The Journal of Laryngology & Otology

cambridge.org/jlo

Predictive value of peripheral blood eosinophil levels for eosinophilic chronic rhinosinusitis: a systematic review and meta-analysis

Xiao Yin, Danyang Chang and Changling Sun

Department of Otolaryngology-Head and Neck Surgery, Affiliated Hospital of Jiangnan University, Wuxi, Jiangsu Province, China

Review Article

Changling Sun takes responsibility for the integrity of the content of the paper

Cite this article: Yin X, Chang D, Sun C. Predictive value of peripheral blood eosinophil levels for eosinophilic chronic rhinosinusitis: a systematic review and meta-analysis. *J Laryngol Otol* 2025;1–7. https://doi.org/10.1017/S0022215124001208

Received: 10 February 2024
Revised: 8 May 2024
Accepted: 29 May 2024

Keywords:
rhinosinusitis; nasal polyps; eosinophilia; predictive value of tests

Corresponding author:
Changling Sun;
Email: winterc126@sina.com

Abstract

Objective. To evaluate the predictive value of peripheral blood eosinophil levels for eosinophilic chronic rhinosinusitis.

Methods. Electronic searches were conducted in PubMed, Embase and the Cochrane Library. Data were analysed using Stata 16.0.

Results. In total, 23 studies that fulfilled the inclusion criteria were analysed. For peripheral blood eosinophil percentage in identifying eosinophilic chronic rhinosinusitis, the pooled sensitivity was 0.77 (95 per cent confidence interval (CI) = 0.69–0.83) and specificity was 0.74 (95 per cent CI = 0.68–0.80), with a positive likelihood ratio of 2.97 (95 per cent CI = 2.38–3.72) and a negative likelihood ratio of 0.31 (95 per cent CI = 0.24–0.42). Similarly, for peripheral blood eosinophil count, the pooled sensitivity was 0.78 (95 per cent CI = 0.73–0.82) and specificity was 0.73 (95 per cent CI = 0.69–0.77), with a positive likelihood ratio of 2.93 (95 per cent CI = 2.45–3.50) and a negative likelihood ratio of 0.30 (95 per cent CI = 0.24–0.37).

Conclusion. There is not sufficient evidence to support peripheral eosinophilia as a good predictor of eosinophilic chronic rhinosinusitis.

Introduction

Chronic rhinosinusitis is a persistent inflammatory disease affecting the nasal cavity and paranasal sinuses for longer than 12 weeks. Traditionally, chronic rhinosinusitis was classified into two subtypes primarily based on the absence or presence of nasal polyps: chronic rhinosinusitis without nasal polyps and chronic rhinosinusitis with nasal polyps.[1] Furthermore, it can be classified as eosinophilic chronic rhinosinusitis and non-eosinophilic chronic rhinosinusitis based on the eosinophilic infiltration level in the nasal mucosa or polyps.[2] The latest European Rhinologic Society Guidelines propose a classification method based on the type of associated inflammation (type 2 or non-type 2 inflammation).[3] Eosinophilic chronic rhinosinusitis is a type 2 inflammatory disease characterised by good steroid responsiveness, worse olfactory dysfunction and high recurrence rate after surgery. In contrast, non-eosinophilic chronic rhinosinusitis responds well to medical or surgical interventions and exhibits the features of lower post-operative recurrence rate.[4–6] Thus, it is important to discriminate the patients' endotypes and formulate a personalised treatment strategy for chronic rhinosinusitis with nasal polyps patients. It is therefore necessary to find a simple classification method that is applicable pre-operatively.

Recently, examination of peripheral blood eosinophil has been used as a predictor for the identification of eosinophilic chronic rhinosinusitis.[7–29] Unfortunately, the results of these studies are not consistent. Some authors showed that examination of peripheral blood eosinophil may be a useful method for the differential diagnosis of eosinophilic chronic rhinosinusitis,[7,9–13,16,19,23–25] whereas others suggested that serum eosinophilia was not a good marker of tissue eosinophilia.[8,14,15,17,18,20–22,26–29] The associations between peripheral blood eosinophils and tissue histopathology are yet to be defined. This study aimed to perform a systematic review and meta-analysis to evaluate the predictive value of peripheral blood eosinophil levels for eosinophilic chronic rhinosinusitis.

Methods

This systematic review and meta-analysis were conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Supplementary Material 1).[30] The protocol used in this article has been registered on PROSPERO and the registry number for this study is CRD42023402824.

Search strategy

A literature search was performed on PubMed, Embase and the Cochrane Library up to 8 April 2024 by two independent reviewers. The search terms were: (((((((chronic rhinosinusitis) OR (nasal polyps)) OR (CRSwNP)) OR (eosinophilic chronic rhinosinusitis)) OR

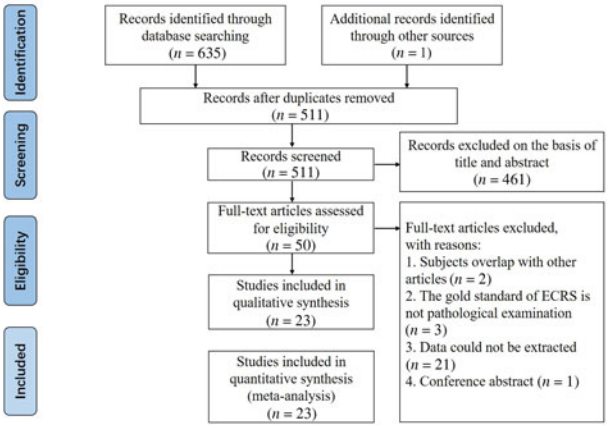

Figure 1. Flow diagram of the systematic literature search and study selection process.

(ECRS)) OR (ECRSwNP)) AND ((((blood eosinophil count) OR (blood eosinophil percentage)) OR (eosinophil ratio)) OR (blood eosinophilia))) AND ((((((sensitivity) OR (specificity)) OR (area under the curve)) OR (AUC)) OR (ROC curves)) OR (receiver operating characteristic curves)). No restrictions regarding the publication language were applied. The titles and abstracts of each retrieved study were screened to determine records that should be further evaluated for eligibility. Full texts of the eligible studies were retrieved for further assessment. In addition, the reference lists of the relevant articles were also scanned to identify other potentially eligible studies.

Selection criteria

The inclusion criteria were follows: (1) studies that evaluated the predictive value of peripheral blood eosinophils for the diagnosis of eosinophilic chronic rhinosinusitis; (2) studies that reported complete data on the predictive value of blood eosinophil examination or in which the number of true–positive, false–positive, true–negative and false–negative outcomes could be extracted; and (3) the 'gold standard' for diagnosis of eosinophilic chronic rhinosinusitis came from histopathological examination. The exclusion criteria were as follows: (1) case reports, reviews, comments, thesis, conference abstracts, editorials and letters; (2) studies for which data could not be fully extracted; and (3) repeated publications (the research with the largest sample size was selected).

Data extraction

Two reviewers extracted the following data independently: first author, publication date, nationality, number of patients, diagnostic criteria of eosinophilic chronic rhinosinusitis, blood eosinophil related predictors, cut-off values of predictors for the prediction of eosinophilic chronic rhinosinusitis. The outcomes of true–positive, true–negative, false–positive and false–negative were extracted and cross-checked.

Table 1. Characteristics of the studies included for the meta-analysis

Author (year)	Country	No. of patients	Criteria of ECRS (tissue eosinophils)	Blood eosinophil related predictors	Cut-off value of predictors for the diagnosis of ECRS
Chen (2021)	China	77	>10%	BEP, BEC	BEP = 2.8%, BEC = 0.2085 × 109/L
Du (2020)	China	119	>10%	BEP, BEC	BEP = 2.35%, BEC = 0.18 × 109/L
Han (2022)	China	88	>10/HPF	BEP, BEC	BEP = 3.25%, BEC = 0.175 × 109/L
Ho (2018)	Australia	245	>10/HPF	BEP, BEC	BEP = 4.265%, BEC = 0.235 × 109/L
Hu (2012)	China	190	>10%	BEP, BEC	BEP = 3.05%; BEC = 0.215 × 109/L
Li (2024)	China	81	>10%	BEP	BEP = 5.25%
Li (2024-2)	China	1352	>55/HPF	BEC	BEC = 0.205 × 109/L
Li (2019)	China	89	>27%	BEP, BEC	BEP = 1.9%, BEC = 0.12 × 109/L
Liu (2019)	China	48	>10%	BEP	BEP = 3.40%
Lv (2020)	China	70	>10%	BEP, BEC	BEP = 3.2%; BEC = 0.2 × 109/L
Ma (2023)	China	408	>10%	BEP	BEP = 4%
Sivrice (2020)	Turkey	299	>50%	BEC	BEC = 0.25 × 109/L
Tang (2023)	China	139	>10/HPF	BEP	BEP = 3.45%
Wu (2024)	China	116	>10/HPF	BEC	BEC = 0.265 × 109/L
Xu (2020)	China	99	>10%	BEP	BEP = 3.95%
Zhang (2022-1)	China	149	>10%	BEP	BEP = 3.0%
Zhang (2022-2)	China	91	>10%	BEP, BEC	BEP = 3.950%; BEC = 0.275 × 109/L
Zhong (2021)	China	65	>10%	BEC	BEC = 0.39 × 109/L
Zhou (2021)	China	127	>10%	BEC	BEC = 0.195 × 109/L
Zhou (2023)	China	37	>10/HPF	BEC	BEC = 0.28 × 109/L
Zhu (2020)	China	82	>10%	BEC	NR
Zhu (2023)	China	431	>10%	BEC	BEC = 0.215 × 109/L
Zuo (2014)	China	105	>5/HPF	BEP, BEC	BEP = 2.05%, BEC = 0.16 × 109/L

ECRS = eosinophilic chronic rhinosinusitis; BEP = blood eosinophil percentage; BEC = blood eosinophil count; HPF = high power field; NR = not reported

https://doi.org/10.1017/S0022215124001208

Qualitative assessment

The risk of bias of each included study was assessed based on the Quality Assessment of Diagnostic Accuracy Studies–2 tool. This tool comprises four domains: patient selection, index test, reference standard, and flow and timing. Each domain contains a set of signalling questions and is scored high, low or unclear by two independent reviewers. Review Manager 5.4 was used for the evaluation of methodological quality in this meta-analysis.

Any discrepancies in the process of article selection, data extraction and quality assessment were resolved through discussions or elucidated by a third party.

Statistical analysis

Statistical analysis of the data was performed using Meta-Disc 1.4 and Stata 16.0. The Q test and I^2 statistic were used to evaluate heterogeneity among the outcomes of included studies. Significant heterogeneity was indicated by p less than 0.05 in the Q tests and I^2 greater than 50 per cent. Pooled sensitivity, specificity, positive likelihood ratio, negative likelihood ratio and diagnostic odds ratio with 95 per cent confidence interval (CI) were calculated for each blood eosinophil predictor. We also developed a symmetric receiver operator characteristic curve and calculated the area under the curve. Meta-regression, sub-group analyses and sensitivity analyses were performed to explore the sources of heterogeneity. Deek's funnel plot asymmetry test was used to assess publication bias and p less than 0.05 was considered statistically significant.

Results

Eligible studies

We identified 635 potentially relevant articles after initial electronic searching. One additional article was identified through a review of reference lists of the relevant articles. Fifty articles were left for further selection after removal of duplicates and a review of the titles and abstracts. After full-text screening, 3 studies were excluded because the diagnostic criterion of eosinophilic chronic rhinosinusitis was not pathological examination, 2 studies were excluded because the research subjects overlapped with another study, 21 studies were excluded because the essential data could not be extracted and 1 study was excluded because it was a conference abstract. Finally, 23 studies fulfilled the inclusion criteria and underwent data extraction. Study selection and screening proceeded based on the strategy outlined in the standard PRISMA statement. The article selection process is given in Figure 1. The characteristics of the included studies are summarised in Table 1.

Quality assessment

Figure 2 shows the results of the quality assessment of the included studies according to Quality Assessment of Diagnostic Accuracy Studies–2 criteria. Of the 23 included studies, 1 study fulfilled 6 items, 8 studies fulfilled 5 items and 14 studies met 4 items. Among these, 22 studies were labelled as unclear in the patient selection domain because the author did not report whether the patients were consecutive or randomly selected. Overall, 22 studies were classified as high risk in the index test domain because the threshold used was not pre-specified. The reference standard domain of 15 studies was evaluated as unclear risk because authors did not report whether reference standard results were interpreted without knowledge of the results of the index tests.

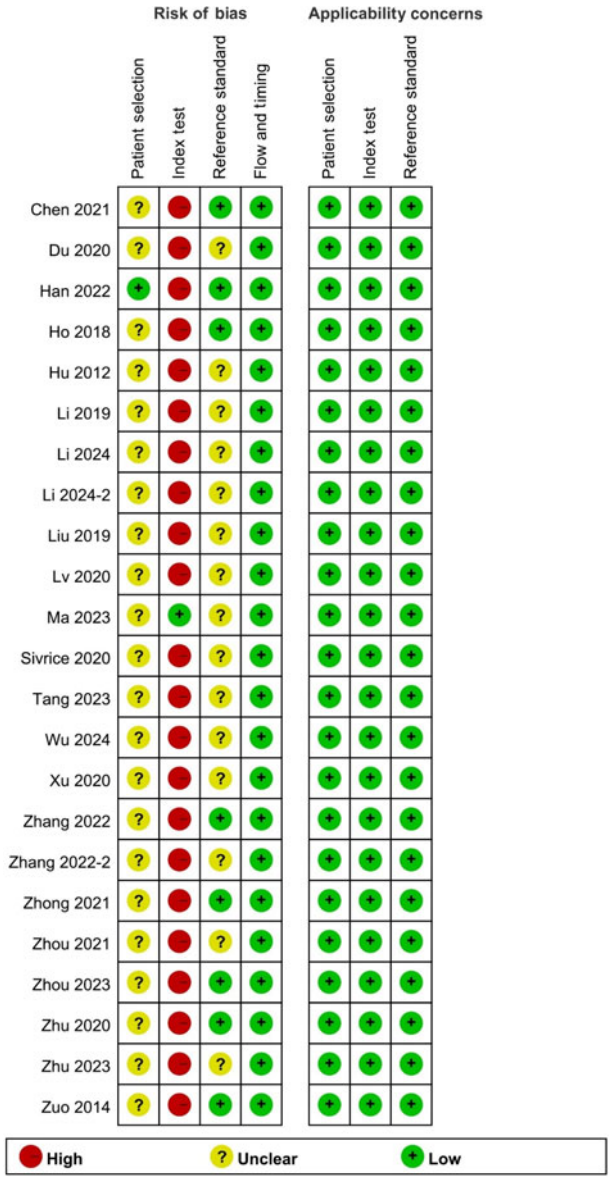

Figure 2. Methodological quality assessment of included studies according to Quality Assessment of Diagnostic Accuracy Studies–2 (QUADAS-2) criteria.

Predictive value of peripheral blood eosinophils for eosinophilic chronic rhinosinusitis

Of the 23 included articles, 15 reported the predictive value of peripheral blood eosinophil percentage for identification of eosinophilic chronic rhinosinusitis. The Spearman correlation coefficient of the blood eosinophil percentage was 0.35 ($p = 0.20$), suggesting that there was no threshold effect. The pooled sensitivity and specificity were 0.77 (95 per cent CI = 0.69–0.83) and 0.74 (95 per cent CI = 0.68–0.80), respectively (Figure 3A). The overall positive and negative likelihood ratios (positive likelihood ratio and negative likelihood ratio) were 2.97 (95 per cent CI = 2.38–3.72) and 0.31 (95 per cent CI = 0.24–0.42), respectively. The pooled diagnostic odds ratio (DOR) was 9.47 (95 per cent CI = 6.31–14.22). The area under the summary receiver operating characteristic (SROC) curve was 0.82 (95 per cent CI = 0.78–0.85) (Figure 4A; Supplementary material, Table 2).

https://doi.org/10.1017/S0022215124001208

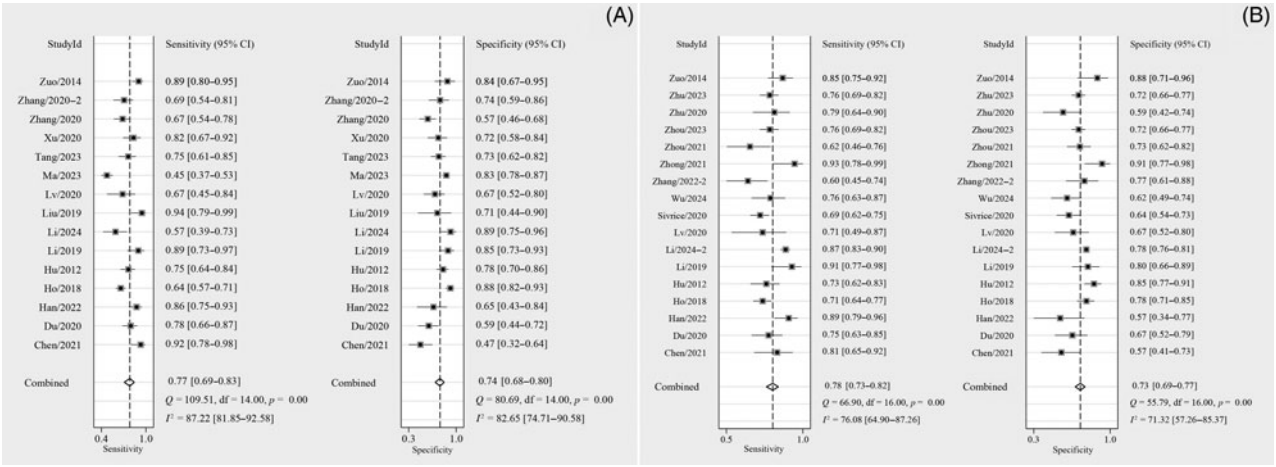

Figure 3. Forest plot of the sensitivity and specificity of the blood eosinophil percentage (A) and blood eosinophil count (B) for ECRS. CI = confidence interval; df = degrees of freedom

Seventeen studies reported the predictive values of peripheral blood eosinophil count for eosinophilic chronic rhinosinusitis. The Spearman correlation analysis revealed a coefficient of −0.10 for blood eosinophil count ($p = 0.71$), indicating the absence of a threshold effect. The following results were obtained: pooled sensitivity, 0.78 (95 per cent CI = 0.73–0.82); pooled specificity, 0.73 (95 per cent CI = 0.69–0.77) (Figure 3B); pooled positive likelihood ratio, 2.93 (95 per cent CI = 2.45–3.50); pooled negative likelihood ratio, 0.30 (95 per cent CI = 0.24–0.37); pooled diagnostic odds ratio, 9.74 (95 per cent CI = 6.73–14.08). The area under the SROC (summary receiver operating characteristic) curve was 0.82 (95 per cent CI = 0.78–0.85) (Figure 4B; Supplementary material, Table 3).

Meta-regression and sub-group analysis

Because of the high heterogeneity in the included studies, we performed meta-regression including patient number (sample size) and the diagnostic criteria of eosinophilic chronic rhinosinusitis. The meta-regression of the blood eosinophil percentage (Figure 5A) showed that diagnostic criteria had an influence on the heterogeneity of sensitivity and specificity, and patient number led to a difference of sensitivity. The meta-regression of blood eosinophil count (Figure 5B) showed that both patient number and diagnostic criteria are likely to be the sources of heterogeneity.

Sub-group analyses were conducted based on the number of patients (≥100 or <100) and the diagnostic criteria of eosinophilic chronic rhinosinusitis (proportion of tissue eosinophils to the total number of inflammation cells or tissue eosinophils per high-power field) to explore the effects of various study characteristics on the predictive value of blood eosinophil percentage and blood eosinophil count for eosinophilic chronic rhinosinusitis. The results of blood eosinophil percentage (Figure 5A) indicated that the sub-group with at least 100 patients exhibited lower sensitivity compared with the sub-group with fewer than 100 patients ($p < 0.01$). In addition, the sub-group using the diagnostic criteria of the proportion of tissue eosinophils to the total number of

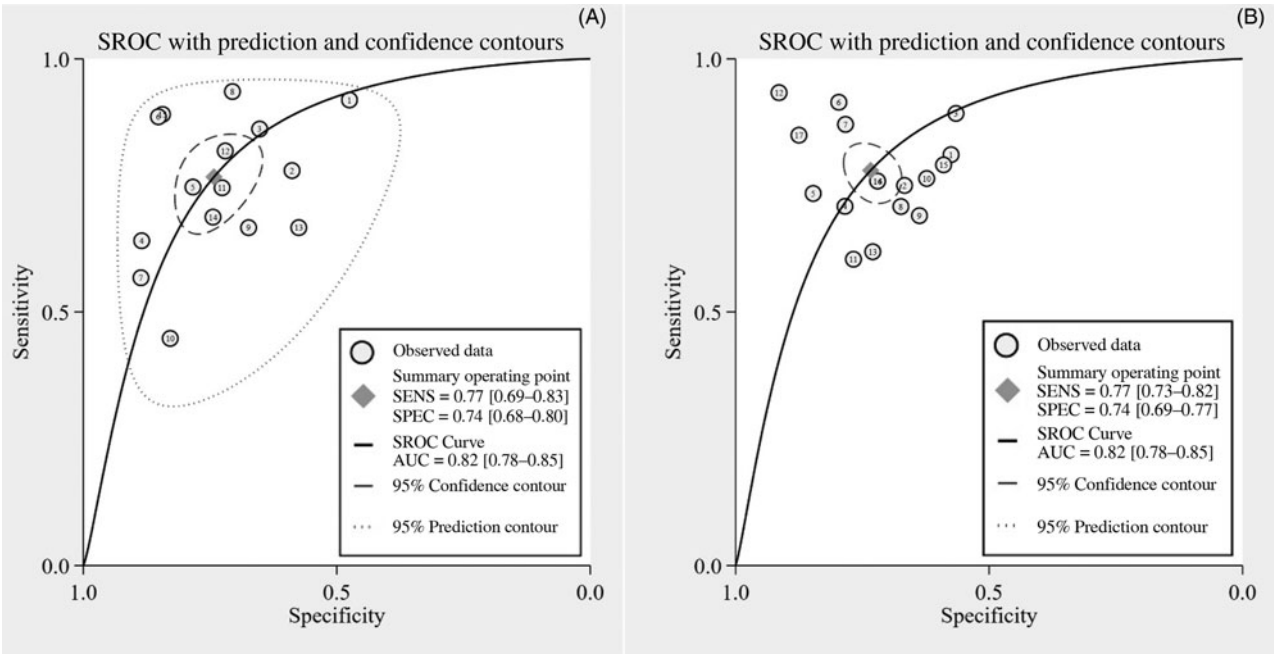

Figure 4. Summary receiver operating characteristic curve for blood eosinophil percentage (A), and blood eosinophil count (B). SROC = summary receiver operating characteristic; SENS = sensitivity; SPEC = specificity; AUC = area under the curve

https://doi.org/10.1017/S0022215124001208

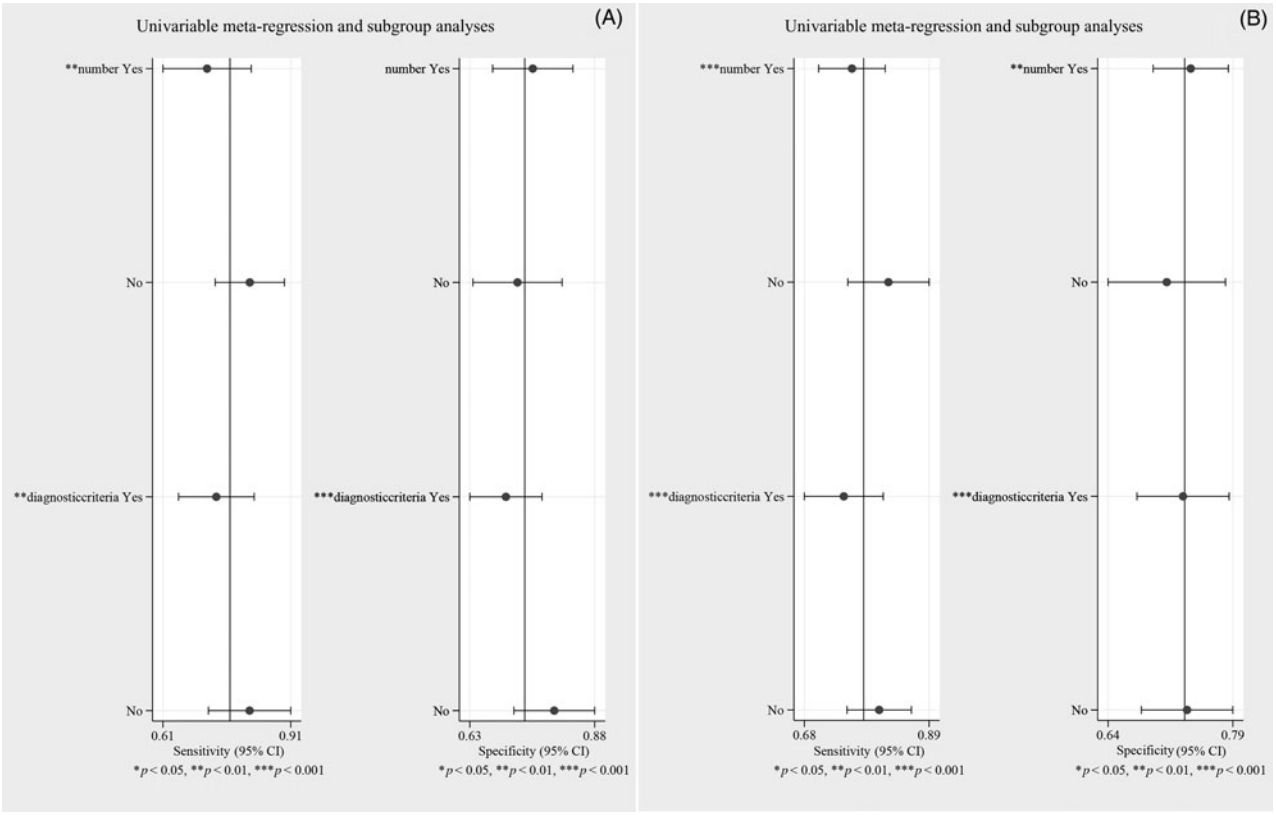

Figure 5. Meta-regression for blood eosinophil percentage (A), and blood eosinophil count (B) in the identification of ECRS.

inflammation cells was less sensitive ($p < 0.05$) and specific ($p < 0.01$) compared with the sub-group using tissue eosinophils per high-power field. Regarding the results of blood eosinophil count (Figure 5B), the sub-group with at least 100 patients exhibited lower sensitivity ($p < 0.001$) but higher specificity ($p < 0.01$), while the sub-group using the diagnostic criteria of the proportion of tissue eosinophils to the total number of inflammation cells had lower sensitivity ($p < 0.001$) and specificity ($p < 0.001$).

Sensitivity analysis

We performed a sensitivity analysis by excluding the included studies one by one. The pooled effect size of blood eosinophil percentage (Figure 6A) showed no significant change, indicating the findings were relatively robust. The pooled effect size of blood eosinophil count (Figure 6B) decreased significantly after excluding the study by Li (2024–2) and increased after excluding the study by Sivrice (2020), indicating that the findings of blood eosinophil count are not so robust.

Publication bias analysis

Publication bias was assessed by Deeks' funnel plot asymmetry test. The results (Figure 7) showed that publication bias was not statistically significant for studies regarding blood eosinophil percentage ($p = 0.17$) and blood eosinophil count ($p = 0.30$).

Discussion

Principal findings

Peripheral blood is an easily accessible biological sample capable of reflecting the inflammatory state of the body. Some authors

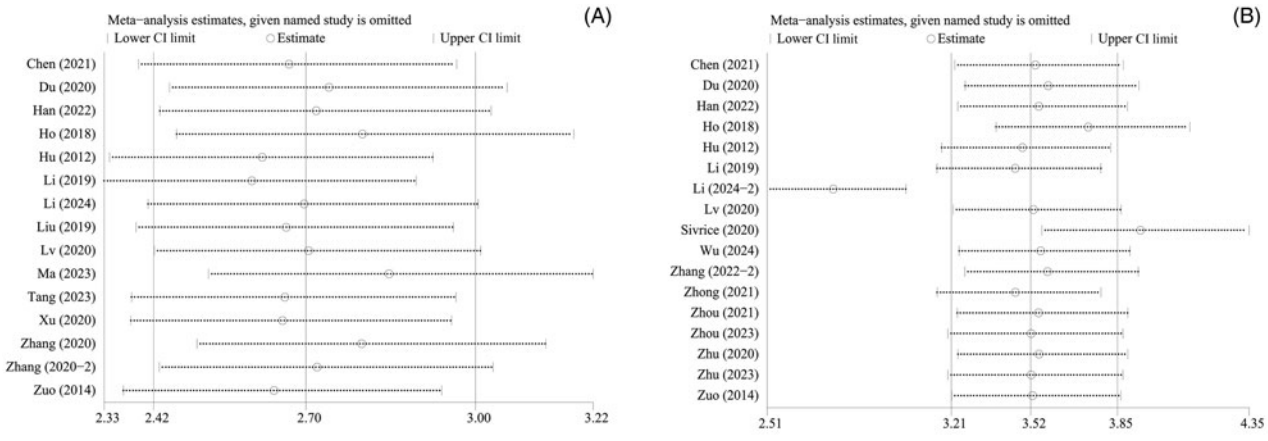

Figure 6. Sensitivity analysis of blood eosinophil percentage (A), and blood eosinophil count (B) in the prediction of ECRS; CI indicates confidence interval.

https://doi.org/10.1017/S0022215124001208

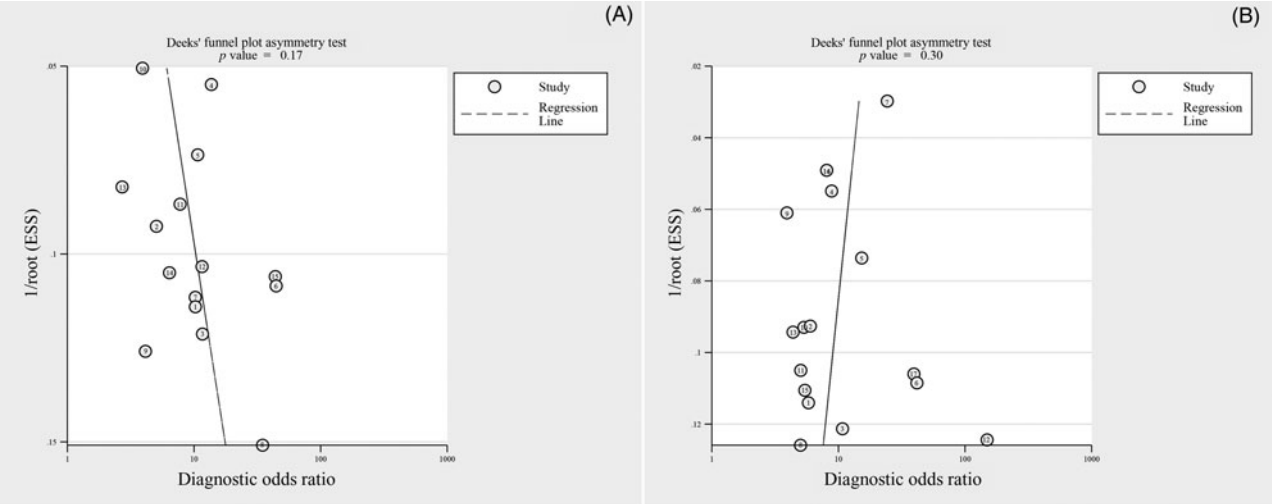

Figure 7. Deek's funnel plot asymmetry test of blood eosinophil percentage (A), and blood eosinophil count (B). ESS = effective sample size

recently attempted to examine blood eosinophil percentage and blood eosinophil count to evaluate their predictive value for eosinophilic chronic rhinosinusitis patients.[7–29] The systematic review and meta-analysis by Kim *et al.* compared the differences in blood eosinophil percentage and blood eosinophil count between eosinophilic chronic rhinosinusitis and non-eosinophilic chronic rhinosinusitis patients. The results showed that both blood eosinophil percentage and blood eosinophil count were significantly higher in the eosinophilic chronic rhinosinusitis sub-group than in the non-eosinophilic chronic rhinosinusitis sub-group, suggesting that the blood eosinophil parameter may be used as a simple indicator for subclassification of eosinophilic chronic rhinosinusitis and non-eosinophilic chronic rhinosinusitis. However, they did not analyse the predictive ability of the blood eosinophil percentage and blood eosinophil count for eosinophilic chronic rhinosinusitis.[31] In the present study, we conducted a systematic review and meta-analysis of the included 23 clinical studies to evaluate the predictive efficiency of blood eosinophil percentage and blood eosinophil count for the identification of eosinophilic chronic rhinosinusitis. The results showed that the pooled sensitivity, specificity, positive likelihood ratio, negative likelihood ratio and diagnostic odds ratio of the blood eosinophil percentage were 0.77, 0.74, 2.97, 0.31 and 9.47 respectively. The blood eosinophil count exhibited similar values for the identification of eosinophilic chronic rhinosinusitis with a pooled sensitivity of 0.78, pooled specificity of 0.73, pooled positive likelihood ratio of 2.93, pooled negative likelihood ratio 0.30 and diagnostic odds ratio of 9.74.

- The results of previous systematic reviews or meta-analyses showed that both peripheral blood eosinophil percentage and peripheral blood eosinophil count were significantly higher in eosinophilic chronic rhinosinusitis patients than in non-eosinophilic chronic rhinosinusitis patients
- Examination of peripheral blood eosinophil has been used as a predictor for the identification of eosinophilic chronic rhinosinusitis
- This systematic review and meta-analysis of 23 studies that fulfilled the inclusion criteria evaluated the predictive value of peripheral blood eosinophil levels for the identification of eosinophilic chronic rhinosinusitis
- The results of this meta-analysis suggest that there is not sufficient evidence to support peripheral eosinophilia as a good predictor of eosinophilic chronic rhinosinusitis

Clinical implications

Receiver operating characteristic curve analysis has been widely used to evaluate diagnostic predictors in many fields. The predictive efficiency of a predictor was evaluated by the area under the receiver operating characteristic curve.[32] An area under the receiver operating characteristic curve greater than 0.9 indicates high accuracy, while an area under the curves of 0.7–0.9 or 0.5–0.7 is considered to have moderate or low accuracy, respectively.[33] The results of this study showed that the area under the curve of blood eosinophil percentage and blood eosinophil count was 0.82, indicating moderate diagnostic accuracy for eosinophilic chronic rhinosinusitis. In clinical practice, it is important to know how a particular test result predicts the risk of abnormality. The likelihood ratio is a comprehensive index calculated by pooling sensitivity and specificity. It can be used to calculate the probability of abnormality and thus might be more helpful than sensitivity and specificity. According to literature reports, positive likelihood ratio greater than 10 and negative likelihood ratio less than 0.1 suggests excellent accuracy, and positive likelihood ratio greater than 5 and negative likelihood ratio less than 0.2 indicates strong predictive power.[34] The results of this study showed that the positive likelihood ratio of blood eosinophil percentage and blood eosinophil count are 2.97 and 2.93, while the negative likelihood ratio is 0.31 and 0.30, indicating neither blood eosinophil percentage nor blood eosinophil count exhibited sufficient predictive value for eosinophilic chronic rhinosinusitis.

Limitations

This study is limited by several factors. Firstly, studies included in this meta-analysis have a certain degree of risk of bias. For instance, the cut-off values of blood eosinophil percentage and blood eosinophil count for diagnosis of eosinophilic chronic rhinosinusitis were not preset, but the optimal cut-off value determined based on the receiver operating characteristic curve, which might improve their diagnostic value. Secondly, moderate heterogeneity was found among the included studies. We used meta-regression and sub-group analysis to explore the heterogeneity of data. The results of meta-regression and sub-group analysis indicated that the sample size and diagnostic criteria of eosinophilic chronic rhinosinusitis

https://doi.org/10.1017/S0022215124001208

can explain the heterogeneity of included studies. However, in the included studies in the present study, different histological criteria were applied to define eosinophilic chronic rhinosinusitis, including 16 criteria for the percentage of eosinophils and/or inflammatory cells (>10 per cent, >27 per cent, >50 per cent), 7 criteria for absolute eosinophil count (>5, >10, >55 eosinophils per high power field). Thirdly, the vast majority of included studies were performed in the Chinese population. Given the difference in the prevalence of T Helper Cell Type 2 (TH2) inflammation and eosinophilic disease between eastern and western countries,[35–38] the results of this meta-analysis may not be applicable to other populations.

Conclusion

This meta-analysis indicates that there is not convincing evidence to support peripheral eosinophilia as a good predictor of eosinophilic chronic rhinosinusitis. Given the aforementioned limitations, the conclusion of this meta-analysis should be interpreted with caution.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S0022215124001208.

References

1 Fokkens WJ, Lund VJ, Mullol J, Bachert C, Alobid I, Baroody F *et al.* EPOS 2012: European position paper on rhinosinusitis and nasal polyps 2012. A summary for otorhinolaryngologists. *Rhinology* 2012;**50**:1–12
2 Ishitoya J, Sakuma Y, Tsukuda M. Eosinophilic chronic rhinosinusitis in Japan. *Allergol Int* 2010;**59**:239–45
3 Fokkens WJ, Lund VJ, Hopkins C, Hellings PW, Kern R, Reitsma S *et al.* European Position Paper on Rhinosinusitis and Nasal Polyps 2020. *Rhinology* 2020;**58**:1–464
4 Ahn SH, Lee EJ, Ha JG, Hwang CS, Yoon JH, Kim CH *et al.* Comparison of olfactory and taste functions between eosinophilic and non-eosinophilic chronic rhinosinusitis. *Auris Nasus Larynx* 2020;**47**:820–7
5 Sakuma Y, Ishitoya J, Komatsu M, Shiono O, Hirama M, Yamashita Y *et al.* New clinical diagnostic criteria for eosinophilic chronic rhinosinusitis. *Auris Nasus Larynx* 2011;**38**:583–8
6 Wang ET, Zheng Y, Liu PF, Guo LJ. Eosinophilic chronic rhinosinusitis in East Asians. *World J Clin Cases* 2014;**2**:873–82
7 Chen W, Wang L, Xie B, Xie SB, Wang FJ. The role of serum B cell activation factor in the diagnosis and phenotypes of chronic rhinosinusitis with nasal polyps. *Lin Chuang Er Bi Yan Hou Tou Jing Wai Ke Za Zhi* 2021;**35**:886–90
8 DU Y, Kong H, Yu B, Xia X, Zhang N, Guo J. Correlation analysis between modified nasal endoscopic score and ELR value and subtype of chronic sinusitis with nasal polyps. *Lin Chuang Er Bi Yan Hou Tou Jing Wai Ke Za Zhi* 2020;**34**:306–10
9 Han J, Wang W, Zhu Z, Wang L, Chen Y, Wang R *et al.* Profile of tissue immunoglobulin e in eosinophilic chronic rhinosinusitis with nasal polyps. *Int Arch Allergy Immunol* 2022;**183**:835–42
10 Ho J, Hamizan AW, Alvarado R, Rimmer J, Sewell WA, Harvey RJ. Systemic predictors of eosinophilic chronic rhinosinusitis. *Am J Rhinol Allergy* 2018;**32**:252–7
11 Hu Y, Cao PP, Liang GT, Cui YH, Liu Z. Diagnostic significance of blood eosinophil count in eosinophilic chronic rhinosinusitis with nasal polyps in Chinese adults. *Laryngoscope* 2012;**122**:498–503
12 Li T, Li JP. Comparison of clinical indexes in predicting eosinophilic chronic rhinosinusitis. *J Shanghai Jiao Tong Uni* (*Med Sci*) 2019;**39**:903–6
13 Liu C, Yan B, Qi S, Zhang Y, Zhang L, Wang C. Predictive significance of Charcot–Leyden crystals for eosinophilic chronic rhinosinusitis with nasal polyps. *Am J Rhinol Allergy* 2019;**33**:671–80
14 Lv H, Liu PQ, Xiang R, Zhang W, Chen SM, Kong YG *et al.* Predictive and diagnostic value of nasal nitric oxide in eosinophilic chronic rhinosinusitis with nasal polyps. *Int Arch Allergy Immunol* 2020;**181**:853–61
15 Sivrice ME, Okur E, Yasan H, Tüz M, Kumbul YÇ, Akın V. Can the systemic immune inflammation index preoperatively predict nasal polyp subtypes? *Eur Arch Otorhinolaryngol* 2020;**277**:3045–50
16 Xu Q, Du K, Zheng M, Duan S, Jia S, Chen H *et al.* Application of clinical scores in the differential diagnosis of chronic rhinosinusitis with nasal polyps in a Chinese population. *Am J Rhinol Allergy* 2020;**34**:401–8
17 Zhang Z, Ma F, Liu J, Xie L, Cao W, Zhang Y. Expression and predictive value of type Ⅱ inflammatory cytokines in nasal secretion in eosinophilic chronic rhinosinusitis with nasal polyps. *Lin Chuang Er Bi Yan Hou Tou Jing Wai Ke Za Zhi* 2022;**36**:934–9
18 Zhang Y, Zhu K, Chen J, Xia C, Yu C, Gao T *et al.* Predictive values of serum IL-33 and sST2 in endotypes and postoperative recurrence of chronic rhinosinusitis with nasal polyps. *Mediators Inflamm* 2022;**2022**:9155080
19 Zhong B, Yuan T, Du J, Tan K, Yang Q, Liu F *et al.* The role of preoperative blood eosinophil counts in distinguishing chronic rhinosinusitis with nasal polyps phenotypes. *Int Forum Allergy Rhinol* 2021;**11**:16–23
20 Zhou FW, Zhang T, Jin Y, Ma YF, Xian ZP, He XC *et al.* Predictive diagnostic value of serum 25-hydroxyvitamin D3 in eosinophilic chronic rhinosinusitis with nasal polyps. *Zhonghua Er Bi Yan Hou Tou Jing Wai Ke Za Zhi* 2021;**56**:1051–8
21 Zhu M, Gao X, Zhu Z, Hu X, Zhou H, Liu J. The roles of nasal nitric oxide in diagnosis and endotypes of chronic rhinosinusitis with nasal polyps. *J Otolaryngol Head Neck Surg* 2020;**49**:68
22 Zhu KZ, He C, Li Z, Wang PJ, Wen SX, Wen KX *et al.* Development and multicenter validation of a novel radiomics-based model for identifying eosinophilic chronic rhinosinusitis with nasal polyps. *Rhinology* 2023;**61**:132–43
23 Zuo K, Guo J, Chen F, Xu R, Xu G, Shi J *et al.* Clinical characteristics and surrogate markers of eosinophilic chronic rhinosinusitis in Southern China. *Eur Arch Otorhinolaryngol* 2014;**271**:2461–8
24 Li F, Wang S, Cha X, Li T, Xie Y, Wang W *et al.* Blood eosinophil percentage and improved sinus CT score as diagnostic tools for ECRS. *OTO Open* 2024;**8**:e106
25 Li S, Zhang Z, Wang L, Yan X, Jiang Y, Yu L. Diagnostic significance of peripheral blood indices for eosinophilic chronic rhinosinusitis in Chinese adults. *Eur Arch Otorhinolaryngol* 2024;**281**:1337–45
26 Ma JH, Hsieh BH, Huang SS, Li YT, Tsou YA, Lin CD *et al.* Clinical feature-based diagnosis criteria of eosinophil and non-eosinophil chronic rhinosinusitis in Taiwan. *Laryngoscope Investig Otolaryngol* 2023;**8**:1459–67
27 Tang B, Tu J, Zhang M, Zhang Z, Yu J, Shen L *et al.* Diagnostic value and underlying mechanism of nasal nitric oxide in eosinophilic chronic rhinosinusitis with nasal polyps. *Mol Immunol* 2023;**159**:1–14
28 Wu S, Lao J, Jian F. Analysis of the construction of a predictive model for eosinophilic chronic rhinosinusitis. *J Asthma Allergy* 2024;**17**:133–41
29 Zhou H, Fan W, Qin D, Liu P, Gao Z, Lv H *et al.* Development, validation and comparison of artificial neural network and logistic regression models predicting eosinophilic chronic rhinosinusitis with nasal polyps. *Allergy Asthma Immunol Res* 2023;**15**:67–82
30 Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, Ioannidis JP *et al.* The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. *BMJ* 2009;**339**:b2700
31 Kim DH, Kim SW, Basurrah MA, Hwang SH. Clinical and laboratory features of various criteria of eosinophilic chronic rhinosinusitis: a systematic review and meta-analysis. *Clin Exp Otorhinolaryngol* 2022;**15**:230–46
32 Eusebi P. Diagnostic accuracy measures. *Cerebrovasc Dis* 2013;**36**:267–72
33 Fischer JE, Bachmann LM, Jaeschke R. A readers' guide to the interpretation of diagnostic test properties: clinical example of sepsis. *Intensive Care Med* 2003;**29**:1043–51
34 Deeks JJ. Systematic reviews in health care: systematic reviews of evaluations of diagnostic and screening tests. *BMJ* 2001;**323**:157–62
35 Jankowski R, Bouchoua F, Coffinet L, Vignaud JM. Clinical factors influencing the eosinophil infiltration of nasal polyps. *Rhinology* 2002;**40**:173–8
36 Zhang N, Van Zele T, Perez-Novo C, Van Bruaene N, Holtappels G, DeRuyck N *et al.* Different types of T-effector cells orchestrate mucosal inflammation in chronic sinus disease. *J Allergy Clin Immunol* 2008;**122**:961–8
37 Wang X, Zhang N, Bo M, Holtappels G, Zheng M, Lou H *et al.* Diversity of TH cytokine profiles in patients with chronic rhinosinusitis: a multicenter study in Europe, Asia, and Oceania. *J Allergy Clin Immunol* 2016;**138**:1344–53
38 Kim SJ, Lee KH, Kim SW, Cho JS, Park YK, Shin SY. Changes in histological features of nasal polyps in a Korean population over a 17-year period. *Otolaryngol Head Neck Surg* 2013;**149**:431–7