Biomedical Data Science
2026, VOL. 6, NO. 1, 78-82
DOI: 10.47297/wspbdsWSP2752-630517.20260601

Preventing and Treating Pediatric Allergic Conjunctivitis via the Gut-Eye Axis from the Spleen

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ABSTRACT
Allergic Conjunctivitis (AC) is a common immune-related ocular surface disease in children, characterized by a prolonged course and frequent recurrence, which severely impacts patients' quality of life. With its rising global incidence, modern medicine primarily relies on topical anti-allergic treatments that, while controlling symptoms, have limitations in long-term efficacy and recurrence prevention. In contrast, Traditional Chinese Medicine (TCM) offers unique advantages in symptomatic improvement and prevention through holistic management. Based on the emerging "gut-eye axis" theory, this article explores the pathological mechanisms of gut microbiota involvement in AC and the close relationship between the Spleen in TCM and gut microbiota. It proposes that the pathogenesis of pediatric AC stems from "Spleen deficiency as the root, Dampness accumulation as the basis, and Wind-Phlegm attacking the eyes." Emphasizing strengthening the Spleen as the fundamental treatment principle, this paper discusses AC prevention and management from three aspects— "prevention before disease onset, prevention of exacerbation during disease, and prevention of recurrence after disease" —aiming to expand TCM diagnostic and therapeutic approaches for pediatric AC.

KEYWORDS
Pediatric allergic conjunctivitis; gut-eye axis; intestinal microbiota; Spleen deficiency; TCM

1 Introduction

Allergic conjunctivitis (AC) refers to an immune-mediated ocular disease primarily characterized by Type I and Type IV hypersensitivity reactions triggered by allergen exposure to the conjunctiva [1]. Children are susceptible due to their underdeveloped immune systems. Studies indicate a rising global prevalence of pediatric AC, ranging from 3.4% to 40% [2]. Recurrent AC can lead to complications such as dry eye and tic disorders, impacting children's daily lives and potentially causing emotional distress [3]. While modern medical treatments can rapidly control acute symptoms, long-term efficacy remains suboptimal with high recurrence rates[1]. In recent years, the gut-eye axis concept has opened new diagnostic and therapeutic avenues for various ocular diseases. Research indicates a potential link between gut microbiota dysbiosis and AC development [4]. Within traditional Chinese medicine theory, the spleen is regarded as the foundation of acquired constitution and the source of qi and blood generation. Its functional strength directly influences the body's defensive capabilities and the production of pathological substances like phlegm-dampness. Children, characterized by "inherent spleen deficiency," are particularly susceptible to spleen deficiency-related illnesses.

2 Investigating Allergic Conjunctivitis from the Perspective of Gut Microbiota

2.1 Gut-Eye Axis

The gut microbiota refers to a complex and dynamic microbial ecosystem primarily colonizing the digestive tract, consisting mainly of bacteria, fungi, and other microorganisms. It performs functions including digestion and absorption, nutrient synthesis, barrier maintenance, and immune regulation. Multiple studies have demonstrated a bidirectional communication mechanism between the gut and the eye [5]. When gut microbiota dysbiosis occurs, systemic immune and metabolic balance is disrupted, potentially triggering or exacerbating various ocular diseases. Gut microbiota can cross the blood-retinal barrier, causing autoimmune damage to retinal ganglion cells and contributing to glaucoma pathogenesis [6]. The association between glaucoma and other ocular diseases with gut dysbiosis confirms the existence of the "gut-eye axis." The concept of the gut-eye axis is driving a shift in ophthalmic diagnosis and treatment from local to systemic regulation.

2.2 Mechanisms of the Gut-Eye Axis in Pediatric Allergic Conjunctivitis

The gut microbiota during childhood constitutes a rapidly developing, highly unstable ecosystem that is susceptible to

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various factors such as delivery methods and environmental influences. When gut dysbiosis occurs, allergens and toxins enter the bloodstream, creating a systemic inflammatory environment. Concurrently, the immune response shifts excessively toward the Th2 pathway, leading to overproduction of IgE. Inflammatory mediators and IgE circulate via the bloodstream to the ocular region, causing heightened sensitivity in the ocular conjunctiva and thereby triggering allergic conjunctivitis.

2.2.1 Microbiome Dysbiosis Induces Systemic Immune Dysregulation

Dysbiosis promotes excessive activation of pro-inflammatory cells such as helper T cells 17 (Th17) while suppressing the function of anti-inflammatory cells like regulatory T cells (Tregs). This disrupts the Th1/Treg balance, causing the immune system to skew toward Th2 dominance. Consequently, Th2 cells and their produced cytokines—including IL-4 and IL-13—increase systemically, placing the ocular conjunctiva in a state of allergic inflammation [7].

2.2.2 Leaky Gut Causes Systemic Low-Grade Inflammation

Dysbiosis of the gut microbiota suppresses the expression of tight junction proteins between intestinal epithelial cells, leading to increased intestinal permeability and the development of leaky gut. This allows undigested food proteins and bacterial metabolites, such as bacterial lipopolysaccharides, to enter the bloodstream, activating systemic immune cells and triggering systemic low-grade chronic inflammation. Persistent inflammation lowers the threshold for ocular surface immune tolerance, exacerbating the severity of allergic reactions.

2.2.3 Intestinal-Derived Substances Remotely Regulate Ocular Inflammation

The gut and ocular conjunctiva both belong to the mucosal immune system, sharing similar immune structures and cell populations. When gut microbiota dysbiosis occurs, the immune system may mistakenly attack ocular surface tissues, triggering an autoimmune-like inflammatory response. Simultaneously, activated immune cells and inflammatory mediators from the gut can circulate to the eye, contributing to ocular inflammation. Bacterial lipopolysaccharides in the gut can directly activate ocular immune cells, exacerbating ocular inflammatory processes.

3 The Relationship Between the Spleen in Traditional Chinese Medicine and the Gut Microbiome

The spleen in Traditional Chinese Medicine (TCM) belongs to the Zang-Xiang theory, representing an integrated functional system centered on digestion and absorption. It encompasses functions corresponding to the digestive and immune systems in modern medicine. The gut microbiota colonizes the digestive tract, and modern research indicates its functions extend beyond digestion to include protecting the intestinal barrier and participating in mucosal immune regulation. The healthy functioning of the TCM "spleen" and the homeostasis of the gut microbiota exhibit a high degree of functional coupling.

3.1 "The Spleen Governs Transformation and Transportation" and Microbiome Metabolism

The spleen governs transformation and transportation, digesting and absorbing food and drink to generate qi and blood while maintaining fluid metabolism balance. The gut microbiota provides energy by participating in complex carbohydrate breakdown and vitamin synthesis, while preserving intestinal mucosal barrier integrity to maintain fluid equilibrium. Impaired spleen function often manifests as qi and blood deficiency or internal retention of dampness and turbidity. Research indicates that spleen deficiency often accompanies dysbiosis, leading to reduced short-chain fatty acid production and metabolic pathway abnormalities that impair energy metabolism [8], manifesting as "qi and blood deficiency." In cases of spleen deficiency with excessive dampness, intestinal barrier disruption allows endotoxins to enter the bloodstream, triggering inflammatory responses and resulting in "damp-toxin accumulation." When employing spleen-tonifying formulas like Shenling Baizhu Powder, they effectively improve microbial structure and repair the intestinal mucosal barrier, thereby achieving "tonifying the spleen and promoting transport"[9].

3.2 "The Spleen Governs the Muscles" and the Intestinal Barrier

When the spleen functions robustly, muscles become full and strong. The integrity of the intestinal barrier is closely related to muscle metabolism, morphology, and function, hence the concept that "the spleen governs muscles" is connected to the intestinal barrier. A healthy spleen generates qi and blood to nourish muscles and transforms fluids to protect them. When spleen function is impaired, insufficient qi and blood production leads to muscle wasting and

atrophy, while stagnant fluids accumulating in muscles cause heaviness, soreness, and edema. Research indicates that in a mouse model of liver stagnation with spleen deficiency, colonic epithelial cell intercellular junctional protein expression decreases, the mucus layer thins, and dysbiosis occurs, leading to intestinal barrier impairment [10]. This results in "spleen disease affecting the muscles."

3.3 "The Spleen as the Guardian" and Immune Regulation

"The spleen governs the defensive qi" is Traditional Chinese Medicine's concise summary of the spleen's immune function. The immunoregulatory role of the gut microbiota provides a modern biological interpretation of this theory. A robust spleen generates defensive qi, warming and nourishing the skin while repelling external pathogens; It generates qi and blood to nourish the body's vital energy; it anchors the middle jiao and transforms fluids. Thus, a robust spleen preserves vital energy internally, preventing pathogen invasion. When spleen deficiency occurs, vital energy cannot overcome pathogens, manifesting microscopically as a classic imbalance in the "microbiota-immune axis." Research indicates that spleen-tonifying herbs like Atractylodes macrocephala can modulate microbiota composition, repair the intestinal barrier, and exert bidirectional immune regulation [11].

4 Pathogenesis of Allergic Conjunctivitis in Children: The Root Cause Lies in Spleen Deficiency

4.1 The Intrinsic Connection Between the Spleen and the Eyes in Traditional Chinese Medicine

The spleen is the foundation of acquired constitution. When the spleen functions well, the essence of food and drink is abundant, transforming into qi and generating blood that ascends to nourish the eyes. With sufficient blood, the eyes can perceive objects and distinguish colors. When the spleen is deficient and fails to transport and transform, the production of qi and blood becomes depleted. The eyes lose their nourishment, and the eyelids and conjunctiva become lax. With a deficiency of vital energy, the eyes become susceptible to pathogenic factors. Simultaneously, impaired spleen function disrupts fluid metabolism, leading to the internal accumulation of dampness and turbidity. This dampness ascends to the eyes, causing eyelid swelling and sticky secretions. Spleen deficiency leads to a deficiency of vital energy and insufficient qi and blood in the eyes. Combined with the upward flow of dampness and turbidity, and the invasion of wind-damp-heat pathogens from the exterior, this manifests as itchy eyes.

4.2 The Physiological Pathology of Children's "Spleen Deficiency" and the Formation of Allergic Constitution

The five viscera and six bowels of children are formed but not yet fully developed, with "constant insufficiency of the spleen" being their most prominent physiological and pathological characteristic. Weak spleen and stomach function means that even slight dietary indiscretion can easily lead to spleen deficiency. Spleen deficiency disrupts transformation and transportation, resulting in insufficient sources of qi and blood, thereby forming an allergic constitution. When spleen deficiency allows dampness to accumulate internally, it stagnates and transforms into heat. This internal accumulation of damp-heat becomes the latent pathogenic factor underlying the allergic constitution. When external pathogenic factors invade, combining with internal pathogens, they ascend to affect the eyes, manifesting as ocular itching.

In summary, the author posits that in pediatric allergic conjunctivitis, the manifest symptom resides in the eyes, the root cause lies in the spleen, and the underlying foundation is dampness accumulation. When wind-phlegm ascends to invade the eyes, it triggers ocular itching.

5 Preventing and Treating Allergic Conjunctivitis in Children Through the Spleen

Current research has confirmed that dysbiosis of the gut microbiota is a potential pathogenic factor in allergic conjunctivitis [4]. Spleen deficiency is closely associated with gut microbiota imbalance, and children are often characterized by "inherent spleen deficiency." Consequently, spleen deficiency and gut microbiota imbalance jointly form the pathological basis of pediatric allergic conjunctivitis . To address the root cause, treatment should focus on the spleen and stomach, with strengthening their functions as the fundamental approach. This regulates the gut microbiota and prevents AC in children through three aspects: preventing disease before it occurs, preventing disease onset when it threatens, and preventing disease progression once it has developed.

5.1 Preventing Illness Before It Starts: Strengthening the Spleen and Supporting Vitality

For children with allergic constitutions, prevention is key. Focus on daily care to improve their allergic tendencies. Children should be nurtured through the following three aspects: First, dietary care: Children often lack self-control, leading to irregular eating habits and food preferences. Parents should monitor their diet to avoid overindulgence that damages the spleen and stomach. As the five flavors correspond to the five organs, the spleen is associated with sweetness. Children's diets should primarily consist of mildly sweet foods. They can consume more spleen-nourishing foods like Chinese yam, lotus seeds, and millet, while avoiding raw, cold, greasy, and seafood-based foods that may aggravate dampness and harm the spleen. Second, supplement with prebiotics and probiotics: Appropriately supplement with fructooligosaccharides (FOS) to selectively promote the proliferation of beneficial bacteria like bifidobacteria. Targeted supplementation with clinically proven strains that regulate Th1/Th2 balance and enhance barrier function is recommended, such as Bifidobacterium lactis BB-12. Third, lifestyle management: Avoid exposure to allergens like pollen in daily life; maintain regular sleep patterns to prevent fatigue from damaging the spleen; keep a cheerful disposition to avoid mental strain harming the spleen.

5.2 Preventing Illness Before It Starts: Strengthening the Spleen and Resolving Dampness

Children often exhibit prodromal symptoms such as frequent blinking or eye rubbing before an acute AC episode. This represents a window period where the gut microbiota undergoes mild reversible fluctuations in barrier function and a tendency toward immune imbalance—a physiological state. In traditional Chinese medicine, the pathogenesis primarily involves "spleen deficiency with dampness accumulation and external wind stirring." As the ancients said, "The superior physician treats the disease at its inception." At this stage, interventions like dietary therapy and external treatments can interrupt disease progression by "strengthening the spleen, resolving dampness, and restoring spleen-qi equilibrium." Dietary principles emphasize sweet and bland foods to fortify the spleen and consolidate the foundation. Formulas such as Perilla Leaf and Tangerine Peel Decoction or Black Plum and Rock Sugar Decoction may be used, while avoiding raw, cold, sweet, greasy, fried, and seafood items. External therapies like acupoint massage and pediatric tuina can stimulate meridian energy to fortify the spleen and dispel wind. Studies by Shao Huidi et al. demonstrated that pediatric tuina effectively improves spleen deficiency constitution in children, increases beneficial gut bacteria abundance, and enhances immune function [12].

5.3 Preventing Disease Progression and Protecting the Spleen and Stomach

Acute episodes of pediatric allergic conjunctivitis primarily manifest as ocular symptoms such as itching and redness—the superficial manifestations of rheumatic pathogens accumulating in the eyes. However, the root cause lies in spleen-stomach deficiency. During acute flare-ups, treatment must consistently prioritize protecting the spleen and stomach to prevent damage that could deepen the condition, prolong its course, or trigger other allergic disorders.

5.3.1 Reinforcing the Earth to Generate Metal, Control Acute Symptoms

In pediatric AC disease, the eyes are the primary site of manifestation. The lungs open into the eyes, and the ascending and descending functions of lung qi directly influence the distribution of qi and blood to the ocular region. The spleen is the mother of the lungs; when spleen-stomach deficiency occurs, qi, blood, and body fluids cannot ascend to nourish the lungs. This leads to lung qi deficiency, compromising the protective barrier against external pathogens. Wind pathogens, combined with damp-heat, then ascend to the eyes, triggering acute attacks. Treatment prioritizes "nourishing the earth to generate metal" (tonifying spleen to strengthen lung function). While vigorously combating allergies, it simultaneously protects the spleen and stomach, fortifies the middle jiao to enhance qi and strengthen the source of phlegm production, and regulates intestinal flora to balance immunity, thereby indirectly alleviating ocular allergic reactions. Qiu Mengyao achieved a 96.67% efficacy rate using a qi-tonifying, wind-dispelling, and itch-relieving formula combined with olopatadine hydrochloride eye drops for treating lung-spleen qi deficiency-type allergic conjunctivitis, significantly outperforming the control group [13].

5.3.2 Promote spleen function to transform dampness and eliminate the root of latent pathogens

When the spleen and stomach fail to function properly, phlegm-dampness accumulates. Dampness stagnates and transforms into heat; the interaction of damp-heat forms the "latent pathogen" responsible for recurrent AC episodes. When external wind activates this latent pathogen, it manifests as eye itching. Children with spleen deficiency and damp accumulation often present with persistent ocular symptoms that are difficult to resolve. Relying solely on wind-dispersing and heat-clearing agents is like skimming the surface of a boiling pot. Only by invigorating the spleen to

transform dampness can the dampness be eliminated, leaving the heat isolated and without a host for pathogens to attach to—thus addressing the root cause. Treatment prioritizes "invigorating the spleen to transform dampness." Strengthening the spleen and transforming dampness regulates the intestinal microbiota, repairs the intestinal barrier, and disrupts the immune activation pathway between the "gut-eye axis." Yu Huijun employed Hawthorn-Quinine-Pingwei Powder combined with Allergy Decoction to treat spleen-deficient pediatric AC, achieving marked improvement in both ocular symptoms and systemic conditions [14].

6 Conclusion

The Gut-Eye Axis theory extends the pathological location of pediatric allergic conjunctivitis from the ocular surface to the spleen, stomach, and intestines. This recognition highlights that treatment must not be confined to the eyes but should also focus on maintaining the key to immune homeostasis—the gut microbiota. This theory aligns with Traditional Chinese Medicine's holistic concept and provides modern biological evidence for treating pediatric allergic conjunctivitis through spleen-centered approaches. The author posits that pediatric AC fundamentally stems from spleen deficiency. The primary therapeutic approach should be "strengthening spleen and stomach function." By implementing prevention strategies across three dimensions—"preventing disease before onset, preventing progression once symptoms appear, and preventing deterioration of existing conditions"—we can effectively control ocular symptoms while improving the child's allergic constitution and reducing recurrence rates. This offers a novel TCM diagnostic and therapeutic perspective for the clinical management of pediatric allergic conjunctivitis.

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