

Inflammatory Bowel Disease and Gut Microbiota

Current Strategies and
Future Prospects in Nanomedicine



Neeraj Mishra | Sumel Ashique | Ashish Garg
Editors



CRC Press
Taylor & Francis Group

APPLE ACADEMIC PRESS

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This new volume delves into the extensive new research on inflammatory bowel disease (IBD) and gut microbiota that has led to effective therapeutic interventions. Highlighting novel methodologies and innovative treatment approaches, the book provides a comprehensive investigation of IBD, exploring the significance of gut microbiota and investigating the fundamental role of microbial imbalances in the initiation and progression of inflammatory processes as well as the prominent therapeutic consequences of restoring microbial homeostasis. From nanoparticle-based drug delivery systems that advance the bioavailability of the medicament to the use of bio-nanosensors for early detection of disease, the book covers a broad spectrum of inventions that hold potential for revolutionizing IBD treatment. The authors look at the impact of nutraceuticals, probiotics, prebiotics, functional foods, oral siRNA-based nanomedicine, and other novel drug delivery systems on gut microbiota for the management of IBD. The book also explores the role of reactive oxygen species (ROSs), superoxide dismutases (SODs), and inflammation in association with gut microbiota and IBD.

ABOUT THE EDITORS

Neeraj Mishra, PhD, is a Professor at the Amity Institute of Pharmacy, Gwalior, India. He has 20 years of teaching and research experience. A brand ambassador at Bentham Science, he has published more than 100 papers on recent concepts of novel drug delivery systems, oral delivery of synbiotics, localized drug delivery, targeted and controlled drug delivery of nanocarriers/microparticles for the treatment of breast and colon cancer, and neurodegenerative disorders. He has also written more than 15 books and 25 book chapters and has been granted several patents. He was a recipient of an Indian Council of Medical Research Senior Research Fellowship and a Distinguished Professor Award from the Indian Department of Science and Technology, National Science and Technology Management Information System, Synergizing Pharma Academic-Industry Collaboration Systems.

Sumel Ashique, MPharm, is a Research Scholar at the School of Pharmaceutical Sciences at Lovely Professional University, Punjab, India, where he is pursuing his PhD. His research area is probiotics, postbiotics, gut microbiota, and inflammatory disorders. With knowledge in drug delivery, nanotechnology, and targeted treatment strategy, he has four years of teaching experience and has published book chapters with international publishers and over 100 papers in accredited reputed journals. He has also six granted intellectual property (IP) patents from IP India and Australia. He is currently editing 13 books with Elsevier, Apple Academic Press, CRC Press, Taylor and Francis, and others.

Ashish Garg, PhD, is a Professor at the Guru Ramdas Khalsa Institute of Science and Technology (Pharmacy), Jabalpur, M.P., India. He has around ten years of teaching and research experience and has 80 publications in national and international journals of repute. He has authored 27 book chapters and edited several books on recent concepts of nanotechnology, novel drug delivery systems, cancer targeting, etc. Dr. Garg has been granted three international patents and has published three Indian patents. He also acts as an editorial board member and reviewer for several journals.

CHAPTER 5

Management of Gut Microbiota-Derived Bacterial Metabolites Induced Inflammatory Bowel Disease

MONIKA VISHWAKARMA,^{1,2} POORNIMA AGARWAL,^{1,3}

MD. FAHEEM HAIDER,⁴ TANWEER HAIDER,^{1,5} and VANDANA SONI¹

¹*Department of Pharmaceutical Sciences, Doctor Harisingh Gour University, Sagar, Madhya Pradesh, India*

²*Faculty of Pharmacy, Kalinga University, Naya Raipur, Chhattisgarh, India*

³*Institute of Pharmaceutical Research, GLA University, Mathura, Uttar Pradesh, India*

⁴*Faculty of Pharmacy, Integral University, Lucknow, Uttar Pradesh, India*

⁵*Gyan Vihar School of Pharmacy, Suresh Gyan Vihar University, Jaipur, Rajasthan, India*

ABSTRACT

Inflammatory bowel disease (IBD) is the most common issue in every generation of individuals due to their eating habits, stress, and unhealthy lifestyle. IBD occurs due to chronic inflammation of digestive tract tissues, mainly characterized by symptoms such as diarrhea, abdominal cramps, blood in stool, etc. Ulcerative colitis and Crohn's disease are the two variants of IBD that affect the linings of the large intestine, rectum, and gastrointestinal tracts. The human gastrointestinal tract contains trillions of good and bad microorganisms such as bacteria, fungi, viruses, and many others that form gut microbiota. These microorganisms use dietary substances to form metabolites that maintain a healthy gut environment. Excessive use of antibiotics and a

high intake of a westernized diet have led to the degradation of good gut bacteria and an increase in the count of bad bacteria, which release harmful metabolites such as bile acids, short-chain fatty acids, tryptophan metabolites, and sphingolipids. These metabolites induce several diseases, of which IBD is one. Prebiotics, probiotics, and fecal microbiota transplantation are employed for treating bacterial-induced IBD. In this chapter, we will discuss the bacterial metabolites that induce IBD and its treatment strategy.

5.1 INTRODUCTION

Inflammatory bowel disease (IBD) is an immune-mediated, chronic inflammatory disease that affects the entire gastrointestinal tract (GIT) of living beings (Mishra et al., 2022). IBD is clinically classified into Crohn's disease and ulcerative colitis, which cause inflammation in the deeper layers of intestinal walls, mouth, esophagus, stomach, small intestine, and colon area, respectively (Seyedian et al., 2019). The symptoms of IBD are abdominal discomfort or pain, blood in stool, diarrhea, and weight loss. In contrast, the significant risk factors are immunological, environmental, and microbial alterations (Hsu et al., 2022; Fiorindi et al., 2022). The GIT is home to trillions of microorganisms forming the gut microbiota (GM) (Shah et al., 2021). GM plays a pivotal role in maintaining intestinal homeostasis and function by providing nutrition, enhancing immunity, and contributing to host defense (Nishida et al., 2018). Modern lifestyles, eating habits, excessive use of antibiotics, and smoking have altered the balance of gut microbiota, which has resulted in a drastic increase in the incidence of IBD, rising to 6.2 million people globally (Barbina et al., 2023). The highest incidence of IBD is reported in Europe (1 million) and North America (2.5 million). In contrast, there is a significant increase in incidences in developing countries in Asia, South America, and Africa (Guan, 2019; Kaplan, 2015). On the contrary, GM also nurtures the colonization of several pathogenic bacteria, which release metabolites such as bile acids, short-chain fatty acids, tryptophan (Trp) metabolites, and sphingolipids by metabolizing the dietary substrates (Franzosa et al., 2019). These metabolites can cause many diseases, such as asthma, cardiovascular disease, allergies, metabolic syndrome, irritable bowel syndrome, and IBD. The term "dysbiosis" is often used for unfavorable alterations in GM composition that manifest these diseases (Jalandra et al., 2022). Currently, prebiotic, probiotic, and fecal microbiota transplantation strategies are used to treat dysbiosis in the case of IBD (Lazar et al., 2022). Some antibiotics are also often used to inhibit the growth of pathogenic microorganisms in the GIT. In this chapter,