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News on Septicemia, Use of Biotics and Fecal Microbiota Transplantation

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Abstract

Deaths in the Intensive Care Unit due to sepsis are characterized by colonization of pathogenic microorganisms resistant to various drugs. In this, the abolition of key elements of the patient's transcriptome is decisive, such as the decrease in butyrate expression. The union between sepsis and intestinal microbiota is extremely complex. Sepsis drives intestinal dysbiosis, with the intestinal microbiome participating in its development by impacting the susceptibility of the host. In this review we analyze the relationship between the intestinal microbiota and sepsis, as well as everything related to the process such as the pathophysiology of sepsis, the immunological process, the much-cited gut-brain axis, dysbiosis, Short Chain Fatty Acids. How the intestinal microbiota affects Multiple Organ Dysfunction Syndrome. The controversy over the use of antibiotics; the treatment of sepsis. The use of biotics, septic complications and, finally, the usefulness of fecal microbiota transplantation are evaluated.

Keywords: septicemia; short-chain fatty acids; intestinal microbiota; fecal microbiota transplantation

Introduction

Although much remains to be learned about the relationship between intestinal microbiota (GM) and septicemia (SEPT), there are studies, such as that of Jiahui Hu [1], and his team, who identify the current situation, trends and evolution of the impact of GM on SEPT, through bibliometric analysis; (1,882 articles). Pointing out current research sub-directions and new trends, through comparisons and analysis, which will help the development of this topic. Jungen Tang, et al [2]. Reveal that Lentisphaeria, order Victivallales and the genus Eubacterium eligens may be related to the risk of sepsis. While Zhao J, and his group [3] manifest a marked interaction between the genus Coprococcus and the metabolite α-hydroxybutyrate in the SEPT environment. Suggesting that the consideration of metabolites provides perspectives for interesting research. Piccioni A, and his team [4], refer to sepsis as an affliction characterized as a clinical syndrome, with a severe and uncontrolled inflammatory response to an infection, which can cause septic shock and death. They add that there is a close union between SEPT and GM.

Intestinal Microbiome in Sepsis

With advances in high-throughput sequencing technology, the connection between SEPT and gut dysbiosis has become a new focus of research [5]. Recent evidence has demonstrated a union between the gut microbiome and SEPT. Adelman MW. et al [6]. report that early GM increases the tendency to sepsis by allowing pathogenic bacterial development; by preparing the immune system for a strong inflammatory response and by decreasing the production of Short Chain Fatty Acids (SCFA). Altered GM then generates end-organ dysfunction. Kulberg FJ et al [7]. followed more than 10,000 people for 6 years, finding that those with less healthy GM developed severe infection. This leads to infections continuing to be a huge global burden of disease, despite constant advances. This is confirmed by the Global Burden Disease [8], which considers that more than 25% of all deaths worldwide are due to infections. The study is extremely interesting, since the latest version evaluates thousands of consequences in more than 200 countries. They reiterate that there is intestinal pathology in hospitalized patients, even before the use of antibiotics. Patients present less intestinal anaerobes and more pathogenic bacteria. Although, it is not

clear whether the subsequent pathology is due to alterations in GM or to processes of the disease itself. SEPT and changes in GM, indicating that our microbiome could play an essential role in pathogenesis and prognosis.

Pathophysiology of Sepsis and Consequences

SEPT is generated by infectious attack, which produces localized inflammation, which develops hypothermia or fever, tachycardia, tachypnea and increased or decreased leukocytes [9]. Severe sepsis may be added, due to metabolic acidosis or disorder of vital organic systems. Colonization with butyrate-producing bacteria is associated with protection against hospitalization due to infectious diseases. SEPT leads to multiple organ dysfunction, due to suppression or activation of endothelial, metabolic, immune, hormonal, bioenergetic and other pathways. These pathways generate circulatory and metabolic alterations, which translate into organ dysfunction and moderate inflammation by cytokines, interleukins, prostaglandins and tumor necrosis factor. The pathophysiology of sepsis has moved away from the pathogen and is focused on the abnormal and exaggerated response of the host [10]. SEPT symbolizes the dysregulated response to host infection, leading to organ dysfunction. In summary, the underlying mechanisms, often seen as dysfunctional, may be adaptive/protective.

Immunology, Sepsis and Intestinal Microbiota

Septic death is identified by colonization of multidrug-resistant pathogens. It has been pointed out that FMT in mice restores the immune system, prevents pathogen colonization and aids in recovery [11]. Determination of the immunophenotype requires further investigation, as well as determination of biomarkers that help diagnosis and therapy. Luo Y, with his collaborators. [12] found in patients with sepsis a reduction of NK cells, as well as plasmacytoid dendritic cells, in CD45+ leukocytes, which do not appear in healthy patients. These statistically reconciled changes with the association of Bacteroides salyersiae with sepsis, suggesting a possible underlying mechanism. And they incorporated a model with B. salyersiae, NK cells in CD45+ leukocytes and PCR, demonstrating that this prototype distinguishes sepsis from non-sepsis. Preclinical templates attest that a diverse and balanced GM enhances host immunity against enteric and systemic pathogens and is a consequence of dysregulated immune response to infection. It is noted that GM metabolites prevent immunopathology [13]. The integrity of the intestinal epithelium and adaptive immune responses are severely compromised during sepsis; confirming that the mucosal microbiome has a transcendent role in adaptive immunity, where prokaryotes and the host are linked in both directions (careful balance between normal GM and pathogenic organisms) [14]. SEPT is identified by concurrent unbalanced hyperinflammation and immune suppression. There are aberrant immune responses during it [15].

Gut-brain Axis in Sepsis

Bidirectional communication network between the gut and brain, which monitors digestive functions, emotional responses, body immunity, brain development and overall health [16]. It is linked to psychiatric and neurological disorders, including Alzheimer's disease and depression. And, it is related to SEPT-associated encephalopathy, as an early process of organic dysfunction, which can lead to acute and long-term cognitive impairment. The axis uses several pathways, the vagus nerve, neuroendocrine, serotonin and bacterial regulation among others (bacterial metabolites). Gareau MG, points out [17] that the gut-microbiota-brain axis facilitates communication between intestinal microorganisms and the brain, regulating behavior. Di Napoli A et al. [18] show, through a review of 532 articles, updated to January 2024, that in healthy people the GM is linked to the connectivity of areas related to memory, cognitive and emotions. The amygdala and the temporal cortex showed structural and functional differences, related to bacterial abundance, especially in patients with Inflammatory Bowel Syndrome. Meanwhile, OHara TE and team [19], discuss how the GM modulates brain behavior and activity and how the brain, through bidirectional communication, influences the function and composition of the GM, involving biochemical and cellular mediators, consisting of intimate connections between chemosensory epithelial cells and sensory nerve fibers.

Intestinal Dysbiosis and Sepsis

Intestinal dysbiosis could be a determining factor in the pathophysiology of SEPT, by increasing the dominance of pathobionts and producing intestinal barrier dysfunction, with immune response of the host. The dysbiosis of GM, say Gai X and his team [20], has a transcendental function in the

pathophysiology of sepsis. They comment on this when carrying out research on FMT, in the function of the inflammatory response, the function of the intestinal barrier and survival, in mice with ligation and fecal puncture. Liu Z et al. [21] They performed systematic analysis on stool samples from patients with sepsis, including 16S rDNA sequencing, metabolomic and meta-proteomic analyses. Detecting that the composition of GM was significantly altered in patients with sepsis compared to healthy individuals. In addition, several GM strains and microbial metabolites were correlated with serum levels of total bilirubin in patients with sepsis. Summarizing, enteric dysbiosis could promote inflammation and organ injury in SEPT, as well as alter the intestinal microenvironment, promoting the epithelial cell barrier.

The Importance of Short Chain Fatty Acids in Sepsis

Short chain fatty acids (SCFA) play a crucial role in modulating the inflammatory response and maintaining intestinal barrier function. Specifically, higher abundance of butyrate-producing bacteria is associated with reduced risk of hospitalization for infections [22]. Lou X and his team [23] analyzed 16S rRNA from fecal samples from healthy people and patients with sepsis to determine whether alterations in intestinal bacteria are associated with sepsis. They found that the GM constitution of patients with sepsis differed significantly from healthy people and that the amount of Proteobacteria in sepsis was much higher than that of the control group, while the amount of Firmicutes was significantly lower. Concluding that SCFA could regulate the abundance of bacteria such as Firmicutes, Proteobacteria, Escherichia, Shigella and Lactobacillus, restoring them to levels comparable to that of healthy mice. Intestinal bacteria have the potential to produce a wide range of metabolites that can modulate human functions, including molecules with neuroactive potential [24]. One of these molecules is γ-aminobutyric acid (GABA), the main inhibitory neurotransmitter of the central nervous system in animals. Metagenomic analyses suggest that the genomes of numerous intestinal bacteria encode glutamate decarboxylase, an enzyme that catalyzes the production of GABA. Butyrate, a metabolite derived from the microbiome, increases the antimicrobial activity of monocytes and affects the immune environment of the lung. Likewise, butyrate-producing anaerobic intestinal bacteria protect against systemic infections [25].

Multiple Organ Dysfunction Syndrome and Intestinal Microbiota

Since GM dysbiosis is significant in infections, it becomes a possible therapeutic vs. Multiple organ dysfunction syndrome. Although FMT has been investigated in this condition on rare occasions, as occurred in men aged 65 and 84 years, diagnosed with cerebellar hemorrhage and cerebral infarction, respectively. Both patients developed multiple organ dysfunction syndrome, septic shock and severe watery diarrhea. Having confirmed intestinal dysbiosis by molecular analysis 16S rRNA and treated with nasal administration of microbiota; after two days both patients were monitored and their body temperatures decreased significantly, normalizing. In both patients, a significant increase in Firmicutes and a severe decrease in Proteobacteria was observed [26].

Antibiotics, Sepsis and Intestinal Microbiota

Antibiotic therapy can decrease the number of commensal bacteria and increase the risk of developing subsequent diseases, where GM dysbiosis may be a factor. The prolonged use of broad-spectrum antibiotics could inhibit sensitive microorganisms, produce more drug-resistant bacteria and, finally, cause GM disorders, worsening the disease, as well as producing negative impacts, by reducing bacterial diversity, with antibiotic resistance and the emergence of Clostridiodes difficile [27]. The use of antibiotics has become problematic because it unintentionally alters the delicate balance of GM. Above all, broad-spectrum antibiotics by destroying beneficial microorganisms essential to preserve health. Intestinal dysbiosis negatively affects GM, generating favorable circumstances for a decrease in microbial diversity and the creation of an adequate environment for the arrival of resistant strains [28].

Preventing Sepsis [29]. Avoid infections. Control chronic diseases. Get recommended vaccinations. Practice good hygiene. Wash your hands. Keep wounds clean and covered until healed. Know the symptoms. Symptoms may include one or a combination of these: confusion, disorientation, shortness of breath, rapid heart rate, fever, chills, shaking, extreme pain, and clammy or sweaty skin. Act fast. Seek medical care immediately if you suspect sepsis or have an infection that does not improve or worsens.

Current Treatment of Sepsis

Management of sepsis is a clinical challenge. Maintaining or restoring GM and metabolite composition may be a therapeutic or prophylactic against critical illness. Both biotics and FMT have limited efficacy, although it has been suggested that trends toward improving GM may be helpful. Management of SEPT includes selective digestive decontamination, probiotics, prebiotics, synbiotics, postbiotics and FMT, all of which have shown potential, albeit variable, results [30]. These approaches could not only improve patient prognosis, but also reduce reliance on antibiotic therapies and promote more targeted and sustainable treatment strategies. However, there is still limited clarity regarding the ideal composition of GM, which should be further characterized in the near future. Current studies on metabolomics, genomics and other aspects aimed at continuously discovering potential probiotics are providing theoretical basis for restoring GM homeostasis for subsequent treatment of sepsis. Liu Q and his group [31], report a 44-year-old woman with septic shock and severe watery diarrhea 4 days after undergoing vagotomy. They consider the presence of intestinal dysbiosis and perform 16S rRNA. Severe alterations were observed, so the patient was successfully administered fecal suspension through a naso-duodenal tube. SEPT is common in older adults, affecting mainly cancer and immunosuppression. When severe, it generates multiple organ dysfunction, including immunological alterations and catabolism. Several treatments have not been successful in clinical trials, so therapies are directed at the organ and immunological dysfunction induced by sepsis [32]. SEPT can have phenotypes, depending on the predominant dysregulated response of the host. These can vary from hyperinflammatory states to immunosuppressive and even mixed phenotypes. There are immunomodulatory therapies such as extracorporeal support, those directed at molecular or cellular pathways [33]. Greater emphasis is placed on antibiotics, vasopressors, complementary therapies and renal replacement [34]. Bassetti M, and his team [35], reiterate the mechanisms in which the microbiome can contribute, highlighting the susceptibility and the outcome of SEPT. Polat G et al. [36], comment that SEPT is a complex disease with simultaneous inflammation and coagulation, produced by bacterial aggression and present new therapeutic approaches.

Biotics in Septicemia

Dysbiosis could improve with probiotic supplementation, among others. Based on the mode of action, preferably the production of SCFA. Probiotics may be a valid option. Influencing the disease, through their metabolites [37]. Khailova L and her team [38], despite pointing out that there is no certainty when using probiotics in SEPT, conclude that there is a decrease in mortality after the disease, regardless of the type of probiotic used.

Complications of FMT

In general, FMT is usually effective and has favorable and limited side effects. There are adverse events, but they are usually not serious. Such as reversible gastrointestinal discomfort. Severe phenomena may occur, although these occur due to technical incompetence.

Is Fecal Microbiota Transplant Useful in Sepsis?

FMT has shown a correlation with the restoration of the intestinal microbial structure and a decrease in the inflammatory response, requiring further validation. It could reverse the course of SEPT by restoring host immunity in an interferon regulatory factor 3-dependent manner. Related to the expansion of butyrate-producing Bacteroidetes. Together, these results suggest that FMT may be a treatment option in sepsis associated with immunosuppression [39]. Lou X and his group, [40] analyzed 16Sr DNA, healthy and sick with SEPT to determine whether alterations in intestinal bacteria are associated with sepsis. The composition of the GM of patients with sepsis differed significantly from healthy people. Having decreased Firmicutes, being able to regulate them, at the level of healthy people, including Escherchia, Shigella and Lactobacillus with the use of FMT and SCFA.

Multiple Donors of Fecal Microbiota in Septicemia

Due to splanchnic ischemia, antibiotics and the underlying process, septic patients lose 90% of intestinal microorganisms - within hours - after being attacked by pathogens. These microorganisms grow exponentially, disrupting metabolic, immune and neurocognitive functions. Transforming the intestine into multi-organ failure and systemic inflammation [41]. It is said that the use of multiple donors usually gives a better result, by generating greater diversity in patients. FMT in patients admitted to Intensive Care becomes interesting, but studies are needed to guide the use of this procedure in this type of patients.

Pricila Romão et al. [42] They report that Lactobacillus casei and rhamnosus reduce oxidative stress and inflammation. Biotics provide better immunomodulation, including the macrobiotic: FMT, and therefore could be an alternative in SEPT.

Conclusion

- GM metabolites prevent immunopathology.
- SCFA play a crucial role in modulating the inflammatory response and maintaining intestinal barrier function.
- Butyrate-producing anaerobic intestinal bacteria protect against systemic infections.
- FMT has been shown to correlate with restoration of intestinal microbial structure and decreased inflammatory response, requiring further validation.
- Synbiotics and FMT may offer additional immunomodulatory benefits.

Declarations

Conflicts of Interest

The authors declare that do not have affiliation or participation in organizations with financial interests.

Ethical Approval

This report does not contain any study with human or animal subjects carried out by the authors.

Informed Consent

The authors obtained informed written consent from the patients, in order to develop this article.

Declaration on the Use of Artificial Intelligence

The authors declare that no generative artificial intelligence was used in the writing of this manuscript.

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