medical, Shenzhen, China). Serum procalcitonin (PCT) levels were detected using commercial kits (H151-1-2, Nanjing Jiancheng Bioengineering Institute, Nanjing, China). Given the alternation of inflammatory factors were sensitive in nasal mucosa of patients with allergic rhinitis, the levels of interleukin-1β (IL-1β) and tumor necrosis factor-α (TNF-α) in nasal lavage fluid were measured. Specifically, 10 mL sterile normal saline was injected into the subjects' nasal cavity using a syringe. The nasal lavage was collected and centrifuged (4 ℃, 1200×g, 10 min). The supernatant was collected for the analysis. The IL-1β and TNF-α levels were measured using kits (H002-1-2 [IL-1β], H052-1-2 [TNF-α], Nanjing Jiancheng Bioengineering Institute, Nanjing, China). The collection and processing of samples were all completed by trained physicians and laboratory personnel following standardized procedures.

2.5 Statistical Analysis

SPSS 27.0 (IBM Corp., Armonk, NY, USA) was applied for statistical analysis. The Shapiro–Wilk test was employed to assess the normality of data distribution. One-way analysis of variance (ANOVA) with Tukey's post hoc test was used for the inter-group comparisons of normally distributed data, which are expressed as mean $\pm$ standard deviation (SD). The Kruskal–Wallis test with Dunn's post hoc test was used for analyzing non-normal data, which are expressed as median and quartiles. The Chi-square test and Fisher's exact test were used for comparing data of categorical variables, which are presented as frequency or rate. Spearman correlation analysis was employed to explore the correlation of the tested variables with depression and anxiety. $p < 0.05$ was considered statistically significant.

Table 1. Comparison of general information among three groups.

General information	Control group (n = 79)	Mild group (n = 90)	Moderate/severe group (n = 98)	F/H/χ^2	p
Age (years)	45.05 ± 7.79	44.43 ± 8.68	44.97 ± 7.77	0.153	0.858
Gender (n, %)				1.798	0.408
Female	41 (51.90%)	38 (42.22%)	43 (43.88%)		
Male	38 (48.10%)	52 (57.78%)	55 (56.12%)		
BMI (kg/m^2)	23.75 (21.14, 26.07)	22.85 (20.90, 25.40)	22.68 (20.19, 24.74)	3.549	0.170
Smoking history (n, %)				3.592	0.166
Yes	27 (34.18%)	25 (27.78%)	21 (21.43%)		
No	52 (65.82%)	65 (72.22%)	77 (78.57%)		
Drinking history (n, %)				2.415	0.299
Yes	28 (35.44%)	24 (26.67%)	25 (25.51%)		
No	51 (64.56%)	66 (73.33%)	73 (74.49%)		

Abbreviation: BMI, body mass index.

Table 2. Comparison of inflammatory indicators among the three subject groups.

Inflammatory indicators	Control group (n = 79)	Mild group (n = 90)	Moderate/severe group (n = 98)	F/H	p
CRP (mg/L)	6.25 ± 1.23	7.92 ± 1.56*	10.41 ± 2.38*$^{\&}$	116.596	<0.001
PCT (ng/mL)	0.03 (0.02, 0.04)	0.04 (0.03, 0.05)*	0.06 (0.05, 0.07)*$^{\&}$	104.052	<0.001
IL-1β (pg/mL)	4.45 ± 1.25	12.17 ± 3.44*	29.34 ± 4.12*$^{\&}$	1370.216	<0.001
TNF-α (pg/mL)	34.33 ± 8.89	74.55 ± 17.75*	113.10 ± 27.80*$^{\&}$	328.979	<0.001

Note: *$p < 0.05$ compared with the control group, $^{\&}p < 0.05$ compared with the mild group.

Abbreviations: CRP, C-reactive protein; IL-1β, interleukin-1 beta; PCT, procalcitonin; TNF-α, tumor necrosis factor alpha.

3. Results

3.1 General Information of Patients

The general information of AR patients is displayed in Table 1. There was no significant difference in general information among three groups ($p > 0.05$).

3.2 Comparison of Inflammatory Indicators

There were significant differences in inflammatory indicators among the three subject groups ($p < 0.001$). Compared with the control group, the AR patients exhibited significantly increased levels of CRP, PCT, IL-1β and TNF-α ($p < 0.05$). Within the AR subjects, the mild group had lower levels of these inflammatory indicators compared to the moderate/severe group ($p < 0.05$) (Table 2).

3.3 Comparison of Nasal Function

The NAR and NMCT in the control group were lower than those in the AR patients ($p < 0.05$). Compared with the mild group, the moderate/severe group showed higher NAR and NMCT ($p < 0.05$) (Table 3).

Table 3. Comparison of nasal function among the three subject groups.

Group	NAR (Pa/cm^3/s)	NMCT (min)
Control group (n = 79)	0.30 ± 0.08	8.50 ± 1.10
Mild group (n = 90)	0.66 ± 0.14*	11.02 ± 1.64*
Moderate/severe group (n = 98)	0.79 ± 0.18*$^{\&}$	14.57 ± 2.28*$^{\&}$
F	268.867	260.500
p	<0.001	<0.001

Note: *$p < 0.05$ compared with the control group, $^{\&}p < 0.05$ compared with the mild group.

Abbreviations: NAR, nasal airway resistance; NMCT, nasal mucociliary clearance time.

3.4 Comparison of Anxiety and Depression

There were significant differences in anxiety, depression, the number of clinical anxiety and depression among three groups ($p < 0.001$, <0.001, <0.001, 0.001). Compared with the control group, the anxiety and depression scores in AR patients were significantly increased ($p < 0.05$). The anxiety and depression scores in the mild group were lower than these in the moderate/severe group ($p < 0.05$). The number of clinical anxiety and depression cases in the moderate/severe group were higher than those in the mild group (16.33% and 12.24% vs. 13.33% and 11.11%) (Table 4).

3.5 Correlations of Inflammation- and Nasal Function-Related Indicators With Anxiety and Depression in AR Patients

In the mild group, anxiety and depression were correlated with the NAR (r = 0.334 and 0.442; p = 0.001 and <0.001), CRP (r = 0.476 and 0.458; both $p < 0.001$), PCT (r = 0.234 and 0.234; p = 0.027 and 0.026), IL-1β (r = 0.356 and 0.449; p = 0.001 and <0.001), and TNF-α (r = 0.493 and 0.395; both $p < 0.001$). NMCT was correlated with the depression in mild AR patients (r = 0.242, p = 0.022) (Table 5).

Table 4. Comparison of anxiety and depression among the three subject groups.

HAD	Control group (n = 79)	Mild group (n = 90)	Moderate/severe group (n = 98)	H/χ^2	p
Anxiety	3 (2, 4)	7 (5, 8)*	8 (6, 10)*&	125.899	<0.001
Depression	4 (2, 5)	6 (3, 9)*	7 (6, 9)*&	78.994	<0.001
Number of clinical anxiety cases (n, %)	0 (0)	12 (13.33%)	16 (16.33%)	/	<0.001
Number of clinical depression cases (n, %)	0 (0)	10 (11.11%)	12 (12.24%)	/	0.001

Note: Clinical depression is defined as a HAD depression score $\geq$11, whereas clinical anxiety is defined a HAD anxiety score $\geq$11. *$p < 0.05$ compared with the control group, &$p < 0.05$ compared with the mild group.
Abbreviation: HAD, Hospital Anxiety and Depression.

Table 5. Correlations of inflammation- and nasal function-related indicators with anxiety and depression in the mild group (n = 90).

	Anxiety		Depression	
	r	p	r	p
NAR	0.334	0.001	0.442	<0.001
NMCT	0.119	0.264	0.242	0.022
CRP	0.476	<0.001	0.458	<0.001
PCT	0.234	0.027	0.234	0.026
IL-1β	0.356	0.001	0.449	<0.001
TNF-α	0.493	<0.001	0.395	<0.001

Abbreviations: CRP, C-reactive protein; IL-1β, interleukin-1 beta; NAR, nasal airway resistance; NMCT, nasal mucociliary clearance time; PCT, procalcitonin; TNF-α, tumor necrosis factor alpha.

Table 6. Correlations of inflammation- and nasal function-related indicators with anxiety and depression in the moderate/severe group (n = 98).

	Anxiety		Depression	
	r	p	r	p
NAR	0.699	<0.001	0.566	<0.001
NMCT	0.490	<0.001	0.528	<0.001
CRP	0.699	<0.001	0.540	<0.001
PCT	0.351	<0.001	0.298	0.003
IL-1β	0.619	<0.001	0.578	<0.001
TNF-α	0.546	<0.001	0.459	<0.001

In the moderate/severe group, anxiety and depression were correlated with the NAR (r = 0.699 and 0.566; both $p < 0.001$), NMCT (r = 0.490 and 0.528; both $p < 0.001$), CRP (r = 0.699 and 0.540; both $p < 0.001$), PCT (r = 0.351 and 0.298; $p < 0.001$ and =0.003), IL-1β (r = 0.619 and 0.578; both $p < 0.001$), and TNF-α (r = 0.546 and 0.459; both $p < 0.001$) (Table 6).

4. Discussion

On a global scale, AR contributes to considerable medical and health burdens. Primarily caused by the interaction between allergens and immunoglobulin E (IgE) antibodies on the surface of airway cells [21], AR is clinically manifested by sneezing, runny nose, nasal congestion, and itching. Continuous exposure to allergens precipitates the development of chronic inflammation, which leads to nasal mucosa damage—a trigger of various nasal symptoms. AR not only causes breathing challenges, but may also lead to teary eyes, loss of taste and smell. Patients with AR typically experience sleep disorders, fatigue, and irritability, which markedly diminish their quality of life, causing significant disruptions to their social and daily life [14,22]. In this study, compared with healthy individuals, AR patients scored highly for depression and anxiety, and a significantly greater portion of these patients presented with clinical symptoms of depression and anxiety. Compared with the mild AR patients, the patients with moderate/severe AR had significantly higher anxiety and depression scores, and more subjects from this group reported manifestations of clinical anxiety and depression symptoms. These findings indicate that throughout the course of the disease, AR promotes negative emotions of depression and anxiety, with patients affected by severe conditions showing more pronounced impacts. A previous cross-sectional study conducted in Portugal also reported similar results, showing that patients with moderate/severe AR exhibited higher scores for anxiety and depression [14]. But the proportion of anxiety and depression in AR patients (27.8% and 36.5%) was higher than that in our study, probably due to the different statistical methods utilized in analyses. In their research, patients with a HAD score >7 points were classified as having anxiety and depression. In our study, we did not further distinguish between moderate and severe patients because further subdivision might increase workloads for the attending physicians and did not aid in enhancing therapeutic efficacy in clinical practice [19]. Several previous studies have adopted the same classification method as ours [12,14].

The mucociliary system is an important defense mechanism that protects the nasal mucosa from allergens. Through the coordinated, directional movement of cilia, mucus and the trapped foreign particles (such as dust, bacteria, and allergens) from the nasal cavity can be moved toward the nasopharynx, where they will be ultimately swallowed or expelled [23]. The damage of nasal mucociliary clearance (NMC) can lead to recurrent episodes of AR [12,24]. The saccharin test is commonly used to evaluate

NMC, with the advantages of ease of operation, noninvasiveness, and low cost. It measures the time required for saccharin granules to be transported from the back of the nasal turbinates to the pharynx, until the subject perceives a sweet taste [25]. The NAR measurement reflects the degree of nasal ventilation in an individual. In the AR contexts, allergens stimulate the nasal mucosa, causing blood vessel wall thickening and expansion of fibrous tissue, which are the contributory factors of increased nasal resistance [26]. In this study, both NAR and NMCT were significantly higher in AR patients compared to healthy controls. The NAR and NMCT of moderate/severe AR patients were higher than those of mild AR patients, indicating the possibility of nasal dysfunction exacerbation with AR severity. The ciliary structure in the nasal epithelium of AR patients is generally damaged, characterized by sparse cilia, disorganized microtubule arrangement, and loss of motor arms [27]. AR is also accompanied by allergic reaction resulting in increased mucus secretion and the alteration in composition and properties of mucus [28,29]. These changes contribute to longer NMCT in AR patients. Batmaz and Alicura Tokgöz [12] reported an increasing trend of NMCT in children with AR as the disease worsened in severity. We also observed a similar trend in adult patients with AR in the present study.

Chronic inflammation of the nasal mucosa is the primary factor underlying persistent AR. Exposure to allergens stimulates the nasal mucosa, leading to the accumulation of inflammatory cells and the release of various inflammatory mediators, which in turn cause damage to the nasal mucosa [5,6]. Among these inflammatory mediators is CRP, which rapidly augments the response to infection or tissue damage and can activate the complement system as well as regulate phagocytosis. PCT serves as a direct marker of the intensity of systemic inflammation [30]. An increase in IL-1β has been reported to promote leukocyte recruitment and acute-phase protein synthesis. Another critical inflammatory mediator is TNF-α, which is secreted by macrophages, T lymphocytes, and monocytes, and possesses pro-inflammatory properties [31]. In this study, the AR patients exhibited higher inflammation levels than the healthy individuals. Meanwhile, levels of CRP, PCT, IL-1β, and TNF-α in patients with moderate/severe AR were higher than those in mild AR patients, suggesting that changes in these inflammatory markers are dependent on AR severity. In this study, we found that the inflammatory indicators and nasal function were correlated with anxiety and depression in AR patients, with varying strengths of correlation in the moderate/severe and mild groups. To interpret the magnitude of correlation, r value $<$ 0.3 was negligible correlation, r value of 0.3–0.5 was weak correlation, r value of 0.5–0.7 was moderate correlation, and r value $>$ 0.7 was consider as strong correlation [32,33]. In mild AR patients, NAR, CRP, IL-1β and TNF-α showed weak correlations with anxiety and depression; whereas NMCT was not correlated with anxiety, only showing negligible correlation with depression. Overall, the correlations between patient emotions (anxiety and depression) and inflammatory factors and nasal function were mostly weak in mild AR. This is possibly attributed to the less severe symptoms in patients with mild AR. For moderate/severe AR patients, the anxiety and depression were moderately correlated with NAR, CRP, and IL-1β; NMCT and PCT have weak correlation. TNF-α was moderately correlated with anxiety, and weakly correlated with depression. These correlations were stronger in moderate/severe AR than those in mild AR. For patients with moderate/severe disease, AR has a profoundly negative impact on their quality of life.

Several limitations of this research should be acknowledged. Owing to the retrospective design of this study, the results may be subject to potential bias. Therefore, a clinical prospective study is warranted to validate our findings in the future. In addition, this study only included patients with persistent AR and did not consider those with intermittent AR. Future studies could take disease persistence into account to provide a more comprehensive analysis.

5. Conclusion

As the severity of AR increases, patients exhibit higher levels of anxiety and depression, elevated inflammation levels, and impaired nasal function. Anxiety and depression are correlated with both nasal function and inflammation levels, with these correlations being more pronounced in patients with moderate/severe AR than in those with mild disease.

Key Points

• Patients with moderate/severe allergic rhinitis (AR) exhibit higher levels of C-reactive protein (CRP), procalcitonin (PCT), interleukin-1 beta (IL-1β), and tumor necrosis factor alpha (TNF-α) compared to those with mild disease.

• The nasal mucociliary clearance time (NMCT) and nasal airway resistance (NAR) in moderate/severe AR patients were higher than those in mild AR patients.

• Moderate/severe AR patients experienced worse anxiety and depression compared to mild AR patients.

• In patients with mild AR, anxiety and depression were correlated with NAR, CRP, PCT, IL-1β, and TNF-α, whereas NMCT was correlated only with depression.

• Compared with those with mild AR, patients with moderate/severe AR exhibited stronger correlations of anxiety and depression with NAR, NMCT, CRP, PCT, IL-1β and TNF-α.

Availability of Data and Materials

The data analyzed in this study are available from the corresponding author upon reasonable request.

Author Contributions

WH and LJ designed the research study. WH and XMP performed the research. WH and XPY analyzed the data. WH and LJ wrote the initial draft. All authors contributed to the important editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

This study was approved by the ethics committee of The Second Affiliated Hospital of Heilongjiang University of Chinese Medicine (No. L2024-C01-05). All procedures were carried out in compliance with the Declaration of Helsinki, and informed consent was obtained from every participant.

Acknowledgment

Not applicable.

Funding

This study is supported by Project of Heilongjiang Provincial Administration of Traditional Chinese Medicine (2HY2024-007).

Conflict of Interest

The authors declare no conflict of interest.

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