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Assessment of Serum Interleukin-31 and Total Immunoglobulin E Concentrations and Their Correlation with Disease Severity in Canine Atopic Dermatitis

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ABSTRACT

Background: Canine atopic dermatitis (CAD) often develops skin problems and produce immunoglobulin E (IgE) against environmental allergens. Interleukin-31 (IL-31) is an important itch-inducing cytokine in human atopic dermatitis (AD). The study aimed to quantify serum IL-31 and total IgE in CAD-affected dogs and to evaluate their correlation with disease severity.

Methods: Twelve client-owned dogs with CAD were enrolled after diagnosis based on favrot's criteria. Six apparently healthy dogs were included as the healthy control group. The severity of cutaneous lesions was assessed using the canine atopic dermatitis extent and severity index-04 (CADESI-04) scoring system. Pruritus intensity was evaluated using the pruritus visual analog scale (pVAS). Serum IL-31 and total IgE levels were assessed using canine-specific commercial sandwich ELISA kits (FineTest®, Wuhan, China).

Result: Dogs with CAD exhibited significantly increased serum IL-31 concentrations compared with healthy controls ($p = 0.001$). Likewise, total IgE levels were markedly higher in the CAD group than in the control group ($p = 0.010$). A strong positive association was observed between serum IL-31 levels and pVAS scores (Spearman's rank correlation, $\rho = 0.804$; $p = 0.003$). The study highlights the diagnostic and clinical relevance of serum IL-31 and total IgE as potential biomarkers in CAD.

Key words: Allergens, Correlation, ELISA, Favrot's criteria, Pruritus.

INTRODUCTION

The skin recognized as the body's largest organ; constitutes 12 to 24% of a dog's total body weight depending on the species and age (Moriello, 2011). The functions of skin include sensation, protection, heat regulation, excretion, secretion and Vitamin D synthesis (Garland, 2013). However, it is very sensitive to various inflammatory and allergic responses. Atopic dermatitis (AD) is a prevalent skin disorder affecting both humans and animals (Marsella, 2021). The reported prevalence of canine atopic dermatitis (CAD) in the canine population varies between 3 and 15% (Nodtvedt *et al*., 2006; Saridomichelakis and Olivry, 2016). As companion animals, dogs often share the same environment as their owners and naturally develop skin disorders that are clinically and immunologically similar to human AD (Ozmen and Marsella, 2014).

In recent years, the incidence of AD has notably increased in both species (Ricci *et al*., 2010; Nutten, 2015), likely due to greater exposure to indoor allergens and lifestyles that limit contact with parasites and beneficial microbes, often described as the "hygiene hypothesis" (Tarpataki *et al*., 2006; Favrot *et al*., 2010). In dogs, AD primarily presents with skin-related symptoms (Ozmen and Marsella, 2014; Patrizi *et al*., 2011; Bantz *et al*., 2014). CAD is a genetically predisposed, inflammatory and pruritic allergic skin disease directed against environmental allergens (Halliwell, 2006) and is triggered by an immunoglobulin (Ig) E antibody reaction (Santoro, 2019).

The dynamics of CAD are multifactorial and complex interactions between genetics and environment are

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hypothesized, as in human AD (Nutten, 2015; Bizikova *et al*., 2015). Immune dysregulation is considered one of the major factors involved in the pathogenesis of CAD (Li *et al*., 2021). AD skin lesions are mainly driven by T helper 2 (TH2) immune responses. Interleukin-31 (IL-31) is produced by TH2 cells (Wolf and Wolf, 2012). Evidence suggested that IL-31 was a potent pruritogenic cytokine that played a key role in pruritic skin conditions in humans (Gonzales *et al*., 2013; Saleem *et al*., 2017). Administration of IL-31 induces scratching behaviour in rodents (Arai *et al*., 2013). It also induces scratching in dogs and monkeys (Gonzales *et al*., 2016; Lewis *et al*., 2017). Inflammation, pruritus and infection are all part of a vicious cycle that has an effect on dogs, their owners and veterinarians (Bizikova *et al*., 2015; Hensel *et al*., 2015). CAD has a considerable negative impact on the quality of life of their owners. The primary burden is the high cost of treatment and long-term therapy (Linek and Favrot, 2010).

However, the contribution of IL-31 to the immunopathogenesis of CAD is not yet fully elucidated. The relationship between serum concentrations of IL-31 and total IgE and disease severity remains unclear and is an area of research interest. Despite years of research, clinical and histological evaluation of CAD remains important for accurate diagnosis and understanding of disease dynamics. The study aimed to investigate the immunological alterations reflected by serum IL-31 and total IgE in CAD-affected dogs and explore their potential association with clinical severity indicators. Assessing these biomarkers may aid in improving diagnosis, evaluating disease severity, assessing treatment response and developing targeted therapies for better clinical management of affected dogs.

MATERIALS AND METHODS

Place of work

The present study was conducted during the period from July 2025 to December 2025 at the Department of Veterinary Medicine, College of Veterinary Science and Animal Husbandry, Anjora. Dogs presented to the OPD (Outpatient Department), of Teaching Veterinary Clinical Complex, DSVCKV, Durg (C.G.) with clinical signs suggestive of canine atopic dermatitis (CAD), were employed for the study.

Animal ethics

The study was conducted after obtaining ethical clearance from the Institutional Animal Ethics Committee (IAEC) (Approval No. VMD-PG-5/2025).

Diagnostic work-up

A comprehensive diagnostic approach was adopted to identify cases of CAD. A Step-by-step diagnostic work-up was carried out. A detailed history was collected from the pet owners. Clinical signs and dermatological examinations of the suspected dogs were recorded separately; however, treated accordingly.

Inclusion criteria

The dogs with positive Favrot's criteria were included in the study (Favrot *et al*., 2010). All dogs fulfilled ≥5 of 8 Favrot's criteria.

Exclusion criteria

Dogs with an age of more than 3 years, stray dogs and those infested with ectoparasites and endoparasites were excluded from the study. Dogs older than 3 years were excluded to maintain a relatively homogeneous young-adult study population and to minimize potential age-related variation in clinical presentation and concurrent conditions. Dogs <1 year old, pregnant females and animals with serious systemic diseases were excluded. Dogs with prior administration of glucocorticoids, Janus kinase inhibitors, anti-IL-31 monoclonal antibody therapy, antihistamines, fatty acid supplements, or otic preparations containing glucocorticoids within 30 days before clinical evaluation were excluded from the study. None of the participating dogs had a previous history of receiving allergen-specific immunotherapy. Food allergy was ruled out through an 8-week food elimination trial using Royal Canin Hypoallergenic diet. All dogs underwent cytological screening of skin impression smears for bacterial pyoderma and *Malassezia* overgrowth. Animals diagnosed with bacterial or yeast infections were excluded from the study.

Study design

A total of 12 client-owned dogs (n = 12) diagnosed with CAD based on favrot's criteria were included in the study after excluding other dermatological conditions. Six apparently healthy dogs (n = 6) were enrolled as the control group. Dogs in both groups included males and females of different breeds.

Canine atopic dermatitis extent and severity index-04 (CADESI-04)

A total of 20 body sites, three types of lesions and four grades of severity were assessed, thereby generating a maximum score of $20 \times 3 \times 3 = 180$ (Olivry *et al*., 2014).

Pruritus visual analog scale (pVAS)

Pruritus intensity was assessed using pVAS, scored from 0 to 10 (0 = absent itching; 10 = maximum severity). The pVAS values were determined based on the history and evaluation provided by the owners (Olivry *et al*., 2007).

Collection of blood samples

A 5 mL blood sample was collected from each dog through the cephalic or lateral saphenous vein before commencement of therapy (day 0). The samples were placed in clot activator tubes and maintained at room temperature for 30 min. After centrifugation at 3000 rpm for 5 min, the serum fraction was carefully separated. Serum aliquots were stored at -20°C until analysis of IL-31 and total IgE concentrations.

In vitro quantitative determination of IL-31 and total IgE concentrations in serum

Circulating levels of canine interleukin-31 (IL-31) and total immunoglobulin E (IgE) were assessed in confirmed cases of CAD using canine-specific ELISA kits following the manufacturer's instructions. The IL-31 assay was performed using the kit (Catalogue No.: ECA0091; Batch No.: FN250929; Revision: V4.0) and total IgE assay using the kit (Catalogue No.: ECA0010; Batch No.: FN250929; Revision: V4.0;) supplied by FineTest®, Wuhan (China). Serum IL-31 levels were expressed in pg/mL, while serum total IgE concentrations were expressed in ng/mL.

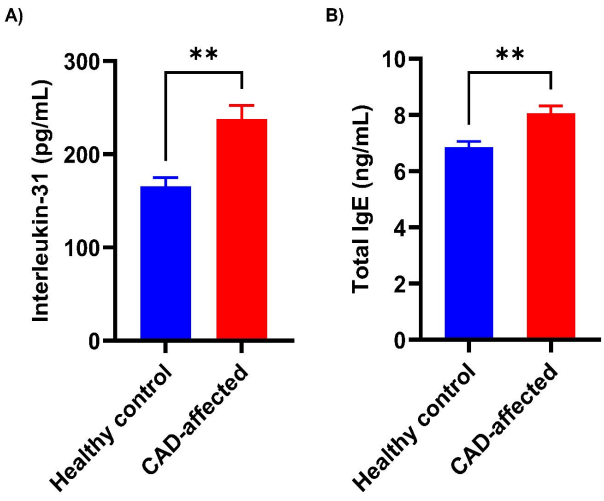
Statistical analysis

The data were initially checked for normality using the Shapiro-Wilk test. Homogeneity of variances between the two groups was evaluated using the F-test. For data that were normally distributed with equal variances, an unpaired Student's *t*-test was used for comparison between groups. For data that deviated from normality, the non-parametric Mann-Whitney U test was applied. The relationship between two continuous variables was assessed using Pearson's correlation coefficient (r) for normally distributed data and Spearman's rank correlation coefficient (ρ) for data not following a normal distribution. All statistical analyses were performed using GraphPad Prism version 11. Values were reported as mean±standard error (SE) and a probability level of $p<0.05$ was regarded as statistically significant.

RESULTS AND DISCUSSION

Serum IL-31 levels were significantly higher in dogs with CAD than in healthy dogs (Fig 1A). The mean (SE) IL-31 concentration was 165.76 (SE: 9.42) in healthy dogs and 237.86 (SE: 14.55) in CAD-affected dogs, which was statistically significant ($p = 0.001$) as presented in Table 1. Increased serum IL-31 levels in CAD-affected dogs indicated active pruritogenic signalling during disease progression. This finding was consistent with previous reports showing that administration of canine IL-31 directly induced pruritic behaviour in dogs (Gonzales *et al*., 2013). Similar evidence demonstrated a positive association between IL-31 levels and disease severity during active flares (Marsella *et al*., 2017). The elevated IL-31 observed in the present study may be attributed to increased production by TH2 cells and its action on sensory nerve fibres through the IL-31 receptor complex, ultimately triggering the itch sensation (Furue *et al*., 2018). A previous study failed to detect IL-31 mRNA in the skin of dogs with AD (Mizuno *et al*., 2009). Therefore, serum IL-31 estimation may be more informative than IL-31 mRNA expression analysis. Long-term caninized anti-IL-31 monoclonal antibody therapy was evaluated in a beagle with severe atopic dermatitis. This was the first clinical study of its kind reported from India. The antibody binds to and neutralizes IL-31. Treatment reduced pruritus, erythema and lesion severity (Sundararajan *et al*., 2026). The marked reduction in pruritus after IL-31 neutralization justifies the role of serum IL-31 as an important itch-inducing cytokine in dogs.

Serum total IgE levels were markedly increased in CAD-affected dogs compared with healthy controls, as illustrated in Fig 1B. The mean (SE) IgE concentration was 6.86 (SE: 0.20) in healthy dogs and 8.06 (SE: 0.27) in CAD-affected dogs. The findings presented in Table 1 showed that serum IgE concentrations were significantly increased in CAD dogs compared with controls ($p = 0.010$). Higher serum IgE levels in CAD-affected dogs reflected IgE-mediated hypersensitivity reactions. Previous findings also reported significantly increased serum IgE concentrations in clinically affected Pugs that were positive on intradermal testing compared with healthy and test-negative dogs, emphasizing the association between elevated IgE levels and true allergic sensitization (Bhagya



(A) Serum IL-31 concentrations in healthy control (n = 6) and CAD-affected dogs (n = 12). Serum concentrations are presented as mean ±SE. **: p<0.01 (Mann-Whitney U test). (B) Serum total IgE concentrations in healthy control (n = 6) and CAD-affected dogs (n = 12). Serum concentrations are presented as mean±SE. **: p<0.01 (unpaired t-test).

Fig 1: Serum concentrations of interleukin-31 (IL-31) and total immunoglobulin E (IgE) in healthy control and CAD-affected dogs.

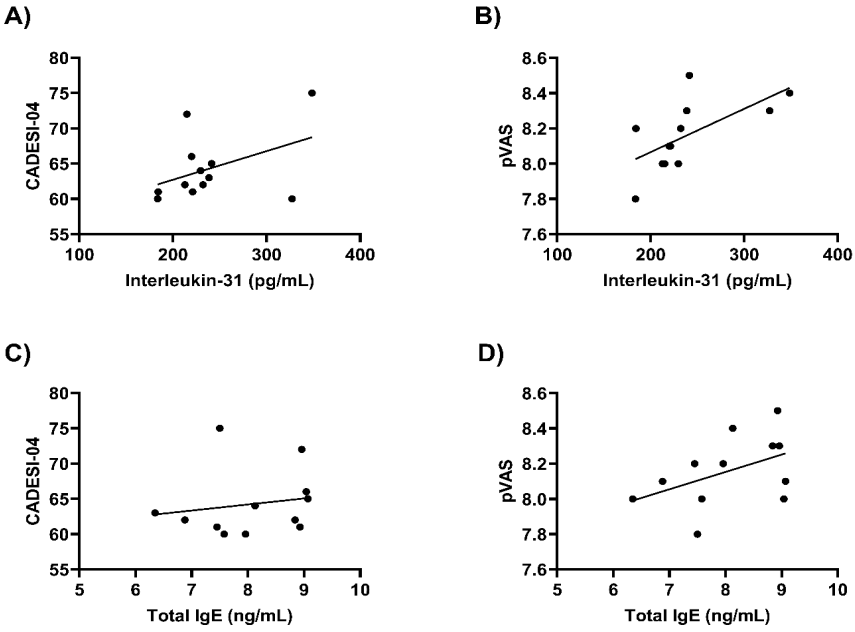
Table 1: Serum IL-31 and total IgE levels in healthy control and CAD-affected dogs.

Parameter	Healthy control (n = 6)	CAD-affected (n = 12)	p-value
Interleukin-31 (pg/mL)	165.76±9.42	237.86±14.55	0.001**
Total IgE (ng/mL)	6.86±0.20	8.06±0.27	0.010**

**p<0.01 was considered statistically significant between groups.

et al., 2023). Damage to the skin barrier allows allergens to penetrate the skin more easily (van den Bogaard *et al*., 2023). This activates TH2 immune responses through antigen-presenting cells. Consequently, IgE production increases (Facheris *et al*., 2023; Wollenberg *et al*., 2021). Elevated IgE contributes to hypersensitivity reactions (Santoro, 2019; Wüthrich, 1978). Increased IgE levels are reported in both serum and skin of affected patients (Wüthrich, 1978). Therefore, IgE plays an important role in the development of atopic dermatitis (AD).

Clinical severity assessment revealed a mean CADESI-04 score of 64.25 (SE: 1.37; median: 62.5; range: 60-75) and a mean pVAS score of 8.16 (SE: 0.06; median: 8.15; range: 7.8-8.5) in CAD-affected dogs. Correlation analysis showed that serum IL-31 levels were strongly and positively related to pVAS scores ($\rho = 0.804$; $p = 0.003$) (Table 2 and Fig 2B). This means that dogs with higher IL-31 levels tended to have more severe itching. However, serum IL-31 levels were not significantly related to CADESI-04 scores ($\rho = 0.327$; $p = 0.297$) (Table 2 and Fig 2A). Serum total IgE levels showed a positive relationship with both CADESI-04 scores ($\rho = 0.320$; $p = 0.308$) and pVAS scores ($r = 0.460$; $p = 0.132$) (Table 2). However, these relationships were not statistically significant (Fig 2C and 2D). The strong positive correlation between IL-31 and pVAS scores indicated that higher IL-31 concentrations were closely associated with increased pruritus intensity. This observation was in agreement with earlier findings reporting significantly elevated IL-31 concentrations in atopic dogs and a significant positive correlation between IL-31 and pVAS scores. These findings further support the association between IL-31 and pruritic activity (Chaudhary *et al*., 2019). A significant positive correlation between serum IL-31 levels and disease severity during active flares



(A) Weak positive correlation between serum IL-31 concentration and CADESI-04 score (Spearman's rank correlation, $\rho = 0.327$; $p = 0.297$). (B) Strong positive correlation between serum IL-31 concentration and pVAS score (Spearman's rank correlation, $\rho = 0.804$; $p = 0.003$). (C) Weak positive correlation between serum total IgE concentration and CADESI-04 score (Spearman's rank correlation, $\rho = 0.320$; $p = 0.308$). (D) Moderate positive correlation between serum total IgE concentration and pVAS score (Pearson's correlation, $r = 0.460$; $p = 0.132$). Each point represents an individual dog.

Fig 2: Scatter plots illustrating the correlation of serum IL-31 and total IgE concentrations with CADESI-04 and pVAS scores in dogs with atopic dermatitis (n = 12).

Table 2: Correlation between serum IL-31 and total IgE concentrations with CADESI-04 and pVAS scores in CAD-affected dogs.

Parameter	CADESI-04		pVAS	
	Correlation coefficient	p-value	Correlation coefficient	p-value
Interleukin-31	0.327	0.297	0.804**	0.003
Total IgE	0.320	0.308	0.460	0.132

**Correlation is significant at the 0.01 level (2-tailed).

was also reported in an experimental CAD model, suggesting IL-31 as a potential biomarker for pruritic activity and therapeutic response (Marsella *et al*., 2017). In contrast, total IgE showed weak and non-significant correlations with both CADESI-04 and pVAS, suggesting that circulating IgE levels were not directly associated with clinical severity of skin lesions or pruritus in the present study. This finding differed from previous observations that reported a significant positive correlation between IgE concentrations and CADESI scores (Lo *et al*., 2012). The lack of significant correlation between IgE and clinical indices in the present study indicates that IgE may reflect atopic status rather than the current severity of lesions or pruritus. One study reported that treatments such as selective Janus kinase inhibitor and corticosteroid improve clinical manifestations without significant changes in serum IgE levels (Aleo *et al*., 2023). Yet, there appear to be no reports on effect of caninized anti-IL-31 monoclonal antibodies on IgE level to compare the observations of the present findings. Therefore, serum IgE may have greater diagnostic value in CAD than its role in monitoring disease severity or treatment response. Furthermore, the small number of atopic dogs included in this study is an important limitation. Therefore, future studies with a larger number of dogs with naturally occurring CAD are needed to confirm these findings and better understand the relationship between serum IL-31and total IgE with disease severity and response to treatment in dogs with CAD.

CONCLUSION

The present study demonstrated a significant elevation of serum IL-31 and total IgE concentrations in dogs affected with AD, supporting their central role in the pathogenesis of CAD. In conclusion, the concurrent elevation of IL-31 and total IgE in the present study confirms the combined involvement of cytokine-mediated pruritus and IgE-driven allergic mechanisms in CAD and supports their diagnostic and therapeutic relevance. Higher IL-31 levels were closely associated with intense pruritus in dogs with atopic dermatitis. Targeted therapies against IL-31 may improve treatment outcomes and reduce itching in dogs with CAD.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

All animal procedures for experiments were approved by the Committee of Experimental Animal care and handling techniques were approved by the University of Animal Care Committee.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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