

Review

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Review

Postoperative Pain and the Microbiota: Role in Current Anesthesiology

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Abstract

The context of the intestinal microbiota has gained increasing relevance in contemporary medicine, particularly regarding its relationship with anesthetic procedures and the perception of postoperative pain. This study aims to describe the changes in the intestinal microbiota that occur following such procedures and to analyze their potential implications for pain perception. Through a theoretical review article, the most recent scientific literature on the topic is compiled and analyzed, establishing connections between microbiota alterations and postoperative pain experiences. The findings indicate that changes in the intestinal microbiota, such as dysbiosis, are associated with inflammatory processes and altered pain perception, suggesting that a healthy microbiota may play a key role in the modulation of postoperative pain. This research suggests that future clinical strategies should consider optimizing the microbiota as an effective approach to improve recovery and pain management after surgery, opening new opportunities for therapeutic interventions focused on intestinal health within the context of anesthesiology and pain medicine. **Objective:** To describe changes in the gut microbiota associated with anesthetic–surgical procedures and their possible impact on postoperative pain perception. **Methods:** We conducted a comprehensive literature review (2019–2025) in PubMed, Scopus, SciELO, and LILACS using DeCS/MeSH descriptors (“Gut Microbiota,” “Anesthesia,” “Postoperative Pain,” “Dysbiosis,” “Probiotics,” “Surgery”). We prioritized systematic reviews, clinical studies, and relevant guidelines. Inclusion: human studies and articles of physiopathological or methodological interest. Exclusion: reports unrelated to microbiota or postoperative pain.

Keywords: gut microbiota; anesthesia; postoperative pain; dysbiosis; postoperative recovery

Introduction

In recent years, the intestinal microbiota has emerged as a key component in the comprehensive understanding of patient health, particularly in the perioperative setting. Various studies have shown that anesthetic agents can alter the composition and diversity of the intestinal microbiota through both intrinsic and extrinsic factors, with a direct impact on the perception of postoperative pain. This relationship between microbiota and anesthesia has become a topic of growing interest in contemporary anesthesiology, expanding the clinical focus beyond the immediate control of pain toward a more holistic vision of recovery.

Traditionally, the microbiota was studied primarily from the perspective of its pathogenic potential. However, it is now recognized as playing a fundamental role in immune regulation and the maintenance of homeostasis. This is especially relevant in the surgical context, where immune response and pain management are strongly influenced by microbial balance, given that changes in inflammatory processes have been demonstrated.

Recent studies have begun to provide evidence of this complex interaction. For instance, the impact of bariatric surgery on the intestinal microbiota has been examined, showing an increase in species such as *Akkermansia muciniphila*, whose presence may be associated with reduced pain levels after surgery [1]. Similarly, certain anesthetic techniques have been observed to induce specific

changes in gut flora, underscoring the importance of tailoring anesthetic choice while considering its potential effects on the patient's microbiome.[2]

The role of local anesthetics has also been highlighted from an immunological perspective, suggesting that these agents may modulate the immune system in a microbiota-dependent manner. This approach opens new possibilities for optimizing anesthetic management based on individual microbial characteristics.[3]

It is equally important to explore how microbial variations may influence pain sensitivity during the postoperative period, considering preoperative anxiety. Evidence suggests that its effects are not limited to the cardiorespiratory system but also extend to the gut microbiome.[4]

These observations reveal fertile ground for future research. The integration of microbiota as a key variable in anesthetic practice would not only deepen the understanding of the recovery process but also lead to the design of more effective, personalized strategies for pain management and improved surgical outcomes.

Composition of the Intestinal Microbiota

The composition of the intestinal microbiota is a central topic in microbiological and biomedical research, given its significant impact on individual health. Several recent studies have analyzed how factors such as diet, environment, and host characteristics influence the diversity and composition of the intestinal microbiota. These studies have emphasized how different dietary habits affect the bacterial composition of the intestine as well as the metabolic and immunological interactions between the microbiome and the host, establishing a critical link between diet and intestinal health.[5]

Additionally, animal studies particularly those focusing on amphibian microbiota have considered variables such as sex.[6] These findings suggest that variations in the composition of the intestinal microbiota may be related to host characteristics such as sex and genetics, indicating that intrinsic factors can have a substantial impact on the configuration of the microbiome.

In the context of gastrointestinal health and disease, the intestinal microbiota composition of captive marmosets has been associated with dysbiosis patterns also observed in humans. This provides evidence that environmental conditions, such as living in the wild versus captivity, affect microbial adaptability and diversity. Importantly, it has been demonstrated that captive primates tend to exhibit relatively greater losses of native intestinal microbiome diversity compared to their wild counterparts. Differences in diet are key contributing factors, with wild primates showing better intestinal health and fewer inflammation-related diseases than those living in captivity.[7]

The evidence supports the idea that a diverse intestinal microbiota is not only essential for metabolism but also for immune function.

Relationship Between Microbiota and Surgical Procedures

The relationship between the microbiota and surgical procedures has been the focus of recent research, as it has been demonstrated that changes in the intestinal microbiota can influence the outcomes of surgical interventions and postoperative recovery.

A study by Piñango et al. discusses the incidence of surgical site infections (SSI) and highlights alterations in the intestinal barrier due to prolonged fasting, supporting the claim that such fasting may contribute to postoperative complications.[8] This study emphasizes that prolonged fasting, commonly required before surgery, can disrupt the intestinal barrier and facilitate bacterial translocation, thereby contributing to systemic inflammation.

Adequate nutritional optimization and education programs on intestinal health are therefore fundamental to reducing complications and improving the recovery of patients undergoing surgery. This study suggests that restoring a healthy microbiome could play a critical role in enhancing postoperative recovery, reinforcing the claim that intestinal health is essential for successful outcomes.[9]

Mechanisms of Pain Perception

Pain perception is a complex process mediated by a combination of neurobiological and psychological factors. Nociceptive signals are initially detected by specialized nerve endings, which transmit this information to the central nervous system (CNS). Among the mechanisms involved,

transient receptor potential (TRP) channels, located on these nerve endings, play a key role in detecting thermal and noxious stimuli. These channels are essential in generating pain sensations, and within the TRP family, TRPV-1 receptors are particularly important in nociceptive transmission. When activated, they facilitate pain perception by modulating the excitability of nociceptive neurons, highlighting how molecular and cellular mechanisms are central to pain perception and opening the door to new therapeutic interventions aimed at modulating this response.[10]

On the other hand, a more integrative approach to pain perception recognizes that modulation occurs at both central and peripheral levels. The CNS not only receives and processes nociceptive signals but also influences how these signals are ultimately perceived by the individual. The CNS's ability to inhibit or facilitate pain can be affected by factors such as attention and emotional state, suggesting that pain is also a psychological construct.[11]

This idea is supported by a study on the influence of psychological factors, in which Díaz-Narváez et al. found that negative emotional and behavioral aspects can alter pain perception, underscoring the importance of psychosocial interventions in the management of chronic pain. These findings suggest that, to effectively address pain perception, a multidisciplinary approach that incorporates both neurobiological and psychological components is required.

Strategies for Pain Modulation Through the Microbiota

Pain modulation via the intestinal microbiota has increasingly attracted the attention of the scientific community, as the interaction between the microbiota and the nervous system is recognized as crucial in pain perception. The gut-brain-microbiota axis can influence not only the transmission of pain signals but also the regulation of inflammation and the emotional processes associated with pain perception. Research has shown that, during early stages of life, a healthy intestinal microbiota can establish strong connections with pain pathways in the central nervous system, enabling an appropriate physiological response to noxious stimuli.[12] This evidence suggests that microbiota colonization may provide an opportunity to develop interventions aimed at modulating chronic pain perception through the restoration of a balanced microbiota.

The clinical significance of this relationship is particularly evident in patients with celiac disease, where alterations in the microbiota may result in symptoms such as abdominal pain. In this context, the use of probiotics and prebiotics has been proposed as a strategy to modulate the microbiota and, consequently, alleviate dysbiosis-related pain.[13] Evidence also indicates that fecal microbiota transplantation, combined with vitamin D supplementation, may contribute to pain modulation in syndromes such as irritable bowel syndrome. These studies highlight the importance of strategies that not only address pain symptomatically but also aim to restore the microbiota's composition, thereby achieving long-term relief.[14]

Advances in Anesthetic Techniques

Advances in anesthetic techniques have been a central focus of modern medicine, as these innovations enhance both the efficacy and safety of surgical procedures. A significant development in regional anesthesia is the use of ultrasound guidance, which allows for greater precision in nerve localization and, consequently, reduces the rate of complications compared with traditional techniques. Reports indicate that ultrasound-guided techniques have a success rate of 82.8% for brachial plexus blocks, surpassing conventional methods based on nerve stimulation.[15] This approach not only optimizes postoperative pain control but also lowers the risk of complications, thereby improving the overall patient experience during and after surgery.

Another notable advancement is the introduction of electroencephalography-based sedation monitors, such as the bispectral index (BIS), which enable more precise, real-time adjustments of sedation levels during general anesthesia. These brain-monitoring devices have evolved significantly, offering substantial improvements in the assessment of patients' levels of consciousness. Such devices are essential in preventing episodes of oversedation or intraoperative awareness, both of which may cause anxiety and distress in patients.[16] Taken together, these advancements not only enhance the efficacy of anesthetic techniques but also contribute to improved healthcare quality by striking a balance between effective pain control and patient safety.

Clinical Implications of Microbiota Changes

Changes in the intestinal microbiota have important clinical implications that extend beyond digestion, affecting multiple aspects of the patient's metabolic, immunological, and neurological health. Alterations in the microbiota have been linked to the development of metabolic disorders such as obesity, type 2 diabetes, and metabolic syndrome. A healthy microbiome plays a vital role in nutrient metabolism and immune responses, suggesting that interventions aimed at restoring microbial diversity could serve as key strategies for the prevention and treatment of these conditions [17].

Furthermore, evidence indicates that dysbiosis may contribute to systemic inflammation, a well-known risk factor for the development of chronic diseases. Recent studies have referred to the microbiota as a "forgotten organ," emphasizing its role in modulating inflammation and providing protection against pathogens. Changes in microbial composition can significantly impact host physiology, contributing to the emergence of both intestinal and extraintestinal diseases, as well as immunological disorders [18].

This integrative perspective on the impact of microbiota on health implies that healthcare professionals should consider microbial health as a fundamental aspect of clinical management. It also underscores the need for future research to evaluate therapeutic approaches aimed at restoring microbiota balance and their subsequent effects on patient recovery. These clinical implications open new horizons in medicine, highlighting the importance of investigating microbiota not only in relation to specific diseases but also in terms of overall health and well-being.

Conclusions

The findings of this theoretical review highlight the complex relationship between the intestinal microbiota and anesthetic procedures, as well as their importance in the perception of postoperative pain. Alterations in microbiota composition have been shown to influence inflammatory responses and pain modulation, opening new avenues for understanding how these interactions may affect patient recovery following surgical interventions. Notably, changes in the microbiota resulting from anesthesia may be associated with complications in pain perception, underscoring the importance of a multisectoral approach to postoperative pain management.

With respect to the objective of this review—to describe the changes in intestinal microbiota that occur after anesthetic procedures and their possible implications for postoperative pain perception—the evidence indicates that microbiota alterations have a significant impact on pain management. These changes could be critical for understanding differences in recovery and pain experiences, suggesting that personalized anesthetic approaches may improve postoperative outcomes. As a theoretical review, this article adds context and integrates current references on the state of knowledge in this emerging field.

Finally, the implications of this work point toward areas for future research, such as evaluating microbiota-based interventions using probiotics or prebiotics to improve postoperative recovery and reduce pain. Additionally, further studies are needed to examine the relationship between microbiota and different anesthetic techniques, which may provide significant contributions to clinical practice. The growing understanding of the interaction between microbiota and anesthesia could lead to a more holistic and effective approach to perioperative care, paving the way for future research at the intersection of gastroenterology, anesthesiology, and pain medicine.

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