International Journal of Clinical Practice

WILEY

RESEARCH ARTICLE OPEN ACCESS

Clinical Effectiveness of Dupilumab in Eosinophilic Granulomatosis With Polyangiitis: A Retrospective Observational Study

Oh Chan Kwon[1] | Jang Woo Ha[2] | Min-Chan Park[1] | Yong-Beom Park[3,4] | Jae-Hyun Lee[5,6] | Sang-Won Lee[3,4]

[1]Division of Rheumatology, Department of Internal Medicine, Gangnam Severance Hospital, Yonsei University College of Medicine, Seoul, Republic of Korea | [2]Division of Rheumatology, Department of Internal Medicine, Yongin Severance Hospital, Yonsei University College of Medicine, Seoul, Republic of Korea | [3]Division of Rheumatology, Department of Internal Medicine, Severance Hospital, Yonsei University College of Medicine, Seoul, Republic of Korea | [4]Institute for Immunology and Immunological Diseases, Yonsei University College of Medicine, Seoul, Republic of Korea | [5]Division of Allergy and Immunology, Department of Internal Medicine, Yonsei University College of Medicine, Seoul, Republic of Korea | [6]Institute of Allergy, Yonsei University College of Medicine, Seoul, Republic of Korea

Correspondence: Jae-Hyun Lee (jhleemd@yuhs.ac) | Sang-Won Lee (sangwonlee@yuhs.ac)

Received: 11 April 2025 | **Revised:** 24 September 2025 | **Accepted:** 2 January 2026

Academic Editor: Cornelia Amalinei

Keywords: dupilumab | eosinophilic granulomatosis with polyangiitis | interleukin-4 | interleukin-13 | vasculitis

ABSTRACT

Background: Dupilumab, a monoclonal antibody targeting the interleukin-4 receptor alpha subunit, has shown efficacy in eosinophilic disorders; however, its role in eosinophilic granulomatosis with polyangiitis (EGPA) remains uncertain. This study compared the clinical outcomes of patients with EGPA treated with conventional therapy, with or without dupilumab, focussing on its effects on disease activity and vasculitic phenotypes.

Patients and Methods: From a prospective, single-centre cohort of patients with antineutrophil cytoplasmic antibody-associated vasculitis, we retrospectively selected three patients with EGPA who received conventional therapy with dupilumab and six age- and sex-matched patients who received conventional therapy without dupilumab. The Birmingham Vasculitis Activity Score (BVAS), peripheral eosinophil count, erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) levels were assessed at EGPA diagnosis, dupilumab initiation and last follow-up. Changes in vascular manifestations before and after dupilumab treatment were evaluated.

Results: The eosinophilic conditions for which dupilumab was initiated were well controlled in all three patients receiving the drug. In contrast, two of the six patients who did not receive dupilumab showed worsening eosinophilic manifestations. All three patients demonstrated clinical improvement in EGPA following dupilumab treatment, with reductions in the BVAS, eosinophil count, ESR and CRP levels. No worsening of vasculitic phenotypes was observed, even after prolonged exposure (up to 45 months).

Conclusions: Dupilumab may help control the eosinophilic phenotypes of EGPA, thereby contributing to overall disease activity control without exacerbating vasculitic phenotypes. However, given the small sample size and retrospective nature of this study, larger prospective trials are required to confirm its efficacy in EGPA.

Sang-Won Lee and Jae-Hyun Lee equally contributed to this work as co-corresponding authors.

1 | Introduction

Eosinophilic granulomatosis with polyangiitis (EGPA) is a rare antineutrophil cytoplasmic antibody (ANCA)–associated vasculitis (AAV) characterised by late-onset asthma, marked eosinophilia and necrotising vasculitis, predominantly affecting small- to medium-sized vessels [1, 2]. Unlike other forms of AAV, EGPA exhibits significant heterogeneity and manifests through distinct clinical phases: a prodromal phase dominated by asthma and sinusitis, an eosinophilia-driven phase causing eosinophil-mediated tissue injury and a vasculitic phase characterised by systemic vasculitis features [2, 3]. Consistent with these clinical phases, clinical phenotypes of EGPA can be classified into eosinophilic phenotypes (such as asthma, sinusitis, pulmonary infiltrates and eosinophilic cardiomyopathy) and vasculitic phenotypes (such as purpura, glomerulonephritis and peripheral neuropathy.) [2, 3].

The pathogenesis of EGPA involves complex immune dysregulation, with a prominent role in eosinophil-mediated inflammation. Interleukin (IL)-5, produced by activated T-helper (Th)-2 cells, plays a central role in EGPA by promoting eosinophil maturation, proliferation, activation and survival [4]. Consequently, mepolizumab, an IL-5-targeting therapy, has been successfully implemented as a treatment option for EGPA [5, 6]. Mepolizumab has demonstrated efficacy not only in controlling eosinophilic phenotypes but also in managing vasculitic phenotypes of EGPA [7].

In addition to IL-5, other cytokines produced by Th-2 cells, such as IL-4 and IL-13, contribute significantly to eosinophilic and allergic inflammation by facilitating eosinophil recruitment and activation. This mechanism contributes to the pathogenesis of EGPA as well as allergic diseases such as asthma and chronic rhinosinusitis [8–10]. Recently, dupilumab, a monoclonal antibody targeting the IL-4 receptor alpha subunit, which inhibits both IL-4 and IL-13 signalling pathways, has demonstrated promising effectiveness for allergic conditions, including severe asthma and chronic rhinosinusitis [11, 12]. However, the role of dupilumab in EGPA remains controversial.

A retrospective observational study suggested that dupilumab may be effective in EGPA-related ear, nose, and throat (ENT) manifestations (i.e., eosinophilic phenotypes), thereby reducing overall disease activity as assessed by the Birmingham Vasculitis Activity Score (BVAS) [13]. Conversely, some case reports have described new-onset EGPA with the emergence of vasculitic phenotypes following dupilumab use in patients with asthma or chronic rhinosinusitis [14–16]. Owing to these conflicting observations, further evaluation of the potential role of dupilumab in EGPA is warranted.

Accordingly, we compared the clinical outcomes of patients with EGPA who received conventional therapy, with or without dupilumab, and evaluated the effects of dupilumab on overall disease activity and vasculitic phenotypes of EGPA.

2 | Methods

2.1 | Patients

Study patients were selected from the Severance Hospital ANCA-associated VasculitidEs (SHAVE) cohort, a prospective, single-centre cohort consisting of Korean patients with AAV. Details of the SHAVE cohort have been described previously in [17]. From this cohort, we initially screened 65 patients with EGPA, all of whom met the American College of Rheumatology/European Alliance of Associations for Rheumatology classification criteria for EGPA [18]. Of the 65 patients, three patients who received dupilumab during follow-up were selected for inclusion in this study. Age- and sex-matched comparators who did not receive dupilumab during follow-up were selected in a 1:2 ratio ($n = 6$) for comparison (Figure 1).

This study was approved by the Institutional Review Board (IRB) of Severance Hospital (Seoul, Korea, IRB No. 4-2020-1071) and conducted in accordance with the Declaration of Helsinki. Given the retrospective design of the study and the use of anonymised patient data, the requirement for written informed consent was waived.

2.2 | Clinical Outcome Assessments

We assessed disease activity at the following three timepoints: (1) the date of EGPA diagnosis, (2) the date of dupilumab initiation and (3) the date of the last follow-up. The disease activity was measured using the BVAS, a validated scoring system for quantifying clinical manifestations of vasculitis [19]. Additional clinical outcome measures included peripheral eosinophil count,

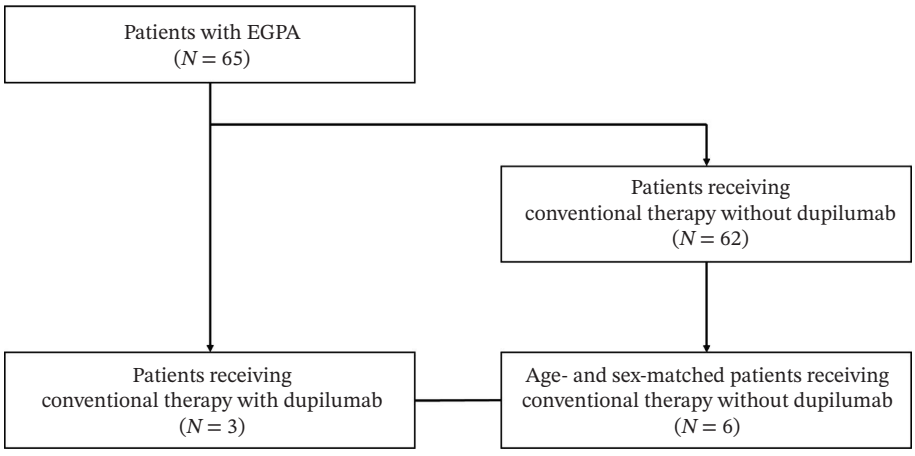

FIGURE 1 | Study patients. EGPA: Eosinophilic granulomatosis with polyangiitis.

erythrocyte sedimentation rate (ESR) and serum C-reactive protein (CRP) levels at each timepoint. We also evaluated changes in vasculitic phenotypes before and after dupilumab administration.

2.3 | Dupilumab Administration

Dupilumab was administered for the treatment of asthma or atopic dermatitis. It was given subcutaneously at an initial dose of 600 mg, followed by 300 mg every other week.

3 | Results

The characteristics of the 65 patients with EGPA in the SHAVE cohort are summarised in Table 1. The median age was 52.0 (interquartile range [IQR], 41.0–62.0) years, and 67.7% were female. Myeloperoxidase-ANCA (or perinuclear ANCA) was positive in 29 patients (44.6%). The median BVAS was 11.0 (IQR, 7.5–17.0). The most common manifestation was ENT involvement (83.1%), followed by pulmonary (70.8%) and neurologic manifestations (60.0%).

TABLE 1 | Characteristics of patients with EGPA at diagnosis ($N = 65$).

Variables	Values
Variables at diagnosis	
Demographic data	
Age (years)	52.0 (41.0–62.0)
Male sex (*N*, (%))	21 (32.3)
Female sex (*N*, (%))	44 (67.7)
BMI (kg/m^2)	22.6 (19.5–24.8)
Exsmoker (*N*, (%))	3 (4.6)
ANCA type and positivity (*N*, (%))	
MPO-ANCA (or P-ANCA) positivity	29 (44.6)
PR3-ANCA (or C-ANCA) positivity	6 (9.2)
ANCA negativity	33 (50.8)
AAV-specific indices	
BVAS	11.0 (7.5–17.0)
FFS	1.0 (0–1.0)
Systemic manifestations based on the items of BVAS	
General manifestation	17 (26.2)
Cutaneous manifestation	22 (33.8)
Mucous membranous and ocular manifestation	2 (3.1)
Otorhinolaryngological manifestation	54 (83.1)
Pulmonary manifestation	46 (70.8)
Cardiovascular manifestation	10 (15.4)
Abdominal manifestation	5 (7.7)
Renal manifestation	15 (23.1)
Neurologic manifestation	39 (60.0)
Laboratory results	
White blood cell count (/mm^3)	10,330.0 (6865.0—14020.0)
Eosinophil count (/mm^3)	790.0 (230.0—3905.0)
Haemoglobin (g/dL)	13.4 (12.1.1—14.4)
Platelet count (× 1000/mm^3)	275.0 (229.0–373.0)
Blood urea nitrogen (mg/dL)	13.0 (10.1–18.1)
Serum creatinine (mg/dL)	0.7 (0.6–0.9)
Serum total protein (g/dL)	6.8 (6.1–7.5)
Serum albumin (g/dL)	3.8 (3.4–4.3)
Acute phase reactants	
ESR (mm/hr)	33.0 (10.0–67.0)
CRP (mg/L)	5.0 (1.1–22.0)

Note: Values are expressed as a median (25–75 percentiles) or *N* (%).
Abbreviations: AAV, ANCA-associated vasculitis; ANCA, antineutrophil cytoplasmic antibody; BMI, body mass index; BVAS, the Birmingham Vasculitis Activity Score; C, cytoplasmic; CRP, C-reactive protein; EGPA, eosinophilic granulomatosis with polyangiitis; ESR, erythrocyte sedimentation rate; FFS, the five-factor score; MPO, myeloperoxidase; P, perinuclear; PR3, proteinase 3.

Among these 65 patients, the three patients (Patients 1–3) who received dupilumab and their age- and sex-matched comparators (Patients 4–9) who did not receive dupilumab are listed in Table 2.

Patient 1 was a male diagnosed with EGPA at 40 years of age. At diagnosis, the patient presented with asthma, sinusitis, nasal polyps, eosinophilia, skin vasculitis with eosinophil infiltration and peripheral nervous system (PNS) involvement. The follow-up duration, defined as the period from the date of EGPA diagnosis to the last follow-up, was 63.5 months. Dupilumab was initiated during follow-up for the treatment of refractory asthma, with an exposure duration (from dupilumab initiation to the last follow-up) of 45 months. The patient demonstrated improvement in asthma with no evidence of worsening vasculitic phenotypes (skin and PNS manifestations). In particular, the annualised rate of asthma exacerbations and forced expiratory volume in 1 s (FEV1) before dupilumab initiation were 1.30 per year and 2.37 L (61.0% of predicted value), respectively, which improved to 0 per year and 2.99 L (78.6% of predicted value), respectively, after dupilumab initiation.

In contrast, of the two matched comparators who did not receive dupilumab (Patients 4 and 5), one patient (Patient 4) exhibited refractory eosinophilic phenotypes, particularly persistent sinusitis. Notably, in Patient 1, the disease activity and other clinical outcomes improved following dupilumab initiation: the BVAS decreased from 15 to 0; eosinophil count decreased from 1940 to 240/mm^3; ESR decreased from 20 to 11 mm/h and CRP decreased from 7.6 to 0.7 mg/L (Figure 2).

Patient 2 was a female diagnosed with EGPA at 37 years of age. At the time of diagnosis, she presented with asthma, sinusitis, nasal polyp, eosinophilia, skin vasculitis and PNS involvement. During the 48-month follow-up period, dupilumab was initiated for the treatment of refractory asthma with an exposure duration of 13 months. The patient showed improvement in asthma without aggravation of vasculitic phenotypes (skin and PNS manifestations). The annualised rate of asthma exacerbations and FEV1 before dupilumab initiation were 0.34 per year and 1.77 L (52.5% of predicted value), respectively, which improved to 0 per year and 2.04 L (62.7% of predicted value), respectively, after dupilumab initiation. The two comparators (Patients 6 and 7) not receiving dupilumab also exhibited no aggravation of eosinophilic and vasculitic phenotypes. Moreover, inPpatient 2, the disease activity and other clinical outcome measures improved after the initiation of dupilumab: the BVAS decreased from 6 to 0; eosinophil count decreased from 740 to 140/mm^3; ESR decreased from 13 to 5 mm/h and CRP from 0.1 to 0.1 mg/L (Figure 2).

Patient 3 was a female diagnosed with EGPA at 25 years of age. At diagnosis, the patient presented with asthma, sinusitis, nasal polyps, eosinophilia, atopic dermatitis, skin vasculitis and kidney involvement. The follow-up duration was 40 months. Dupilumab was initiated during follow-up for the treatment of refractory atopic dermatitis, with an exposure duration of 4 months. The patient demonstrated improvement in atopic dermatitis without evidence of worsening vasculitic phenotypes (skin and renal manifestations). In addition, the annualised rate of asthma exacerbations and FEV1 before dupilumab initiation were 0 per year and 2.14 L (69.2% of predicted value), respectively, and 0 per year and 2.21 L (71.8% of predicted value), respectively, after dupilumab initiation, indicating a stable state of asthma.

In comparison, of the two matched comparators who did not receive dupilumab (Patients 8 and 9), one patient (Patient 8) experienced a flare of eosinophilic phenotypes, particularly sinusitis. Furthermore, in Patient 3, the disease activity and other clinical outcomes improved following dupilumab initiation: the BVAS decreased from 8 to 2; eosinophil count decreased from 240 to 150/mm^3; ESR decreased from 13 to 4 mm/h and CRP decreased from 2.4 to 0.5 mg/L (Figure 2).

4 | Discussion

In this study, we retrospectively analysed the clinical outcomes of nine patients with EGPA who received conventional treatment with or without dupilumab to assess its impact on disease activity and vasculitic phenotypes. Dupilumab administration was associated with clinical improvements in the BVAS, peripheral eosinophil counts, ESR and serum CRP levels, without evidence of worsening vasculitic manifestations. Notably, among age- and sex-matched control patients who did not receive dupilumab, some experienced worsening eosinophilic phenotypes, underscoring the potential therapeutic value of dupilumab. These findings suggest that dupilumab may provide therapeutic benefits in EGPA by stabilising disease activity through eosinophilic manifestation control while maintaining vasculitic manifestation stability.

IL-4 and IL-13 play crucial roles in eosinophil trafficking, activation and tissue infiltration, particularly in allergic inflammation [20]. Although vasculitic phenotypes in EGPA have traditionally been associated with ANCA-mediated endothelial damage [2, 4], emerging evidence suggests that Th2 cytokines may also contribute to vascular inflammation. IL-4 and IL-13 upregulate adhesion molecules and promote eosinophil–endothelial interactions [21], potentially contributing to small vessel inflammation. By inhibiting IL-4 and IL-13 signalling, dupilumab may reduce eosinophil-mediated endothelial damage, thereby stabilising vasculitic manifestations. This mechanism could explain why vasculitic phenotypes remained stable in our study patients. However, the precise mechanisms require further investigation to elucidate the role of Th2 cytokines in vasculitic processes.

Patient 1 demonstrated sustained asthma improvement without exacerbation of vasculitic phenotypes (skin and PNS manifestations) during extended dupilumab therapy (45 months). Given that PNS involvement represents a life-threatening manifestation of EGPA [6], this prolonged disease stability is significant. In contrast, an age- and sex-matched control patient (Patient 4) who did not receive dupilumab developed refractory sinusitis, demonstrating the efficacy of dupilumab in controlling the eosinophilic phenotype. Disease activity markedly improved after dupilumab initiation, with the BVAS decreasing from 15 to 0. These outcomes suggest that IL-4 and IL-13 blockade may contribute to long-term disease control in certain patients with EGPA, warranting investigation in larger cohorts.

Similarly, Patient 2 exhibited improved asthma control without deterioration of vasculitic phenotypes (skin and PNS manifestations) over 13 months of treatment, with the BVAS decreasing from 6 to 0. These results further support the potential role of dupilumab in disease stabilisation through effective management of allergic and eosinophilic disease components. Although

TABLE 2 | Characteristics of EGPA patients receiving conventional therapy with or without dupilumab.

Patient number	Sex	Age at diagnosis (years)	Eosinophilic manifestations at diagnosis	Vasculitic manifestations at diagnosis	Follow-up duration (months)	Target of dupilumab	Follow-up duration from dupilumab initiation (months)	Outcome
1	M	40	Asthma Sinusitis Nasal polyp with eosinophil infiltration Eosinophilia	Skin vasculitis PNS involvement	63.5	Refractory asthma	45	Improvement of asthma No aggravation of vasculitic manifestation
2	F	37	Asthma Sinusitis Nasal polyp Eosinophilia	Skin vasculitis PNS involvement	48	Refractory asthma	13	Improvement of asthma No aggravation of vasculitic manifestation
3	F	25	Asthma Sinusitis Nasal polyp Eosinophilia Atopic dermatitis	Skin vasculitis Renal involvement	40	Refractory atopic dermatitis	4	Improvement of atopic dermatitis No aggravation of vasculitic manifestation
4	M	45	Sinusitis Eosinophilia Myocarditis	Renal involvement	62.7	N/A	N/A	Refractory sinusitis No aggravation of vasculitic manifestation
5	M	41	Asthma Eosinophilia	Skin vasculitis PNS involvement	204.5	N/A	N/A	No aggravation of eosinophilic manifestations No aggravation of vasculitic manifestations
6	F	38	Asthma Sinusitis Eosinophilia	PNS involvement Renal involvement	46.3	N/A	N/A	No aggravation of eosinophilic manifestations No aggravation of vasculitic manifestations
7	F	39	Asthma Sinusitis Eosinophilia	PNS involvement	77.1	N/A	N/A	No aggravation of eosinophilic manifestations No aggravation of vasculitic manifestations
8	F	24	Asthma Sinusitis Eosinophilia	PNS involvement Renal involvement	20.3	N/A	N/A	Flare of sinusitis No aggravation of vasculitic manifestation
9	F	30	Asthma Sinusitis Eosinophilia	Skin vasculitis PNS involvement	59.6	N/A	N/A	No aggravation of eosinophilic manifestations No aggravation of vasculitic manifestations

Abbreviations: EGPA, eosinophilic granulomatosis with polyangiitis; N/A, not applicable; PNS, peripheral nervous system.

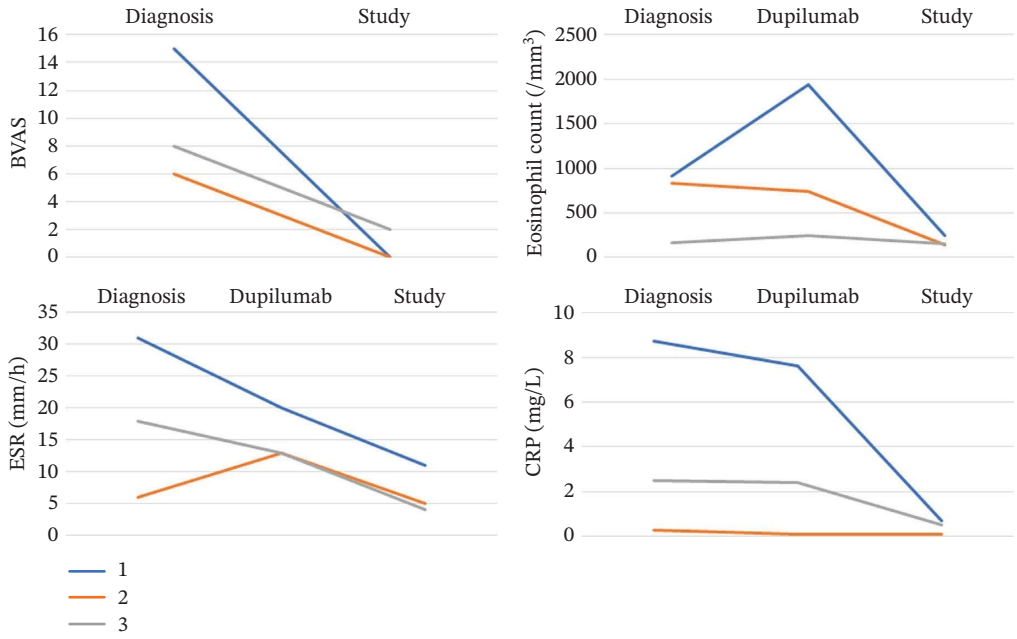

FIGURE 2 | Effect of dupilumab on clinical outcomes. ESR: erythrocyte sedimentation rate; CRP: C-reactive protein and BVAS: The Birmingham Vasculitis Activity Score.

the exposure duration was shorter than that of Patient 1, these findings highlight the need to explore whether IL-4/IL-13 inhibition provides protection against vasculitic phenotypes in EGPA.

Despite a relatively brief dupilumab exposure period (4 months), Patient 3 demonstrated a substantial reduction in the BVAS (from 8 to 2) without experiencing aggravation of vasculitic phenotypes (skin and renal manifestations). While one might attribute the absence of vasculitic phenotype progression to the brief treatment duration, previous literature has documented vasculitic phenotype development after merely one or two dupilumab doses in patients with asthma or sinusitis [14, 15]. Therefore, 4 months represents an adequate duration for assessing the influence of dupilumab on vasculitic phenotype progression. Furthermore, while an age- and sex-matched control patient (Patient 8) developed sinusitis flare (eosinophilic phenotype), Patient 3 showed marked improvement in atopic dermatitis, suggesting that dupilumab augmentation of conventional treatment may enhance eosinophilic phenotype control.

Previous research has raised concerns regarding paradoxical eosinophilia and potential EGPA relapse following dupilumab initiation, possibly due to rebound eosinophilia secondary to IL-4/IL-13 signalling blockade [13]. However, our cohort showed neither EGPA manifestation deterioration nor peripheral eosinophilia exacerbation after dupilumab initiation. These divergent outcomes may reflect differences in patient selection, disease activity status at treatment initiation and concurrent therapies, highlighting the necessity of careful patient selection for dupilumab therapy in EGPA.

Despite the significant observations made, this study also had some limitations. First, the small sample size limits the generalisability of our findings. Second, the observational study design precludes definitive conclusions regarding the efficacy of dupilumab in EGPA. Third, the heterogeneous treatment durations among the three patients introduce variability in the observed outcomes. Fourth, due to the retrospective nature of this study, we lack data on validated ENT outcome measures such as nasal polyp score, Lund–Kennedy endoscopic score and sino-nasal outcome test-22, which would have provided a more systematic assessment of the ENT outcomes. Despite these constraints, our study provides valuable preliminary insights into the potential role of dupilumab in EGPA management and emphasises the need for additional research.

5 | Conclusions

In conclusion, our findings suggest that dupilumab may help control the allergic and eosinophilic components of EGPA, thereby contributing to overall disease activity management without exacerbating vasculitic phenotypes. Large-scale prospective studies are necessary to confirm the efficacy of dupilumab in EGPA treatment.

Acknowledgements

The authors have nothing to report.

Funding

This study was funded by a faculty research grant of Yonsei University College of Medicine, Seoul, Republic of Korea (6-2023-0155), Eisai Korea Inc. Seoul, Republic of Korea (4-2024-0700), and Samsung Bioepis Co., Ltd., Incheon, Republic of Korea (4-2025-1066).

Disclosure

The funder was not involved in the study design, collection, analysis, interpretation of data, the writing of this article, or the decision to submit it for publication. Therefore, we disclose that these analyses were prespecified and conducted independently.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

1. D. Nakazawa, S. Masuda, U. Tomaru, and A. Ishizu, "Pathogenesis and Therapeutic Interventions for ANCA-Associated Vasculitis," *Nature Reviews Rheumatology* 15, no. 2 (2019): 91–101, https://doi.org/10.1038/s41584-018-0145-y.

2. J. White and S. Dubey, "Eosinophilic Granulomatosis With Polyangiitis: A Review," *Autoimmunity Reviews* 22, no. 1 (2023): 103219, https://doi.org/10.1016/j.autrev.2022.103219.

3. G. Trivioli, B. Terrier, and A. Vaglio, "Eosinophilic Granulomatosis With Polyangiitis: Understanding the Disease and Its Management," *Rheumatology* 59, no. Supplement_3 (2020): iii84–iii94, https://doi.org/10.1093/rheumatology/kez570.

4. B. Jakiela, W. Szczeklik, H. Plutecka, et al., "Increased Production of IL-5 and Dominant Th2-Type Response in Airways of Churg-Strauss Syndrome Patients," *Rheumatology* 51, no. 10 (2012): 1887–1893, https://doi.org/10.1093/rheumatology/kes171.

5. S. A. Chung, C. A. Langford, M. Maz, et al., "American College of Rheumatology/Vasculitis Foundation Guideline for the Management of Antineutrophil Cytoplasmic Antibody-Associated Vasculitis," *Arthritis & Rheumatology* 73, no. 8 (2021): 1366–1383, https://doi.org/10.1002/art.41773.

6. B. Hellmich, B. Sanchez-Alamo, J. H. Schirmer, et al., "EULAR Recommendations for the Management of ANCA-Associated Vasculitis: 2022 Update," *Annals of the Rheumatic Diseases* 83, no. 1 (2024): 30–47, https://doi.org/10.1136/ard-2022-223764.

7. B. Terrier, D. R. W. Jayne, B. Hellmich, et al., "Clinical Benefit of Mepolizumab in Eosinophilic Granulomatosis With Polyangiitis for Patients With and Without a Vasculitic Phenotype," *ACR Open Rheumatology* 5, no. 7 (2023): 354–363, https://doi.org/10.1002/acr2.11571.

8. M. Kiene, E. Csernok, A. Müller, C. Metzler, A. Trabandt, and W. L. Gross, "Elevated Interleukin-4 and Interleukin-13 Production by T Cell Lines From Patients With Churg-Strauss Syndrome," *Arthritis & Rheumatism* 44, no. 2 (2001): 469–473, https://doi.org/10.1002/1529-0131(200102)44:2%3c469::aid-anr66%3e3.0.co;2-0.

9. J. Zwerina, R. Axmann, M. Jatzwauk, E. Sahinbegovic, K. Polzer, and G. Schett, "Pathogenesis of Churg-Strauss Syndrome: Recent Insights," *Autoimmunity* 42, no. 4 (2009): 376–379, https://doi.org/10.1080/08916930902832348.

10. B. Hellmich, E. Csernok, and W. L. Gross, "Proinflammatory Cytokines and Autoimmunity in Churg-Strauss syndrome," *Annals of the New York Academy of Sciences* 1051, no. 1 (2005): 121–131, https://doi.org/10.1196/annals.1361.053.

11. K. F. Rabe, P. Nair, G. Brusselle, et al., "Efficacy and Safety of Dupilumab in Glucocorticoid-Dependent Severe Asthma," *New England Journal of Medicine* 378, no. 26 (2018): 2475–2485, https://doi.org/10.1056/nejmoa1804093.

12. C. Bachert, J. K. Han, M. Desrosiers, et al., "Efficacy and Safety of Dupilumab in Patients With Severe Chronic Rhinosinusitis With Nasal Polyps (Liberty NP Sinus-24 and Liberty NP Sinus-52): Results From Two Multicentre, Randomised, Double-Blind, Placebo-Controlled, Parallel-Group Phase 3 Trials," *Lancet* 394, no. 10209 (2019): 1638–1650, https://doi.org/10.1016/s0140-6736(19)31881-1.

13. B. Molina, R. Padoan, M. L. Urban, et al., "Dupilumab for Relapsing or Refractory Sinonasal and/or Asthma Manifestations in Eosinophilic Granulomatosis With Polyangiitis: A European Retrospective Study," *Annals of the Rheumatic Diseases* 82, no. 12 (2023): 1587–1593, https://doi.org/10.1136/ard-2023-224756.

14. P. Persaud, R. Karmali, P. Sankar, and M. Majid, "Dupilumab-Associated Eosinophilic Granulomatosis With Polyangiitis," *Cureus* 14, no. 8 (2022): e27670, https://doi.org/10.7759/cureus.27670.

15. I. Suzaki, A. Tanaka, R. Yanai, et al., "Eosinophilic Granulomatosis With Polyangiitis Developed After Dupilumab Administration in Patients With Eosinophilic Chronic Rhinosinusitis and Asthma: A Case Report," *BMC Pulmonary Medicine* 23, no. 1 (2023): 130, https://doi.org/10.1186/s12890-023-02415-6.

16. K. Yamazaki, T. Nomizo, K. Hatanaka, N. Hayama, T. Oguma, and K. Asano, "Eosinophilic Granulomatosis With Polyangiitis After Treatment With Dupilumab," *The Journal of Allergy and Clinical Immunology Global* 1, no. 3 (2022): 180–182, https://doi.org/10.1016/j.jacig.2022.03.006.

17. P. G. Park, J. Yoon, Y. B. Park, and S. W. Lee, "A New Formula Consisting of the Initial Independent Predictors of All-Cause Mortality Derived From a Single-Centre Cohort of Antineutrophil Cytoplasmic Antibody-Associated Vasculitis," *Journal of Clinical Medicine* 14, no. 3 (2025): 779, https://doi.org/10.3390/jcm14030779.

18. P. C. Grayson, C. Ponte, R. Suppiah, et al., "American College of Rheumatology/European Alliance of Associations for Rheumatology Classification Criteria for Eosinophilic Granulomatosis With Polyangiitis," *Annals of the Rheumatic Diseases* 81, no. 3 (2022): 309–314, https://doi.org/10.1136/annrheumdis-2021-221794.

19. C. Mukhtyar, R. Lee, D. Brown, et al., "Modification and Validation of the Birmingham Vasculitis Activity Score (Version 3)," *Annals of the Rheumatic Diseases* 68, no. 12 (2009): 1827–1832, https://doi.org/10.1136/ard.2008.101279.

20. I. S. Junttila, "Tuning the Cytokine Responses: An Update on Interleukin (IL)-4 and IL-13 Receptor Complexes," *Frontiers in Immunology* 9 (2018): 888, https://doi.org/10.3389/fimmu.2018.00888.

21. K. Nakagome and M. Nagata, "The Possible Roles of IL-4/IL-13 in the Development of Eosinophil-Predominant Severe Asthma," *Biomolecules* 14, no. 5 (2024): 546, https://doi.org/10.3390/biom14050546.