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REVIEW

Gut microbiota and allergy/asthma: From pathogenesis to new therapeutic strategies

Y.B. Kang^{a,b,c,*,1}, Y. Cai^{b,d,1}, H. Zhang^{b,e}

^a Faculty of Environmental Science and Engineering, Kunming University of Science and Technology, Kunming, Yunnan 650500, China

^b Medical Faculty, Kunming University of Science and Technology, Kunming, Yunnan 650500, China

^c Genetics and Pharmacogenomics Laboratory, Kunming University of Science and Technology, Kunming, Yunnan 650500, China

^d Pathogen Biology Laboratory, Kunming University of Science and Technology, Kunming, Yunnan 650500, China

^e Department of Cardiology, First People's Hospital of Yunnan, Kunming, Yunnan 650500, China

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Abstract Asthma and atopy, classically associated with hyper-activation of the T helper 2 (Th2) arm of adaptive immunity, are among the most common chronic illnesses worldwide. Emerging evidence relates atopy and asthma to the composition and function of gut microbiota composition. Moreover, certain gut microbial strains have been shown to inhibit or attenuate immune responses associated with chronic inflammation in experimental models. Although still a relatively nascent field of research, evidence to date suggests that the gut microbiome may represent fertile targets for prevention or management of allergic asthma and other diseases in which adaptive immune dysfunction is a prominent feature. The oral probiotics/prebiotic represents a possible therapeutic for improving asthma and allergic disease. Especially, recent technological developments that permit identification of microbes and their products using culture-independent molecular detection techniques. In this review, we literately summarise the aggravation or improvement of metabolic diseases by role of gut microbiota, probiotics/prebiotic treatment.

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* Corresponding author.

E-mail address: 657151276@qq.com (Y.B. Kang).

¹ Equal contributors.

Introduction

Allergy and Asthma are two major public health problems in industrialised nations, such as the United States.^{1–8} Both diseases are chronic inflammatory disorders caused by aberrant immune responses against common “innocuous” environmental antigens (allergens) in susceptible individuals.⁹ An enhanced T helper (Th)2 immune response and the elaboration of cytokines such as interleukin (IL)-4, IL-13, and IL-5 contribute to the induction and maintenance of these diseases.¹⁰ Often, atopic dermatitis is the first manifestation of atopy in infants who will develop hay fever or asthma in later childhood. The largest and earliest source of microbial exposure in human subjects comes from the intestinal tract. The gut contains a large and diverse population of microbes that is, quantitatively, the most important postnatal source of microbial stimulation of the immune system.^{11,12} Current evidence supports a role for gut colonisation in promoting and maintaining a balanced immune response in early life.¹³ Hence disruption of this process early on in life at a time of dynamic changes^{14,15} in the infant’s gut might have long-term health effects. Both asthma¹⁶ and obesity^{17–19} often begin in early childhood, when the gut microbiota is primarily developed. Recent studies in animal models and in human subjects have found that an altered or less diverse gut microbiota composition has been associated with asthma and allergic disease diseases (Table 1).^{20–26} Moreover, certain gut microbial strains have been shown to inhibit or attenuate immune responses associated with chronic inflammation in experimental models. However, there has been no fully adequate longitudinal study of the relation between the neonatal gut microbiota and the development of asthma and allergic disease. The emergence of promising experimental studies has led to several clinical trials of probiotics (live bacteria given orally that allow for intestinal colonisation) in human subjects. Probiotic trials thus far have shown a consistent preventive or therapeutic effect on asthma and allergic disease. Because previous trials of probiotics have been limited by small sample size, short duration of follow-up, or lack of state-of-the art analyses of the gut microbiota,

a lot of research needs to be done in the future. In this review we first summarise recent research about the relation between the gut microbiota and allergy/asthma, effect of probiotics/prebiotic treatment on asthma and allergic disease.

Method

Literature search was performed by using the PubMed database, the keywords used were gut microbiota (52 searches) and allergy/asthma (169 searches). Of these, 49 articles were shortlisted which discussed relation of gut microbiota and allergy/asthma. These articles were consulted for this review.

Result

Gut microbiota: definition

Intestinal epithelium, mucosal immune system, and bacterial and non-bacterial flora represent a morph-functional system on dynamic balance responsible for the host local intestinal integrity and systemic barrier function.²⁷ Gut harbour about 500 different species of microorganisms, weighing about 1.5kg in the normal subjects.^{28,29} The number of microbial luminal cells is 10-folds more than eukaryotic cells.^{28,30} At the same time, microbiota genome encode 100–1000 times more genetic information than the host genome.³¹ The gut, sterile during the intrauterine, is colonised immediately after birth. The numbers and species of bacteria fluctuate markedly during the early life.³² However, the gut microbiota of adults is comparatively steady over time.³³ Over the course of millions of years of evolution, commensal bacteria have taken on many physiological functions essential to our health, including physical development, the intestinal barrier, immune regulation, metabolism, nutrition absorption, expelling toxin and so on.³⁴ At the same time, gut microbiota are important factors to stimulate the mucosal immune system and systemic

Table 1 Changes in microbiota composition associated with allergy/asthma and novel therapeutic strategies.

Models	Disease	Implicated microbiota	New therapeutic strategies	Implicated microbiota	Reference
Children	Allergy	<i>Coliforms</i> ↑ <i>Staphylococcus aureus</i> ↑ <i>Lactobacilli</i> ↓ <i>Bifidobacteria</i> ↓	NO	NO	20
Infants	Allergy	<i>Lactobacilli</i> ↓ <i>Bifidobacteria</i> ↓	NO	NO	21
Mice	Allergy	NO	House dust (<i>Lactobacillus</i>)	<i>Lactobacillus johnsonii</i> ↑	22
Infants	Allergy	NO	<i>Lactobacillus</i> GG	<i>Lactobacilli</i> ↑	23
Children	Allergy	NO	<i>Lactobacillus rhamnosus</i> 19070-2 and <i>Lactobacillus reuteri</i> DSM 122460	NO	24
Birth cohort	Asthma	<i>Clostridium difficile</i> ↑	NO	NO	25
Mice	Asthma	<i>Clostridium leptum</i> ↓	<i>Clostridium leptum</i>	NO	26

NO: no test or no research.

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