



OPEN ACCESS

EDITED BY

Ya-gang Zuo,
Peking Union Medical College Hospital
(CAMS), China

REVIEWED BY

Xiaoguang Li,
Daqing Oilfield General Hospital, China
Filip Rob,
Charles University, Czechia

*CORRESPONDENCE

Jianmin Chang
✉ changjm0417@126.com

RECEIVED 22 June 2025

REVISED 11 January 2026

ACCEPTED 14 January 2026

PUBLISHED 06 February 2026

CITATION

Chen Y, Sun K and Chang J (2026)
Dupilumab treatment outcomes in bullous
pemphigoid: a systematic review and
single-arm meta-analysis.
Front. Immunol. 17:1651543.
doi: 10.3389/fimmu.2026.1651543

COPYRIGHT

© 2026 Chen, Sun and Chang. This is an
open-access article distributed under the terms
of the [Creative Commons Attribution License
\(CC BY\)](https://creativecommons.org/licenses/by/4.0/). The use, distribution or reproduction
in other forums is permitted, provided the
original author(s) and the copyright owner(s)
are credited and that the original publication
in this journal is cited, in accordance with
accepted academic practice. No use,
distribution or reproduction is permitted
which does not comply with these terms.

Dupilumab treatment outcomes in bullous pemphigoid: a systematic review and single-arm meta-analysis

Yudi Chen, Kailv Sun and Jianmin Chang*

Department of Dermatology, Beijing Hospital, National Center of Gerontology, Institute of Geriatric
Medicine, Chinese Academy of Medical Sciences, Beijing, China

Background: Bullous pemphigoid (BP) is the most common autoimmune subepidermal bullous disease of the skin. Novel biologic agents represent a potential therapeutic option. We explore the use of dupilumab in the treatment of BP.

Methods: Relevant studies published up to Oct. 20th, 2025 were systematically searched using PubMed, Web of Science, Embase, and Cochrane Library. Proportion rates of complete response and disease control were analyzed to determine treatment effects. Data were quantitatively synthesized using a random-effects meta-analysis. Meanwhile, we also conducted statistics on adverse events.

Results: A total of 587 patients from 24 studies were included. Pooled analysis revealed a complete response rate of 68% (95% CI 60%~78%) and disease control rate of 95% (95%CI 92%~98%) in BP treated with dupilumab with/without other systemic therapy. Notably, complete response rate achieved 63% (95% CI 49%~81%) in patients with dupilumab without other systemic therapy. A total of 112 adverse events were reported in 97 patients. Most adverse events were mild and did not lead to treatment discontinuation.

Conclusion: This meta-analysis highlights the efficacy and safety of dupilumab in patients with BP, offering valuable evidence to guide future clinical practice.

Systematic review registration: <https://www.crd.york.ac.uk/PROSPERO/>, identifier CRD420251048550.

KEYWORDS

biologics, bullous pemphigoid, dupilumab, single-arm meta-analysis, systematic review

1 Introduction

Bullous pemphigoid (BP) is the most common autoimmune subepidermal blistering dermatosis, which typically develops in patients older than 70 years (1). The global incidence of BP was reported as 0.0419 per 1000 person-years (2). The severity of itch and cutaneous

lesions significantly disturbs the quality of life in affected patients. BP is mediated by tissue-bound and circulating autoantibodies directed against BP antigen 180 (BP180) and BP antigen 230 (BP230) which are hemidesmosomes proteins (1). Recent evidence has linked the pathogenesis of BP to Th2 inflammation, and this relationship is mediated by Th2-related cytokines, such as interleukin(IL)-4 and IL-13 which are found elevated in the skin, sera and blister fluid of BP patients. Studies identified that these Th2-related cytokines could induce IgE production in B cells contributing to the loss of tolerance against BP antigens and eosinophilia (3).

Dupilumab inhibits both IL-4 and IL-13 signaling by blocking the IL-4 receptor alpha subunit. Dual blockade of IL-4 and IL-13 elicits two key anti-inflammatory effects: it not only impedes the migration and subsequent recruitment of eosinophils to inflammatory foci, but also restricts B-cell proliferation and class-switching, ultimately resulting in decreased IgE production (3). Decreased eosinophil infiltration at inflammatory sites markedly mitigates pruritus driven by eosinophil degranulation. Concurrently, diminished IgE synthesis not only abrogates its T-cell activation-promoting capacity, but also attenuates degranulation of eosinophils and mast cells, leading to amelioration of erythema, blisters and pruritus in patients (4).

Systemic corticosteroids are widely used in the treatment of bullous pemphigoid, which is recommended by several clinical practice guidelines (1, 5, 6). However, long-term application of corticosteroids may cause serious side effects, especially in elderly population. New therapeutic pharmacologic biologic agents such as dupilumab can selectively inhibit inflammatory cascade and it may be a safer and effective treatment option. Satisfactory therapeutic effect of dupilumab in BP has been observed in several studies (please refer to the [Supplementary Table S2](#)).

To date, there remains a paucity of meta-analyses addressing dupilumab use in BP. No randomized controlled trial (RCT) on dupilumab for BP has been published up till now. Additionally, the potential severity of the disease poses significant challenges for conducting randomized placebo-controlled trials in this patient population. Based on the clinical studies that have been published so far, we conducted a single-arm meta-analysis assessing the efficacy and safety of dupilumab in BP to provide comprehensive evidence for clinical practice.

2 Methods

The systematic review was performed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (7). The study protocol has been registered with PROSPERO (CRD420251048550).

2.1 Data sources and search strategy

Two authors (Y.D.C. and K.L.S.) conducted a bibliographic search of all articles published up to Oct. 20th, 2025 using PubMed, Web of Science, Embase, and Cochrane Library. Search terms included combinations of terms related to dupilumab, bullous

pemphigoid (BP), and clinical trials. To ensure thoroughness, we also reviewed references from relevant published studies and review articles to address any gaps in the keyword search. The complete search strategy can be found in [Supplementary Table S1](#).

2.2 Eligibility criteria and study selection

Inclusion criteria were (1): RCTs, single-arm trials, observational studies and case series involving patients with BP regardless of disease severity (2): studies involving dupilumab treatment for BP (3): studies reporting resolution outcomes on biologic treatment. Irrelevant studies were excluded based on the following criteria (1): duplicate studies from the same trials (2): reviews, case reports or case series with sample size less than 5, clinical guidelines, protocols and conference abstracts (3): publications did not report resolution outcome (4): publications written in languages other than English.

Two authors (Y.D.C. and K.L.S.) independently screened all potentially eligible studies. Full texts were assessed for eligibility when abstracts provided insufficient information. Any discrepancies were resolved through group discussion with the senior author (J.M.C.).

2.3 Data extraction

For each selected study, the following information was extracted: first author, publication year, study design, region, sample size, sex, age, BP duration, potential trigger, treatment regimens, resolution outcomes (complete remission, disease control, no remission, deterioration), baseline Bullous Pemphigoid Disease Activity Index (BPDAI), and adverse events. If a study didn't report data on a specific demographic characteristic, the data from that study shall be excluded from the descriptive statistics of this demographic characteristic. And it will be marked as "NR" as shown in [Table 1](#), [Supplementary Table S2](#).

Resolution outcomes on treatment are defined as follows (1). complete remission: The total resolution of BP lesions. The publications use the terms "complete remission", "complete response", "complete control", or "symptom-free" (2). partial remission: Improvement yet lack the complete resolution of BP lesions. The publications use the terms "partial remission", "partial response", "improved", and "clinical improvement" (3). disease control: New lesions cease to form and established lesions begin to heal. Both "complete remission" and "partial remission" can be regarded as "disease control" (4). no remission: No changes in BP lesions. The publications use the terms "no resolution" or "no response" (5). deterioration: Exacerbation of BP lesions.

2.4 Risk of bias and statistical analysis

ROBINS-I tool was used to assess risk of bias in non-randomized studies (8). Statistical information, including the

TABLE 1 Summary of demographic information.

Demographics	N=587
Age, y	
Mean	75.1
Range	35~101
NR, n (%)	36 (6.1)
Sex, n (%)	
Female	241 (41.1)
Male	310 (52.8)
NR	36 (6.1)
BP duration, months	
Mean	19.2
Range	0.5~180
NR, n (%)	72 (12.3)
BPDAl at baseline	
Mean	50.6
NR, n (%)	376 (64.1)
Treatment outcomes, n (%)	
Complete response ^a	330 (56.8)
Disease control ^b	439 (90.7)
Drug-induced BP, n (%)	
117 (19.9)	
immunotherapy-associated	35 (29.9)
DPP-4 inhibitor-associated	32 (27.4)
Diuretic-associated	28 (23.9)
ACEI-associated	18 (15.4)
NR	4 (3.4)
Patients with no other systemic therapy, n (%)	
179 (30.5)	
Patients with concomitant systemic therapy, n (%)	
408 (69.5)	
Systemic corticosteroids, n (%)^c	
304 (74.5)	
Antibiotics	
Doxycycline, n (%)	20 (4.9)
Minocycline, n (%)	138 (33.8)
Dapsone, n (%)	11 (2.7)
Immunosuppressants	
Methotrexate, n (%)	15 (3.7)
Azathioprine, n (%)	15 (3.7)
Cyclosporine, n (%)	3 (0.7)
Cyclophosphamide, n (%)	1 (0.2)

(Continued)

TABLE 1 Continued

Demographics	N=587
Patients with concomitant systemic therapy, n (%)	
408 (69.5)	
Mycophenolate mofetil, n (%)	7 (1.7)
Tacrolimus, n (%)	3 (0.7)
Biologics	
Omaliuzumab	1 (0.2)
Others	
Tripterysium glycosides tablets, n (%)	16 (3.9)
Niacinamide, n (%)	7 (1.7)
Thalidomide, n (%)	1 (0.2)
Albumin, n (%)	2 (0.4)
Immunoglobulin, n (%)	4 (1.0)
Antihistamine, n (%)	1 (0.2)
NR, n (%)	42 (10.3)

^aThe study of *Jinghui Li 2024* did not report complete response rate (n=6).^bThe study of *Planella-Fontanillas 2024* (n=103) did not report disease control rate.^cProportion of number of patients using each concomitant systemic therapy in all patients with concomitant systemic therapy.

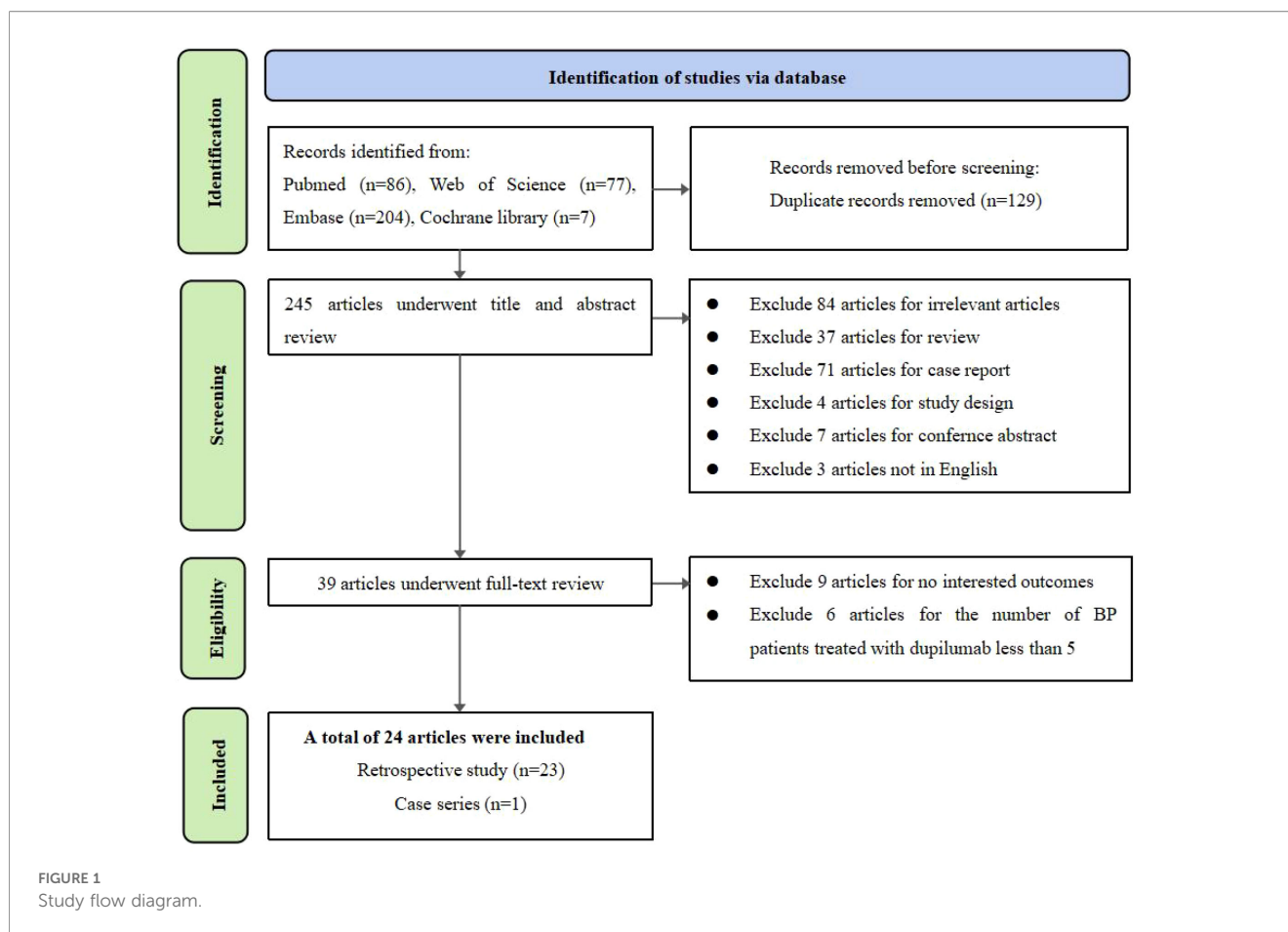
ACEI, angiotensin-converting enzyme inhibitor; BP, bullous pemphigoid; BPDAl, Bullous Pemphigoid Disease Activity Index; DPP-4, dipeptidyl peptidase-4; NR, not reported.

single-arm proportion rate of the outcomes and 95% confidence intervals (CIs), was analyzed to determine treatment effects. Heterogeneity was assessed using I^2 values. Data of resolution outcomes were quantitatively synthesized using a random-effects meta-analysis. All tests were two-sided, and a p-value < 0.05 was considered significant. Sensitivity analyses were conducted to assess the robustness and reliability of the combined results. Analyses were performed using R statistical software version 4.2.3.

3 Results

3.1 Study characteristics

Our search identified 245 potentially relevant non-duplicate articles. All studies were reviewed by title and abstract. Subsequently, 206 articles were excluded because they did not fulfill inclusion criteria. The remaining 39 studies were evaluated in full length. As 9 articles (*Greenberg 2025, Jin 2025, Liang 2025, Huang 2023, Bin 2023, Lukac 2023, Yang 2022, Bur 2022, Phillips 2019*) did not report the proportion or number of BP patients achieved “complete remission” or “partial remission” or “disease control” under dupilumab therapy, these 9 articles were excluded (9–17). Meanwhile, as 5 articles (*Svara 2025, Young 2024, Oren-Shabtai 2023, Merli 2023, Liu 2021*) only contained 1 participate and 1 article (*Lo 2022*) only contained 4 participates receiving dupilumab therapy, these articles were also excluded (18–23). Finally, 24 studies fulfilled all of the eligibility criteria and were



included in our systematic review (Figure 1). All of the included studies were non-randomized studies, including 23 retrospective studies and 1 case series. Detailed information is summarized in Supplementary Table S2. ROBINS-I was utilized for assessing risk of bias of included studies. Detailed information can be found in Supplementary Table S3.

3.2 Demographic characteristics

The 24 included studies were performed on 587 adult patients with BP. Among these 587 patients (mean age were 75.1 years old, ranging from 35 to 101 years old), 41.1% (n=241/587) were women, 52.8% (n=310/587) were men, and 6.1% (n=36/587) had no gender information. Mean BP duration was 19.2 months (ranging from 0.5 to 180 months). Drug-induced BP were reported in 117 (19.9%) patients, resulting from immunotherapy, dipeptidyl peptidase-4 (DPP-4) inhibitors, diuretics, angiotensin-converting enzyme inhibitors, etc. During dupilumab treatment period, a total of 179 (30.5%) patients received no other systemic therapy. The rest 408 (69.5%) patients received at least one concomitant systemic therapy, including systemic corticosteroids, antibiotics (doxycycline, minocycline, or dapson), immunosuppressants, tripterygium

glycosides tablets, etc. The demographic characteristics are summarized in Table 1.

3.3 Treatment outcomes

The study of *Jinghui Li 2024* (n=6) did not report complete response rate (24). Therefore, a total of 23 studies on 581 patients were included for the pooled analysis of proportion of complete response with/without other systemic therapy. We observed a complete response rate of 68% (95% CI 60%~78%) among these 581 patients (Figure 2).

The study of *Planella-Fontanillas 2024* (n=103) did not report disease control rate (25). Therefore, a total of 23 studies on 484 patients were included for the pooled analysis of proportion of disease control with/without other systemic therapy. We observed a disease control rate of 95% (95%CI 92%~98%) among these 484 patients (Figure 3).

Notably, 14 studies reported the treatment outcomes of patients with monotherapy of dupilumab. We excluded 5 studies in which number of participants using monotherapy less than 5 (24, 26–29). A total of 9 studies on 111 patients using dupilumab without other concomitant systemic therapy were included in the pooled analysis.

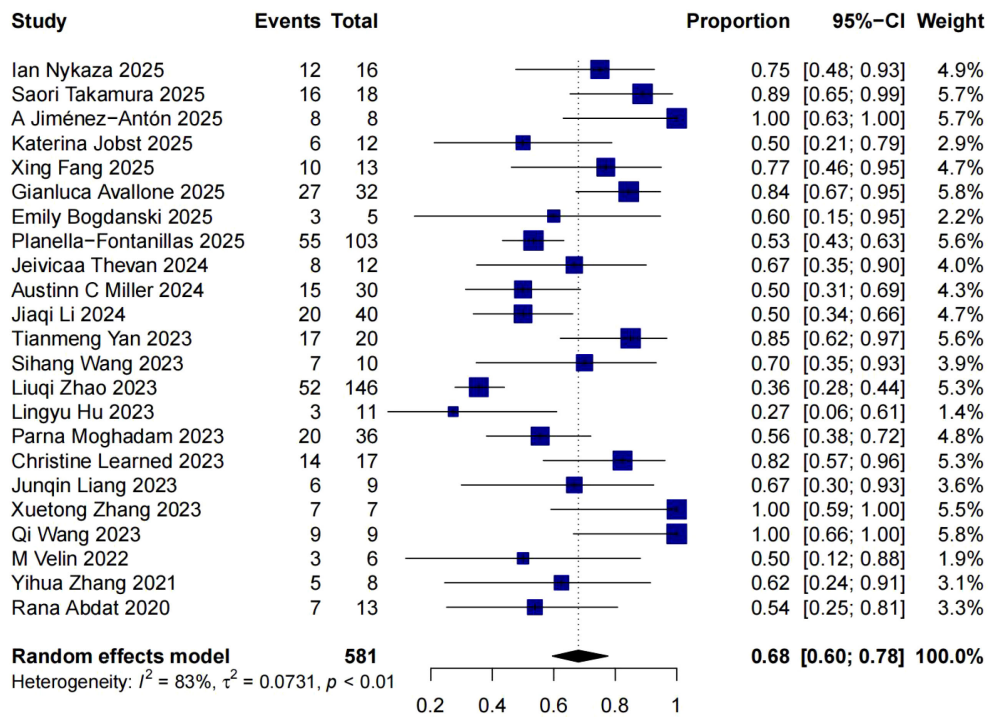


FIGURE 2 Pooled analysis of proportion of complete response with/without other systemic therapy.

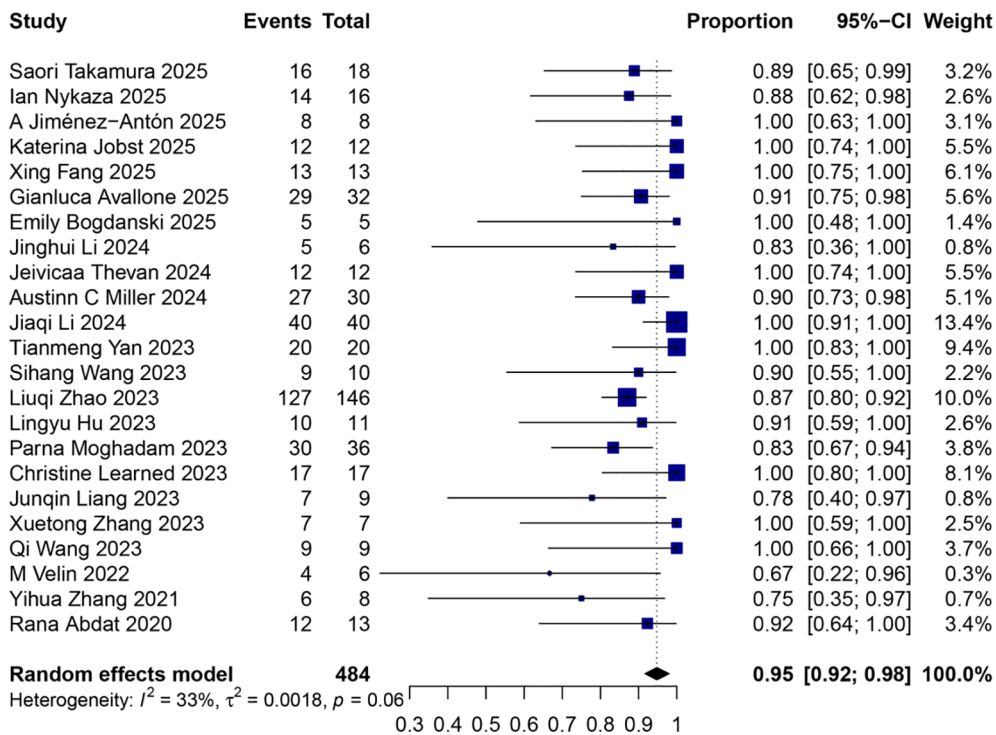
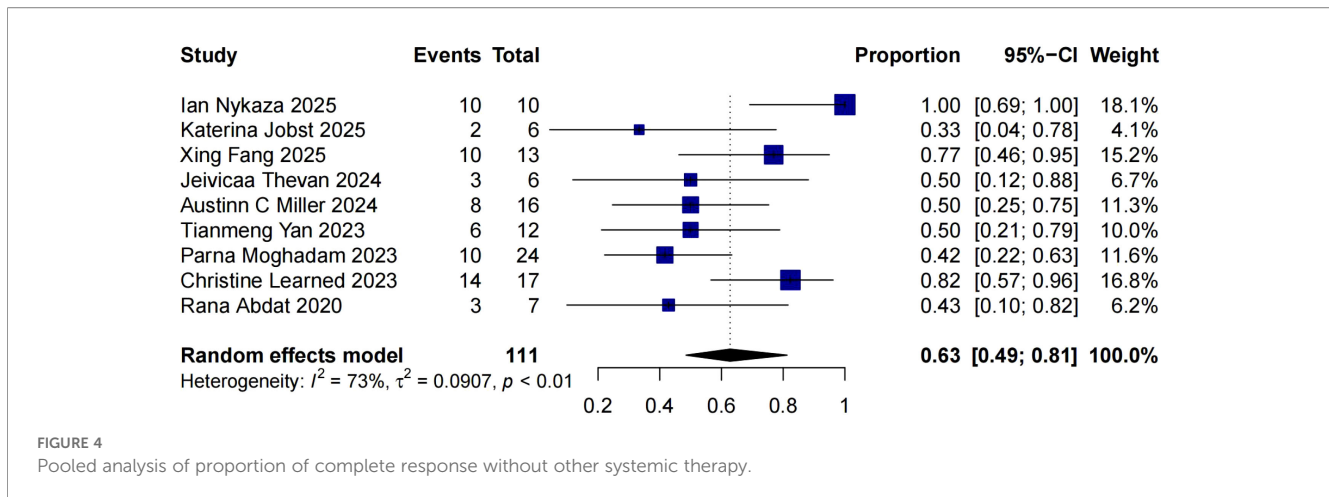


FIGURE 3 Pooled analysis of proportion of disease control with/without other systemic therapy.



We observed a complete response rate of 63% (95% CI 49%~81%) among these 111 patients (Figure 4).

3.4 Safety

Two studies did not provide information on adverse events (Jinghui Li 2024, n=6; Jiaqi Li 2024, n=40). Safety data were available for 541 patients, and 82.1% (n=444/541) of them reported no adverse events. A total of 112 adverse events were reported in the remaining 97 patients. Most adverse events were mild and did not lead to treatment discontinuation. The most common adverse events were skin and soft-tissue infections (n=17), eosinophilia (n=11), and diabetes (n=10). However, diabetes was considered more likely to be related to concomitant use of systemic corticosteroids. During the follow-up period, 17 deaths were reported, and none of them were associated with dupilumab treatment. Reports of adverse events are summarized in Table 2.

4 Discussion

This systematic review examines the effectiveness and safety of dupilumab in BP treatment.

For the treatment of bullous pemphigoid, systemic corticosteroids represent a widely used therapeutic option, and this approach is recommended in several clinical practice guidelines (1, 5, 6). However, the long-term use of systemic corticosteroids is also associated with relapse and increased mortality. Off-label immunosuppressants (e.g. methotrexate, azathioprine, mycophenolate mofetil) and antibiotics with anti-inflammatory properties (e.g. doxycycline, minocycline) can also be used. However, all of them are associated with various side effects and limited therapeutic efficacy.

The mechanisms of BP development are not completely understood. However, mounting evidence indicates that a type 2 inflammatory response may play a key role in BP development. Studies demonstrate elevated levels of the type 2 cytokines IL-4, IL-5 and IL-13, elevated levels of the chemokine eotaxin-1 and greater

numbers of eosinophils in BP lesions and peripheral blood as well as increased serum IgE in patients with BP (30). Dupilumab, a fully humanized monoclonal antibody, can block the shared receptor component for IL-4 and IL-13 which are key and central drivers for type 2 inflammation in multiple diseases.

Given these findings, dupilumab may be effective in BP. Several observational studies explored the use of dupilumab in BP. Cao et al. conducted a systemic review using descriptive statistics exploring efficiency of biologic treatment in BP in 2022 (31). In this systemic review, dupilumab led to complete remission in 66.7% (n=24/36) and partial remission in 19.4% (n=7/36) of patients without any reported adverse events in the 36 patients from 11 studies (including 7 case reports) included (31). What's more, Abduelmula et al. also conducted a descriptive systemic review in 2022 (32). Abduelmula et al. included 39 patients from 12 studies (including 8 case reports) using dupilumab with/without other systemic therapy in BP, leading to complete remission in 82.1% (n=32/39) of patients (32). Previous reviews were systemic review using descriptive statistics which didn't apply meta-analysis of treatment outcomes. Reporting only a single value of "overall effective rate" fails to reflect the impact of inter-study heterogeneity on the results. Our study applied weighted pooled analysis of "effective rate" from different studies and excluded studies with excessively small sample sizes (n<5) to control the quality of included studies. Meta-analysis can report standardized effect sizes and 95% confidence intervals (95% CI) so as to reflect the relative differences in treatment efficacy and the precision of the results.

Given the limited studies in this field, Nunes da Silva et al. performed a meta-analysis of comparative studies of dupilumab combined with corticosteroids and conventional corticosteroid therapy alone in patients with moderate-to-severe bullous pemphigoid (33). This meta-analysis included 127 patients from 4 non-randomized studies, demonstrating dupilumab combined with corticosteroids a greater reduction in BPDAl compared with patients who received conventional therapy (33).

Results from our study are consistent with previous reports. Our study included more recent studies from 2022 to 2025, and quantitatively synthesized data from these researches (including 23

TABLE 2 Adverse events.

Adverse event	N=112
Injection site reactions	4
Skin and soft-tissue infections	17
Psoriasis or psoriasis flare-up	6
Rosacea	1
Seborrheic dermatitis	1
Alopecia areata	1
Scabies	1
Asthenia	1
Drowsiness	1
Diarrhea	1
Fever of unknown origin	2
Hypokalemia	1
Eosinophilia	11
Thrombocytopenia	1
Conjunctivitis or keratitis	4
Intracerebral hemorrhage	1
Heart failure	1
Pericardial effusion	1
Pneumonia	9
Pleural effusion	1
Diabetes	10
Renal dysfunction	1
Deep vein thrombosis	2
Arthromyalgia	4
Osteoporosis	6
Thrombosis in lower extremities	1
Unknown cause of infection	5
Death	17
Cause of death	
COVID-19	2
Pneumonia	2
Pulmonary embolism	1
Cardiovascular event	2
Metastatic melanoma	2
Postvaccination sudden death	1
NR	7

NR, not reported.

retrospective studies and 1 case series). Pooled analysis revealed a complete response rate of 68% (95% CI 60%~78%) and disease control rate of 95% (95% CI 92%~98%) in BP treated with dupilumab with/without other systemic therapy.

At present, dupilumab has no indication for bullous pemphigoid, and its clinical efficacy has not been verified in large-sample randomized controlled trials (RCTs). Therefore, it is often used in combination with oral glucocorticoids, immunosuppressants, or other therapies in clinical practice. However, in the studies included in our analysis, a subset of patients received dupilumab as the sole systemic therapeutic agent due to multiple factors such as elderly age or comorbidities, yet still achieved favorable clinical outcomes. Complete response rate achieved 63% (95% CI 49%~81%) in patients with dupilumab without other systemic therapy.

Furthermore, we observed that 17.9% (n=97/541) of patients experienced adverse events (AEs), while most AEs were mild and did not lead to treatment discontinuation. Some of the AEs such as diabetes, osteoporosis and deep vein thrombosis are considered more related to concomitant use of systemic corticosteroids. Dupilumab generally have a strong safety profile for the treatment of BP.

Meanwhile, the first randomized controlled clinical trial (NCT04206553), designed to investigate the efficacy and safety of dupilumab in patients with BP is in progress (34). The results of this study will provide more information for the use of dupilumab in BP.

This study should be interpreted with several limitations. Information on specific demographic characteristics is not available for certain studies which is marked as “NR” in [Table 1](#), [Supplementary Table S2](#). If a study didn't report data on a specific demographic characteristic, the data from that study shall be excluded from the descriptive statistics of this demographic characteristic. As a result, there may be a discrepancy between the statistical data and the actual baseline situation.

Moderate heterogeneity may affect the reliability of the results. The included studies were sourced from 7 distinct countries and encompassed multiple ethnic populations, thus introducing potential demographic heterogeneity. In addition, it should be noted that 408 patients (69.5%) among the included subjects were concurrently receiving other systemic therapies. Besides, efficacy assessments across the included studies were based on investigator-reported outcomes, and inter-investigator variability may have existed in the evaluation of cutaneous symptoms including erythema, vesiculation and pruritus. Finally, the included clinical studies varied in follow-up duration, which may also have resulted in differences in the observation of treatment efficacy and adverse events.

What's more, publication bias is a common concern undermining the accuracy of meta-analyses. Studies with positive results are more likely to be published, while those with negative results may fail to be submitted or accepted. We plotted the funnel plot to assess the potential publication bias. As shown in [Supplementary files Figures S1-S3](#), funnel plot asymmetry observed in this study suggests the potential non-publication of small-sample studies with negative findings. More large-sample,

high-quality clinical studies should be performed in this field to further confirm the therapeutic efficacy of dupilumab.

No randomized controlled trials have yet been published in this field. Published studies are mostly single-center with limited sample size. And limited data on BP treated with dupilumab monotherapy is available. These limitations highlight the need for future studies to better address these issues.

5 Conclusion

This meta-analysis highlights the efficacy and safety of dupilumab in BP treatment, offering evidence for future clinical application. Future randomized controlled trials and well-designed observational studies with larger sample size are required to provide higher level evidence-based support.

Data availability statement

The original contributions presented in the study are included in the article/**Supplementary Material**. Further inquiries can be directed to the corresponding author.

Author contributions

YC: Data curation, Formal Analysis, Methodology, Software, Visualization, Writing – original draft. KS: Data curation, Writing – original draft, Formal Analysis. JC: Data curation, Supervision, Writing – review & editing, Conceptualization, Funding acquisition.

Funding

The author(s) declared that financial support was received for this work and/or its publication. The work was supported by

National High Level Hospital Clinical Research Funding (grant number BJ-2025-128).

Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declared that generative AI was not used in the creation of this manuscript.

Any alternative text (alt text) provided alongside figures in this article has been generated by Frontiers with the support of artificial intelligence and reasonable efforts have been made to ensure accuracy, including review by the authors wherever possible. If you identify any issues, please contact us.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fimmu.2026.1651543/full#supplementary-material>

References

- Borradori L, Van Beek N, Feliciani C, Tedbirt B, Antiga E, Bergman R, et al. Updated S2 K guidelines for the management of bullous pemphigoid initiated by the European Academy of Dermatology and Venereology (EADV). *J Eur Acad Dermatol Venereol*. (2022) 36:1689–704. doi: 10.1111/jdv.18220
- Persson MSM, Begum N, Grainge MJ, Harman KE, Grindlay D, Gran S. The global incidence of bullous pemphigoid: a systematic review and meta-analysis. *Br J Dermatol*. (2022) 186:414–25. doi: 10.1111/bjd.20743
- Liu T, Wang Z, Xue X, Wang Z, Zhang Y, Mi Z, et al. Single-cell transcriptomics analysis of bullous pemphigoid unveils immune-stromal crosstalk in type 2 inflammatory disease. *Nat Commun*. (2024) 15:5949. doi: 10.1038/s41467-024-50283-3
- Maglie R, Ugolini F, De Logu F, Nassini R, Simi S, Nardiello P, et al. Overexpression of helper T cell type 2-related molecules in the skin of patients with eosinophilic dermatosis of hematologic Malignancy. *J Am Acad Dermatol*. (2022) 87:761–70. doi: 10.1016/j.jaad.2021.07.007
- Ujiié H, Iwata H, Yamagami J, Nakama T, Aoyama Y, Ikeda S, et al. Japanese guidelines for the management of pemphigoid (including epidermolysis bullosa acquisita). *J Dermatol*. (2019) 46:1102–35. doi: 10.1111/1346-8138.15111
- Zuo Y, Jin H, Chen J, Dang N, Fu Q, Feng S, et al. Diagnosis and treatment of bullous pemphigoid: an expert consensus statement (2025 edition). *Chin J Dermatol*. (2025) 58:405–15. doi: 10.35541/cjd.20240622
- Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. (2021) 372:n71. doi: 10.1136/bmj.n71
- Sterne JA, Hernán MA, Reeves BC, Savović J, Berkman ND, Viswanathan M, et al. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. *BMJ*. (2016) 355:i4919. doi: 10.1136/bmj.i4919
- Greenberg ABW, Valido K, Vesely M, Leventhal JS. The treatment of cutaneous immune-related adverse events from immune checkpoint inhibitors with biologic therapy: A single-institution retrospective study at a tertiary care cancer center. *J Am Acad Dermatol*. (2025) 93:797–9. doi: 10.1016/j.jaad.2025.04.075
- Jin S, Jin S, Wang S, Wang P. Efficacy and safety of dupilumab in Chinese patients aged over 60 years with bullous pemphigoid and comorbidities. *Indian J Dermatol Venereol Leprol*. (2025) 12:1–3. doi: 10.25259/IJDVL_579_2025

11. Huang D, Zhang Y, Yu Y, Jiang Y, Kong L, Ding Y, et al. Long-term efficacy and safety of dupilumab for severe bullous pemphigoid: A prospective cohort study. *Int Immunopharmacol.* (2023) 125:111157. doi: 10.1016/j.intimp.2023.111157
12. Liang G, Qian H, Sun C, Zhang H, Li Z, Li S, et al. Dupilumab, corticosteroids and their combination for the treatment of bullous pemphigoid. *Bras Dermatol.* (2025) 100:243–52. doi: 10.1016/j.abd.2024.04.012
13. Bin A, Guo T, Wang X, Yao W, Li M, Zhang J. Clinical efficacy of dupilumab injection in combination with systemic low-dose hormones in the treatment of bullous pemphigoid. *Indian J Pharm Sci.* (2023) 85:204–9. doi: 10.36468/pharmaceutical-sciences.spl.798
14. Lukac D, Pagani K, McGee JS. Overview of use, efficacy, and safety of dupilumab in complex patients: a retrospective, case-series study from a large, urban academic center. *Arch Dermatol Res.* (2023) 315:1777–81. doi: 10.1007/s00403-022-02362-y
15. Yang J, Gao H, Zhang Z, Tang C, Chen Z, Wang L, et al. Dupilumab combined with low-dose systemic steroid therapy improves efficacy and safety for bullous pemphigoid. *Dermatol Ther.* (2022) 35:e15648. doi: 10.1111/dth.15648
16. Bur D, Patel AB, Nelson K, Huen A, Pacha O, Phillips R, et al. A retrospective case series of 20 patients with immunotherapy-induced bullous pemphigoid with emphasis on management outcomes. *J Am Acad Dermatol.* (2022) 87:1394–5. doi: 10.1016/j.jaad.2022.08.001
17. Phillips GS, Wu J, Hellmann MD, Postow MA, Rizvi NA, Freites-Martinez A, et al. Treatment outcomes of immune-related cutaneous adverse events. *J Clin Oncol.* (2019) 37:2746–58. doi: 10.1200/JCO.18.02141
18. Svava F, Gomes V, Battilotti C, Nicolò S, Sernicola A, Chello C, et al. Dupilumab as a therapeutic option in autoimmune bullous diseases following SARS-CoV-2 infection and COVID-19 vaccination: a comprehensive case series analysis. *Dermatol Ther.* (2025) 12:1–9. doi: 10.1155/dth/2257832
19. Young JN, Verma H, Kashlan N, Poplasky D, Lamb AJ, Guttman-Yassky E, et al. The use of biologic medications for the treatment of cutaneous immune-related adverse events secondary to immune checkpoint inhibitors: A single-institution real-life study. *JAAD Case Rep.* (2023) 2:1–3. doi: 10.1016/j.jcdr.2023.09.041
20. Oren-Shabtai M, Mimouni D, Nosrati A, Atzmony L, Kaplan B, Barzilai A, et al. Biological treatment for bullous pemphigoid. *Front Immunol.* (2023) 14:1157250. doi: 10.3389/fimmu.2023.1157250
21. Merli M, Accorinti M, Romagnuolo M, Marzano A, Di Zenzo G, Moro F, et al. Autoimmune bullous dermatoses in cancer patients treated by immunotherapy: a literature review and Italian multicentric experience. *Front Med (Laus).* (2023) 20:1208418. doi: 10.3389/fmed.2023.1208418
22. Liu X, Ma J, Qiu X, Hong D, Wang L, Shi Z. Dupilumab, an emerging therapeutic choice for recalcitrant subepidermal autoimmune bullous diseases: a case series of three patients. *Eur J Dermatol.* (2021) 31:846–7. doi: 10.1684/ejd.2021.4190
23. Lo J, Heberton M, Pacha O, Huen A, Patel AB. Biologic therapies for checkpoint inhibitor-induced cutaneous toxicities: a single-institution study of 17 consecutively treated patients. *Support Care Cancer.* (2022) 30:989–94. doi: 10.1007/s00520-021-06548-4
24. Li JH, Yang LY, Wang Y, Zuo YG. Clinical features of chinese patients with bullous pemphigoid induced by immune checkpoint inhibitors. *Zhongguo Yi Xue Ke Xue Yuan Xue Bao.* (2024) 46:872–82. doi: 10.3881/j.issn.1000-503X.16239
25. Planella-Fontanillas N, Bosch-Amate X, Jiménez Antón A, Moreno-Vilchez C, Guerrero MG, Blanes Martínez MDM, et al. Real-world evaluation of the effectiveness and safety of dupilumab in bullous pemphigoid: an ambispective multicentre case series. *Br J Dermatol.* (2025) 192:501–9. doi: 10.1093/bjd/ljae403
26. Hu L, Huang R, Jiang F, You S, Wu Q. Concomitant use of dupilumab with glucocorticoid in bullous pemphigoid reduces disease severity: A preliminary study. *Immun Inflammation Dis.* (2023) 11:e924. doi: 10.1002/iid3.924
27. Wang SH, Shan Y, Li SZ, Zuo YG. Anti-interleukin 4 receptor α antibody for the treatment of Chinese bullous pemphigoid patients with diverse comorbidities and a 1-year follow-up: a monocentric real-world study. *Front Immunol.* (2023) 14:1165106. doi: 10.3389/fimmu.2023.1165106
28. Zhang X, Man X, Tang Z, Dai R, Shen Y. Dupilumab as a novel therapy for bullous pemphigoid. *Int J Dermatol.* (2023) 62:e263–6. doi: 10.1111/ijd.16525
29. Velin M, Dugourd PM, Sanchez A, Bahadoran P, Montaudié H, Passeron T. Efficacy and safety of methotrexate, omalizumab and dupilumab for bullous pemphigoid in patients resistant or contraindicated to oral steroids. A monocentric real-life study. *J Eur Acad Dermatol Venereol.* (2022) 36:e539–42. doi: 10.1111/jdv.17999
30. Zhang L, Chen Z, Wang L, Luo X. Bullous pemphigoid: The role of type 2 inflammation in its pathogenesis and the prospect of targeted therapy. *Front Immunol.* (2023) 14:1115083. doi: 10.3389/fimmu.2023.1115083
31. Cao P, Xu W, Zhang L. Rituximab, omalizumab, and dupilumab treatment outcomes in bullous pemphigoid: A systematic review. *Front Immunol.* (2022) 13:928621. doi: 10.3389/fimmu.2022.928621
32. Abduelmula A, Mufti A, Chong DHY, Sood S, Prajapati VH, Yeung J. Biologic treatment outcomes in refractory bullous pemphigoid: An evidence-based review. *JAAD Int.* (2022) 9:142–5. doi: 10.1016/j.jdin.2022.09.001
33. Júlia Opolski NS, Rodrigo Ribeiro ES, Zattar Ribeiro PV, Farah PS, Steglich RB. Efficacy and safety of dupilumab in patients with moderate-to-severe bullous pemphigoid: a systematic review and meta-analysis. *Bras Dermatol.* (2025) 100:429–38. doi: 10.1016/j.abd.2024.08.008
34. Murrell DF, Joly P, Werth VP, Ujiie H, Worm M, Mangold AR, et al. Study design of a phase 2/3 randomized controlled trial of dupilumab in adults with bullous pemphigoid: LIBERTY-BP ADEPT. *Adv Ther.* (2024) 41:2991–3002. doi: 10.1007/s12325-024-02810-3