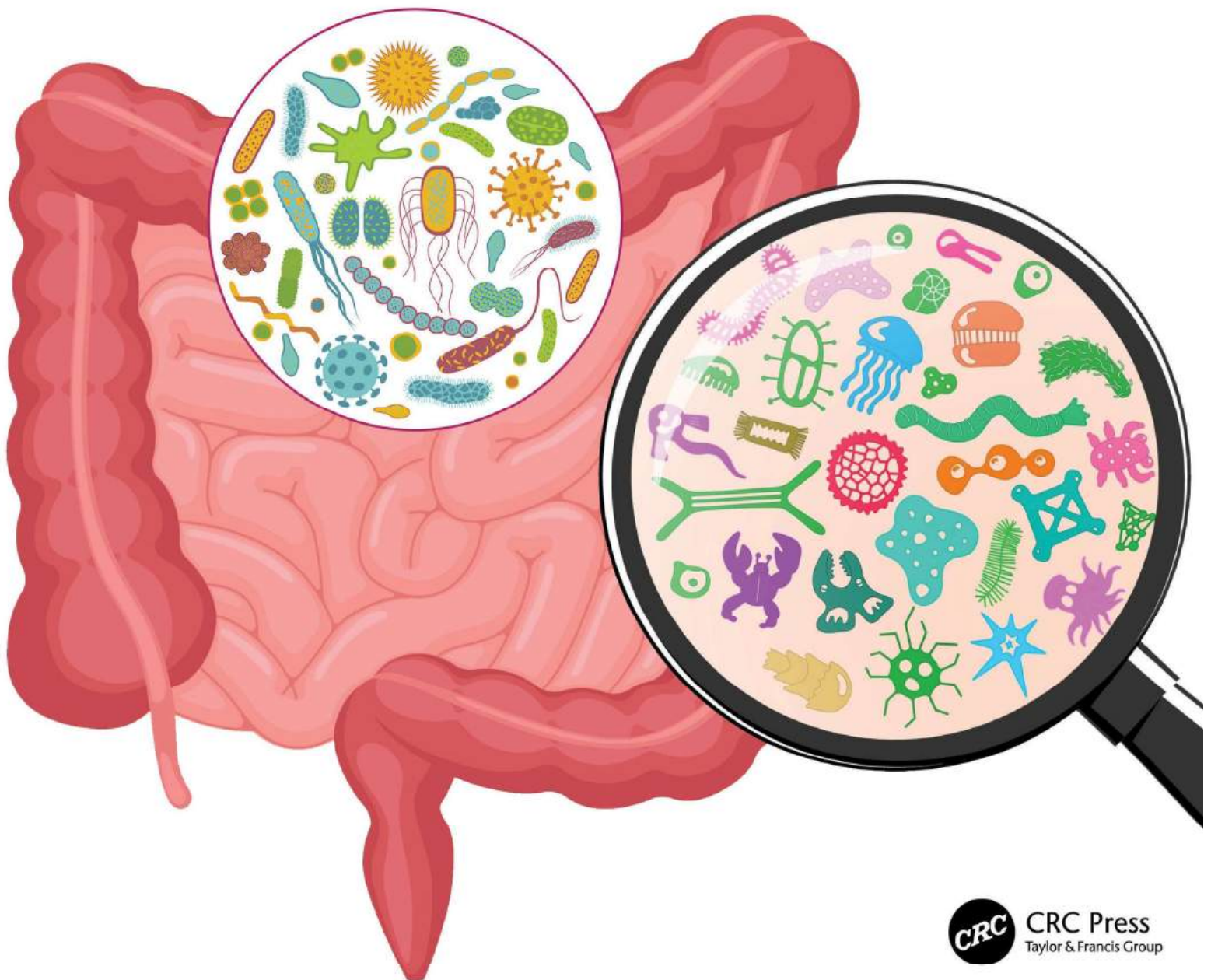


GASTROINTESTINAL INFLAMMATIONS AND GUT MICROBIOTA

Pathophysiology, Management, and Emerging Therapies

Edited by Neeraj Mishra, Sumel Ashique, and Anoop Kumar



Gastrointestinal Inflammations and Gut Microbiota

This book offers a comprehensive and multi-faceted examination of gastrointestinal inflammations, discussing factors that impact gut health. The initial chapters establish a foundational understanding of gastrointestinal inflammations and the critical role of the gut microbiota. The book then delves into the complex pathophysiology and various risk factors associated with these conditions, offering insights into the latest diagnostic, screening, and prevention techniques. It explores the dynamic interactions between the gut and the brain as well as the biochemical interplays involving short-chain fatty acids, reactive oxygen species, and superoxide dismutases. Additionally, the book thoroughly discusses the impact of genetics on gastrointestinal health, the interactions between antibiotics and gut microbiota, and the pivotal role of the immune system in inflammation. It highlights advancements in diagnostic technologies and gut microbiota-based strategies, along with the use of nanoparticles in treatment. The book also examines the psychological aspects associated with gastrointestinal inflammations, emphasizing the importance of mental health for physical well-being. It assesses the potential of functional foods, various types of nanocarriers, and plant-based bioactives in managing gastrointestinal inflammations. As such, this book is primarily intended for researchers and students in the fields of gastroenterology and microbiology.

Key Features:

- Provides an extensive overview of gastrointestinal inflammations, starting from the basic concepts of the gut microbiota to complex pathophysiological aspects
- Delves into the latest advancements in diagnostic, screening, and prevention techniques, highlighting cutting-edge technologies and approaches in gastroenterology
- Explores the role of the immune system and the impact of genetics and diet on gastrointestinal health
- Examines use of probiotics, prebiotics, postbiotics, and various nanotechnology-based approaches for gastrointestinal inflammation management
- Emphasis on the psychological factors associated with gastrointestinal inflammations



Taylor & Francis

Taylor & Francis Group

<http://taylorandfrancis.com>

Gastrointestinal Inflammations and Gut Microbiota

Pathophysiology, Management, and Emerging Therapies

Edited by

Neeraj Mishra, Sumel Ashique, and Anoop Kumar



CRC Press is an imprint of the
Taylor & Francis Group, an **informa** business

Designed cover image: Shutterstock

First edition published 2025

by CRC Press

2385 Executive Center Drive, Suite 320, Boca Raton, FL 33431

and by CRC Press

4 Park Square, Milton Park, Abingdon, Oxon, OX14 4RN

CRC Press is an imprint of Taylor & Francis Group, LLC

© 2025 selection and editorial matter, Neeraj Mishra, Sumel Ashique, and Anoop Kumar; individual chapters, the contributors

Reasonable efforts have been made to publish reliable data and information, but the author and publisher cannot assume responsibility for the validity of all materials or the consequences of their use. The authors and publishers have attempted to trace the copyright holders of all material reproduced in this publication and apologize to copyright holders if permission to publish in this form has not been obtained. If any copyright material has not been acknowledged please write and let us know so we may rectify in any future reprint.

Except as permitted under U.S. Copyright Law, no part of this book may be reprinted, reproduced, transmitted, or utilized in any form by any electronic, mechanical, or other means, now known or hereafter invented, including photocopying, microfilming, and recording, or in any information storage or retrieval system, without written permission from the publishers.

For permission to photocopy or use material electronically from this work, access www.copyright.com or contact the Copyright Clearance Center, Inc. (CCC), 222 Rosewood Drive, Danvers, MA 01923, 978-750-8400. For works that are not available on CCC please contact mpkbookspermissions@tandf.co.uk

Trademark notice: Product or corporate names may be trademarks or registered trademarks and are used only for identification and explanation without intent to infringe.

ISBN: 9781032796383 (hbk)

ISBN: 9781032796468 (pbk)

ISBN: 9781003493143 (ebk)

DOI: 10.1201/9781003493143

Typeset in Times

by Newgen Publishing UK

Contents

Preface.....	vii
About the Editors	ix
Chapter 1 Introduction to Gastrointestinal Inflammation and Gut Microbiota.....	1
<i>Muneeb Ullah, Mishal Safdar, Jin-Wook Yoo, Raees Khan, Abdul Wahab, Khalid Nawaz, and Muhammad Naeem</i>	
Chapter 2 Pathophysiology and Risk Factors Associated With Gastrointestinal Inflammation	14
<i>Sanjesh Kumar, Mansi Singh, Subhajit Mandal, Priyanka Goswami, Sumel Ashique, and Ivan Kahwa</i>	
Chapter 3 Diagnosis, Screening, and Prevention Techniques of Gastrointestinal Inflammations	36
<i>Hafiza Sehrish Kiani, Adeel Ahmad Khan, Fahad Thabet Alsulami, Yousef Saeed Alqarni, Abdullah Saleh Alruwaili, Ahmed Ramdan M. Alanazy, Abdul Malik, Rameesha Abid, Mithun Bhowmick, and Arshad Farid</i>	
Chapter 4 Influence of Gut-Brain Axis on Gastrointestinal Health and Benefits	72
<i>Sindhu Priya E.S., Sandhya Vasanth, Rokeya Sultana, Mohammed Gulzar Ahmed, and B.H. Jaswanth Gowda</i>	
Chapter 5 Interplay Between SCFAs, ROS, SODs, and Gastrointestinal Inflammations.....	90
<i>Aniruddha Sen, Sanjesh Kumar, Pranshul Sethi, Sumel Ashique, Radheshyam Pal, Neeraj Mishra, and Anoop Kumar</i>	
Chapter 6 Role of Probiotics, Prebiotics, and Postbiotics in Management of Gastrointestinal Inflammations.....	107
<i>Aniruddha Sen, Krishnendu Adhikary, Pooja S. Murkute, Sumel Ashique, and Radheshyam Pal</i>	
Chapter 7 Role of Genetic Factor in Gastrointestinal Inflammation	121
<i>Priyanka Ray, Tamalika Chakraborty, and Debojyoti Adak</i>	
Chapter 8 Interaction of Antibiotics With Gut Microbiota and Its Implications for Treating Gastrointestinal Inflammations.....	143
<i>Md Sadique Hussain, Prince Ahad Mir, Nishant Kumar, Adil Farooq Wali, Sumel Ashique, Roohi Mohi-ud-din, and Reyaz Hassan Mir</i>	
Chapter 9 Role of the Immune System in Gastrointestinal Inflammation	167
<i>Tahreem Taj, Mithun Bhowmick, Pratibha Bhowmick, Sumel Ashique, Neeraj Mishra, and Farzad Taghizadeh-Hesary</i>	

Chapter 10	Advancements in Diagnostic Techniques and Technology for Gastroenterology.....	180
	<i>Sunny Rathee, Vishal Pandey, and Sanjay K. Jain</i>	
Chapter 11	Gut Microbiota Based Strategies for the Management of Gastrointestinal Inflammations.....	197
	<i>Sowmiya S., Jasmine R., Selvakumar B.N., Deena Priscilla H., and Rameshkumar Santhanam</i>	
Chapter 12	Nanoparticles-Based Approaches for the Management of Gastrointestinal Inflammations.....	213
	<i>Vasu Peddinti, Biswajit Rout, Shyam Sudhakar Gomte, Tejas Girish Agnihotri, and Aakanchha Jain</i>	
Chapter 13	Experimental Animal Models and <i>In-Vitro</i> Models for Gastrointestinal Inflammation.....	233
	<i>Phool Chandra, Zeeshan Ali, Nishat Fatma, and Neetu Sachan</i>	
Chapter 14	The Neuroinflammation Enigma: Cracking the Code of the Gut-Brain Connection	251
	<i>Abhimanyu Thakur, Dipanjan Ghosh, Rajesh Sarkar, Sera Averbek, Ashok Iyaswamy, Prabhat Upadhyay, Sarika Gupta, Vikas Kumar, and Amrendra K. Ajay</i>	
Chapter 15	Functional Foods and Nanocarriers for the Management of Gastrointestinal Inflammations.....	262
	<i>Amit Anand, Kenganora Mruthunjaya, Santhepete Nanjundiah Manjula, Neeraj Kumar Fuloria, and Hemanth P.R. Vikram</i>	
Chapter 16	Polysaccharide-Based Nanoparticles for the Management of Gastrointestinal Inflammations	280
	<i>Jitu Halder, Tushar Kanti Rajwar, Ajit Mishra, Guru Prasanna Sahoo, Biswakanth Kar, Goutam Ghosh, and Goutam Rath</i>	
Chapter 17	Lipid Nanocarriers for the Treatment of Gastrointestinal Inflammations	292
	<i>Anas Islam, Ambareen Fatima Ahmed, Asad Ahmad, Usama Ahmad, and Yusuf Asad</i>	
Chapter 18	Exosomes Mediated Nanocarriers for Gastrointestinal Inflammation Management	310
	<i>Sakshi Soni, Aashi Jain, Priyanshu Nema, Vandana Soni, and Sushil K. Kashaw</i>	
Chapter 19	Plant-Based Bio-Actives Encapsulated Nanocarriers for Gastrointestinal Inflammations Management.....	322
	<i>Subhasundar Maji, Sandipan Dasgupta, Ria Das, and Slim Smaoui</i>	
Chapter 20	Future Prospects and Clinical Studies for the Treatment of Gastrointestinal Inflammations	346
	<i>Sanjeeb Kumar Kar, Shubhrajit Mantry, Ashutosh Behera, Laliteshwar Pratap Singh, Brijyog, and Deepak Kumar Patra</i>	
Index		363

Preface

Gastrointestinal inflammation pertains to the development of inflammation inside the gastrointestinal tract, encompassing the esophagus, stomach, small intestine, and large intestine. Inflammation within the gastrointestinal (GI) tract can arise from a multitude of factors, and it is frequently linked to conditions such as inflammatory bowel disease (IBD), irritable bowel syndrome (IBS), infectious gastroenteritis, and other related disorders. One of the most common digestive disorders, gastrointestinal inflammations, is characterized by constant, recurrent stomach pain and irregular bowel movements.

The cause of IBS is not fully known and is thought to be extremely complex; consequently, treatments are only somewhat effective. Epidemiologic research on individuals with post-infectious IBS (PI-IBS) has demonstrated a changed microbiota in the human gastrointestinal tract as one of the potential causes of IBS in the last ten years. Previous observational studies have shown that there is a higher risk of developing IBS in the future when the gut microbiota changes because of acute gastroenteritis. Additionally, there is a strong correlation between IBS and antibiotic therapy for extra-intestinal infections, which may change the intestinal flora. IBS is thought to be caused by a complex combination of genetic, environmental, and microbiota-related factors, while its specific cause is yet unknown. Promising therapy

options for IBS include nanocarriers and methods that modify the gut microbiota. Therapeutic medicines can be packaged and delivered via nanocarriers like nanoparticles or liposomes right to the damaged parts of the gastrointestinal (GI) tract. By decreasing drug exposure to healthy tissues, this strategy lessens negative effects. The modified NPs (nanoparticles) have boosted medication concentration, decreased systemic adverse effects, and improved the efficacy and safety of local drug delivery. The development of IBD therapies based on nanotechnology is accelerating exponentially. For optimal health, IBS prescription medication is accessible.

The development of various nanoparticles that will aid in the management of IBS and other gastrointestinal illnesses is a major priority for many pharmaceutical companies. However, further research is necessary to fully comprehend how the effects of the nanoparticle on the gut flora could benefit IBD patients' prognoses. By extending the duration of the therapeutic impact and lowering the frequency of medication administration, controlled-release nanocarriers can increase patient compliance. Researchers are investigating the creation of hybrid systems that combine medicines that target the microbiota with nanocarriers for drug delivery. For instance, probiotics or prebiotics can be added to nanocarriers to increase their therapeutic efficiency.



Taylor & Francis

Taylor & Francis Group

<http://taylorandfrancis.com>

About the Editors

Neeraj Mishra has been serving as a Professor at the Amity Institute of Pharmacy, Gwalior, since July 2019. He brings approximately 20 years of experience in teaching and research. Dr. Mishra has published over 100 papers of international and national significance, focusing on novel drug delivery systems, oral delivery of synbiotics, localized drug delivery, and targeted and controlled drug delivery using nanocarriers and microparticles for treating breast and colon cancer, as well as neurodegenerative disorders. He has also edited more than 15 books and authored 25 book chapters. He is the recipient of the “Distinguished Professor Award” (2019) from DST-NSTMIS, SPAICS, Indore, Madhya Pradesh, and the “Outstanding Scientist Award” (2020) from the 6th International Scientist Awards on Engineering, Science, and Medicine, held in Chennai, India. Further, Dr. Mishra received the “Distinguished Professor Award” in 2021 from the Indian Pharmaceutical Association, MP State Branch, Indore, and the “Best Academician Award” at the Indian Pharmacy Graduate Association’s M.P. State International Conference, held on May 6, 2023, at the DAVV Auditorium, Indore, India.

Sumel Ashique has been working as an Assistant Professor at Bengal College of Pharmaceutical Sciences & Research, Durgapur 713212, West Bengal, India. He has 4 years of teaching experience. He has achieved 80 publications in international and national accredited reputed journals. He has knowledge in drug delivery, nanotechnology and targeted treatment strategy. He is working as a potential reviewer for many well-known publishers (Elsevier, Springer, Dove Press, and Bentham Sc.). He has also five granted patents from IP and Australia, 20 published book chapters in Bentham, Springer, Elsevier, Bentham and Taylor & Francis. Currently he is editing 14 books under CRC Press, Elsevier, Taylor & Francis,

Wiley, Nova Science and Springer. He has published 80+ papers including research, reviews, column articles, editorials in Scopus, and WOS indexed. He is serving as Guest Editor for *JoVE Journal* (IF 1.2, Scopus & WOS indexed), *Current Probiotics* (Bentham Science) & *Current Indian Science Journal*. He is a potential reviewer for Elsevier, Springer, Taylor & Francis and Wiley journals for expertise in the fields of targeted drug delivery, nanotechnology, gut-microbiome, and postbiotics. Currently, he is pursuing his PhD degree from Lovely Professional University, Punjab, India (NAAC A++) in the Pharmaceutical Science department.

Anoop Kumar is currently serving as an Assistant Professor in the Department of Pharmacology and Clinical Research at Delhi Pharmaceutical Sciences & Research University (DPSRU), New Delhi, India. Previously, he held the position of Assistant Professor in the Department of Pharmacology and Toxicology at the National Institute of Pharmaceutical Education and Research (NIPER), Raebareli. He has also served as an Associate Professor and Officiating Head in the Department of Pharmacology at ISF College of Pharmacy, Moga, Punjab. Additionally, Dr. Kumar has worked as a research scientist in the Medical Affairs and Clinical Research Department at Sun Pharmaceutical Limited, Gurugram, and at the Translational Health Science and Technology Institute (THSTI), Faridabad, India. Dr. Kumar has authored over 80 research and review articles and 15 book chapters in internationally renowned journals. He is also the author of three books. He has received research grants from the Indian government. His research interests include drug repurposing using computational, in vitro, and in vivo techniques, meta-analysis, signal analysis in pharmacovigilance, and pharmaco-economic studies.



Taylor & Francis

Taylor & Francis Group

<http://taylorandfrancis.com>

17 Lipid Nanocarriers for the Treatment of Gastrointestinal Inflammations

*Anas Islam^{1,2}, Ambareen Fatima Ahmed², Asad Ahmad¹,
Usama Ahmad^{1*}, and Yusuf Asad³*

¹Department of Pharmacy, Integral University, Lucknow-226026, India

²School of Pharmaceutical Sciences, Integral University, Lucknow-226026, India

³Biomedical Engineering Program, Department of Electrical and Computer Engineering, North Dakota State University, Fargo, ND 58102, United States

17.1 INTRODUCTION

The definition of inflammation has evolved from its four cardinal signs of calor, rubor, tumor, and dolor as proposed by Celsus during the first century A.D. to the addition of the fifth sign of inflammation by Virchow in 1871 as the loss of function. With the advancement of cell-based techniques and molecular biology in the 19th century, the term inflammation has been defined more elaborately. The body's defense response to injury caused by any agent—be it microbial, immunological, physical, or chemical—is called inflammation. Clinically, this definition encompasses a multitude of biological processes (Scott et al., 2004).

Inflammation helps to alleviate harmful substances, flush them out, and promote tissue repair. Two fundamental processes—the early inflammatory response and the subsequent healing process—are involved in inflammation. While both of these processes typically serve as defenses against harmful agents, inflammation and healing can also have serious negative effects on the body (Carton et al., 2006).

The body's initial reaction is known as acute inflammation, which usually goes away quickly after the underlying cause is treated and is followed by healing. It lasts for two weeks or longer. It starts following a particular injury that triggers the migration of neutrophils and macrophages to the site of inflammation by the release of soluble mediators such as cytokines, acute phase proteins, and chemokines. Chronic inflammation develops either immediately after the acute inflammatory stimulation or after a prolonged period of time has elapsed. Chronic inflammation is characterized by its prolonged duration. In chronic inflammation, T lymphocytes and plasma cells go to the site of inflammation (Hannoodie & Nasuruiddin, 2023).

Gastrointestinal inflammations are a type of disease that affects the gastrointestinal tract. This tract runs from the oral cavity to the anal cavity. Several conditions can cause inflammation of the gastrointestinal tract, including gastritis, periodontal disease, peptic ulcer disease, Crohn's disease, and ulcerative colitis. All of these conditions involve chronic inflammation in various parts of the gastrointestinal mucosa, which can result in epithelial compromises and tissue damage. There are also autoimmune components associated with the

inflammatory bowel diseases along with systemic effects (Bamford, 1999).

17.1.1 MAJOR TYPES OF GASTROINTESTINAL INFLAMMATIONS

Of the gastrointestinal tract inflammatory conditions associated with inflammatory bowel disease (IBD), the most frequently occurring conditions are Crohn's disease and ulcerative colitis. The pathological mechanisms involve complex interaction of immunological, microbial, environmental, and genetic variables.

Genetic predisposition is just one of the numerous factors causing immune system dysregulation in inflammatory bowel disease (IBD) (Geremia et al., 2014) as well as dietary habits (Keewan et al., 2020) and the gut microbiome (Matsuoka & Kanai, 2015). Potentially, such mechanisms can take into account cytokine modulation, microbiome therapies, or dietary readjustments to manage and treat IBD.

Gastritis is the other condition of the gastrointestinal inflammation. Gastritis is the inflamed, irritated, or eroded stomach lining as a pathological condition that may manifest abruptly (acute) or develop gradually (chronic). Overindulgence in alcohol or long-term use of nonsteroidal anti-inflammatory medicines (NSAIDs), including ibuprofen or aspirin, are common causes of the illness. Bacterium infection, especially *Helicobacter pylori* (HP), persistent bile reflux, stress, and some autoimmune diseases (Elseweidy, 2017).

Eosinophilic esophagitis (EoE) refers to a persistent inflammatory condition affecting the esophagus, primarily observed among the pediatric demographic. EoE is characterized by clinical symptoms of esophageal dysfunction and eosinophilic infiltration of the esophageal mucosa (Sutton et al., 2015).

In genetically susceptible individuals, duodenal inflammation is the hallmark of celiac disease (CD), a multiorgan autoimmune condition of the chronic intestinal disease group that is triggered by gluten consumption. Today, there is a great deal of research on the pathophysiology of celiac disease, which expands the concept beyond autoimmune alone and explains why the condition is hereditary. The