

Anti-inflammatory Diet for Gastric Cancer Patients: Components, Mechanisms, and Clinical Applications

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Abstract. Gastric carcinoma is a major aggressive malignancy within the gastrointestinal tract globally and represents a particularly grave health burden across China. Persistent subclinical inflammation (PSI) exerts a significant influence throughout the whole process of development, advancement and outcome. Unreasonable diet habits continuously induce an inflammatory microenvironment, therefore driving gastric mucosal malignant transformation, tumor progression and treatment resistance. Conversely, a pro-inflammatory regimen incorporates potent elements including polyphenols, polysaccharides, fiber, omega-3 long-chain polyunsaturated fatty acids, alongside essential vitamins and minerals. Such elements can efficiently suppress pro-inflammatory mechanisms, decrease concentrations of cytokines, mitigate oxidative strain and modulate gut microbiota. Through these mechanisms, anti-inflammatory diets can exert anti-inflammatory and anti-tumor effects, and thus hold great value in the prevention of high-risk populations of gastric cancer, patients' supplementary treatment and rehabilitation management of patients. Some clinical studies indicate that anti-inflammatory diet intervention helps decrease inflammatory indicators, boost immunity, improve nutritional status and quality of life, relieve treatment-related adverse effects, reduce recurrence and improve long-term prognosis of gastric cancer patients. This article is based on domestic and overseas research, systematically illustrates the link between inflammation and gastric cancer, key anti-inflammatory diets and nutrients, clinical outcomes and current challenges, and offers some theoretical support and practical guidance for standardized nutritional management of gastric cancer patients.

Keywords: Anti-inflammatory diet, Gastric cancer, Chronic inflammation, Nutrients, Nutritional intervention

1. Introduction

Gastric carcinoma is a prevalent malignant neoplasm of the alimentary canal, occupying the fifth and third positions regarding the incidence and fatality among every cancer globally. During 2022, roughly 970,000 novel instances of gastric malignancy occurred globally, involving more than 660,000 fatalities, rendering it a major global medical issue posing a significant risk to human existence. And gastric cancer is highly prevalent in East Asia, with China accounting for more than 40% of global new cases and deaths, indicating an extremely severe disease burden. Studies have

shown that the main high-risk population consists of men over 40 years of age, whose incidence rate is approximately twice that of women [1]. The five-year survival probability for primary gastric cancer surpasses 90%, whereas it drops below 30% for advanced cases. Nevertheless, its initial signs are hard to detect, thus diagnosis is frequently delayed until a late phase, resulting in poor therapeutic results and outlooks for affected individuals. Furthermore, the tumor progresses rapidly and severely impairs the patients' digestive system. This leads to reduced food intake, progressive weight loss, further deterioration of nutritional status. These issues exacerbate treatment-related side effects, compromise treatment compliance and tolerance, and drastically impair patients' quality of life.

Chronic low-grade inflammation is not only a critical driver of gastric carcinogenesis but also pervades the entire spectrum of tumor progression, treatment resistance and poor prognosis. Sustained high levels of pro-inflammatory factors in patients exacerbate metabolic disorders, induce cancer cachexia, worsen the patients' condition, thereby reducing treatment tolerance and even forcing treatment discontinuation. In addition, the traditional anti-tumor drugs can cause or worsen systemic inflammation, lead to other adverse effects, further weaken the body of the patient, and thus form a cycle of "treatment-inflammation-nutritional deterioration". Nevertheless, modern approaches to the nutritional management of a patient suffering from gastric cancer tend to concentrate heavily on traditional supportive therapy with only minimal systematic dietary treatments-oriented targeting inflammation. As a result, most people do not have any opportunity to increase their odds of achieving successful treatment outcome.

The anti-inflammatory diet is an eating pattern in which selecting foods with anti-inflammatory properties and reducing the intake of pro-inflammatory foods helps mitigate chronic inflammation as well as the development of related diseases. The concept was proposed by Dr. Barry Sears in 1995, and its title was to eat more fresh fruit and vegetable, whole grain food items and other foods which have anti-inflammatory effects, at the expense of lowering the intake of sugar-containing products, or fatty-rich foods responsible for pro-inflammatory [2]. The foundation of balanced nutrition serves the basis of the anti-inflammatory diet as it requires constant commitment throughout some time period to see outcomes through reduction of processed foods and increase natural sources of anti-inflammatory compounds. Anti-inflammatory nutrition serves as vital connectors in the progression of chronic ailments; it diminishes systemic inflammatory markers across various organs, enhances overall health, and optimizes the living standards of gastric cancer patients. Numerous researches indicate that adopting an anti-inflammatory regimen can minimize gastric cancer hazards and represents a therapeutic strategy; it may mitigate adverse reactions triggered by radiotherapy and chemotherapy post-operation, manage nutritional deficits in terminal cancer, reduce the risk of recurrence and spread, prolong patient survival, and bolster their life quality. It is essential to integrate this approach into conventional protocols to disrupt the "inflammation-starvation-treatment breakdown" loop and demonstrate its authentic medical merit for clinical implementation.

However, because patients and their families do not have professional knowledge about anti-inflammatory diets, they are unable to differentiate between pro-inflammatory and anti-inflammatory foods. The usual mistakes are a high-salt, high-fat diet and random nutritional supplements, which do not meet dietary needs. Most doctors and nurses focus on surgery, radiotherapy and chemotherapy, and do not pay enough attention to anti-inflammatory dietary intervention for tumors. At the same time, there is no regular and normalised guidance system for anti-inflammatory diets of gastric cancer patients. Nurses have different levels of ability to provide dietary guidance, and it is difficult to offer personalised dietary advice according to the specific

conditions, inflammation degrees, nutritional states, etc., of patients. It may cause the disease to worsen or recur seriously affect the health of these people. Most importantly, relevant tumour nutrition rehabilitation services are currently lacking in society. Without further follow-up and professional dietary adjustment advice, a general-purpose Dietary Management System for gastric cancer cannot be developed. Therefore, this paper has compiled and arranged the research results on anti-inflammatory diets to offer a theoretical basis and practical recommendations for the normalisation of their use in clinical practice.

2. The mechanistic association between inflammation and gastric cancer development

Inflammation is a defensive mechanism of the body in response to harmful stimuli such as biological and physical factors as well as necrotic tissues. Chronic low-grade inflammatory status in the human body is one of the critical mechanisms triggering tumorigenesis [3, 4]. After many small injuries to the lining cells of the stomach, a large number of immune cells such as macrophages and neutrophils will be continuously recruited, and at the same time, pro-inflammatory factors such as TNF- α , IL-6 and IL-8 will also be released. The above biomarkers have been found to be useful for the diagnosis of gastric cancer in some studies [5]. At the same time, these pro-inflammatory factors can continuously activate the main inflammatory signal transduction pathway of Nuclear Factor-kappa B (NF- κ B) and Signal Transducer and Activator of Transcription 3 (STAT3). Abnormal activation of the NF- κ B pathway can cause increased abnormal proliferation and reduced apoptosis of gastric mucosal cells, thus promoting the development of cancer cells. STAT3 is still in an activated state and is involved in the spread of cancer cells and chemoresistance. Collectively, the above processes give rise to and develop gastric cancer. These highly expressed inflammatory factors are closely correlated with advanced tumor stage, lymph node metastasis, distant metastasis and poor prognosis. In addition, elevated levels of inflammatory factors exacerbate systemic metabolic disorders, induce anorexia, malnutrition and weight loss, reduce patients' treatment tolerance, and severely impair their quality of life. A comprehensive case-control investigation carried out within Fujian during 2020 (n=336) indicated that a one standard deviation rise in the Chinese Dietary Inflammatory Index (CHINA-DII) corresponded to a 26% higher risk of developing gastric cancer. Participants in the high CHINA-DII group exhibited a 45% elevated gastric cancer risk, with stronger associations observed among younger individuals under 55 years of age, non-smokers, and people under high stress. These findings reveal that inflammation exhibits population heterogeneity in gastric cancer development and provide precise target populations for anti-inflammatory dietary interventions [6].

3. Anti-inflammatory dietary active components and their antitumor mechanisms

Anti-inflammatory nutritional regimens possess significant utility in combating gastric malignancies by modulating persistent systemic irritation via the cumulative impacts of diverse organic bioactive compounds. Phytochemicals, fiber, omega-3 long-chain polyunsaturated fatty acids, particular polysaccharides, micronutrients, and assorted dietary elements sourced from varied culinary options can mitigate regional inflammatory reactions within the gastric epithelium and indirectly suppress the expansion and dissemination of gastric neoplastic cells through several pathways, encompassing curtailing essential pro-inflammatory cascades like NF- κ B, diminishing the production of pro-inflammatory cytokines (such as TNF- α and IL-6), decreasing oxidative stress levels, and modulating gastrointestinal microbial communities. Additionally, anti-inflammatory diets can improve the tumor microenvironment, reduce chemotherapeutic drug resistance, enhance the

cytotoxic effects of radiotherapy and chemotherapy on tumor cells, alleviate treatment-related inflammatory injuries, and improve patients' treatment tolerance. A thorough analysis of the anti-inflammatory targets and pathways involved in these active components provides a theoretical foundation for precision nutritional interventions in gastric cancer patients and lays the groundwork for subsequent clinical efficacy evaluations (Table 1).

3.1. Polyphenolic compounds

Anti-inflammatory diets are rich in polyphenols (such as blueberries, broccoli, green tea, etc.), and also contain flavonoids, anthocyanins and butyl benzoate. These compounds exert definite preventive effects against tumors, neutralize free radicals in the body, and relieve inflammation triggered by oxidative stress [4, 7]. Curcumin and resveratrol are a few important polyphenols that can damage gastric cancer cells directly by regulating the amounts of cyclins and inducing programmed cell death in tumour cells, thereby stopping the spread of the tumour.

Table 1. List of anti-inflammatory dietary components

Items	Ingredient	Source	Mechanism
Polyphenols	Flavonoids, anthocyanins, benzoate esters, curcumin, resveratrol, etc.	Blueberries, broccoli, green tea, etc.	Neutralize free radicals in the body and reduce inflammation induced by oxidative stress; Inhibit cancer cell proliferation and induce apoptosis of cancer cells; Regulate intestinal microbiota, thereby indirectly reducing systemic inflammation; Promote intestinal peristalsis and maintain the integrity of the intestinal barrier;
Dietary Fiber	Cellulose, β -glucan, pectin, and certain hemicelluloses	Grains, legumes, vegetables, nuts, tubers and roots	The short-chain fatty acids regulate intestinal immunity. Enhances satiety, improves eating disorders, and assists in maintaining body weight; Substitutes for gamma-omega-6 fatty acids and reduces the synthesis of pro-inflammatory factors;
Omega-3 unsaturated fatty acids	Alpha-linolenic acid (ALA), eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA), etc.	Salmon, sardines, chia seeds, flaxseeds, walnuts, etc.	Improve lipid metabolism, reduce muscle breakdown, and provide nutritional support; Block the activation of inflammatory pathways and inhibit the synthesis and secretion of pro-inflammatory factors.

Table 1. (continued)

Carbo- hydrate	Monosaccharides: glucose, fructose; Disaccharides: sucrose, lactose, maltose; Polysaccharides: starch, glycogen;	Full grains such as oats, brown rice, and corn	Significantly reduces pro- inflammatory factor levels, helps stabilize blood glucose, and alleviates chronic inflammation. Effectively reduces the incidence risk of many cancers Enhance white blood cell function, promote antibody production, thereby improving immunity and indirectly alleviating inflammatory responses;
Vitamin	Vitamin C, Vitamin D, Vitamin E, etc.	Fruits, vegetables, etc.	Reduce the risk of gastric cancer, inhibit the production of pro- inflammatory factors, and upregulate anti-inflammatory factors; Reduce oxidative stress and lower the risk of chronic inflammation; Regulate inflammatory pathways and inhibit the release of inflammatory factors; Antioxidant effect, protecting cells from damage caused by free radicals;
Mineral substance	Magnesium, selenium, copper, etc.	Nuts, whole grains, leafy vegetables, etc.	Participates in the synthesis of superoxide dismutase (SOD) and jointly contributes to the body's anti-inflammatory defense mechanisms.

At the same time, they can also modify the makeup of the gut microbiome to lessen all-body inflammation. Anthocyanins can suppress the degradation of $\text{I}\kappa\text{B}\alpha$, interfere with $\text{NF-}\kappa\text{B}$, reduce the activation of the $\text{NF-}\kappa\text{B}$ inflammatory pathway, decrease the release of pro-inflammatory factors, and thus alleviate local inflammation in the gastric mucosa, etc [8].

3.2. Gut microbiota and dietary fiber

The Microbes in our Gut also influence Inflammation. Pro-inflammatory diet reduces good bacteria in the gut and promotes the growth of harmful bacteria; thus, it causes gut dysbiosis. Endotoxins that have spread in the blood are also a cause of widespread inflammation. Dietary fibre from cereals, legumes and vegetables in the anti-inflammatory diet can promote gut motility, maintain the integrity of the gut barrier and reduce inflammation due to endotoxin translocation into the blood [6]. Short-chain fatty acids (SCFAs) are produced by microorganisms in the gut through fermentation, and they can activate the immune surveillance of cancer cells and reduce systemic

inflammation in the body. Dietary fibre can also increase a person's sense of fullness, improve appetite and eating behaviors, and help manage weight.

3.3. Omega-3 polyunsaturated fatty acids

Omega-3 polyunsaturated fatty acids, found within salmon, sardines, chia seeds, walnuts, and so forth, can substitute pro-inflammatory omega-6 fatty acids within cell membranes and decrease the synthesis of pro-inflammatory mediators like prostaglandins and leukotrienes. Therefore, there will be fewer inflammatory factors and reduced chronic systemic inflammation [8]. Help the body regulate lipids and is able to keep the muscles healthy. Several investigations have discovered that the synergistic impacts of omega-3 polyunsaturated fatty acids alongside polyphenols could suppress the activation of the NF- κ B p and STAT3 cascades and decrease the synthesis and discharge of pro-inflammatory mediators. For instance, α -linolenic acid diminishes the phosphorylation of the NF- κ B p65 protein and decreases the levels of TNF- α and IL-6.

3.4. Carbohydrates

Whole grains, such as oats, brown rice and corn, are rich in carbohydrates but also have good anti-inflammatory properties and help keep blood sugar stable by preventing large fluctuations in insulin and reducing oxidative stress and inflammation. Studies have shown that high-glycemic index foods can promote inflammation in the tumour microenvironment and promote the growth of cancer cells [9]. Certain purified starches, like polished rice or milled wheat flour, exert a significant influence on glucose and insulin concentrations and might elevate circulating levels of free fatty acids within the body, which is detrimental to the healing of individuals. A low glycemic index diet is relatively poor in promoting inflammation and thus may lead to an increase in high-sensitivity C-reactive protein (hs-CRP), IL-6, etc., and also raise blood sugar. Wheat bran and wheat germ contain a large number of phytochemicals that can help reduce the risk of several cancers [5].

3.5. Vitamins and minerals

Chronic inflammation is frequently associated with an abnormal response of the body to oxidative stress. Excessive Reactive Oxygen Species (ROS) may harm DNA and proteins within the gastric mucosa, intensify inflammation, and so forth. Fruits and vegetables are abundant in vitamins and minerals, and they possess excellent anti-inflammatory characteristics. Sears B pointed out that the anti-inflammatory diet should be two-thirds vegetables and fruits [10]. Vitamin C can promote the activity of white blood cells and increase the production of antibodies to enhance immune function and suppress inflammation. Based on meta-analysis of the 32 prospective cohort studies, it was found that people who regularly take a high dose of vitamin C have a relatively small risk of stomach cancer (29% lower). It was not the same [6]. Vitamin D can reduce the production of IL-6 and TNF- α and promote the production of IL-10 to alleviate chronic inflammation. Reduce the damage caused by free radicals in the body and lower the risk of chronic inflammation. Magnesium can reduce the amount of pro-inflammatory cytokines by regulating the NF- κ B pathway. Magnesium-rich food is good for combating inflammation, so nuts, whole grains and dark green vegetables should be eaten regularly. Selenium is an anti-oxidant that can protect cells of the body from damage by free radicals. Copper participates in the synthesis of SOD and is also one of the anti-inflammatory defense mechanisms in the body.

4. Clinical efficacy of an anti-inflammatory diet in gastric cancer patients

4.1. Improvement of inflammatory factors and oxidative stress markers

Nutritional anti-inflammatory approaches can substantially lower circulating concentrations of pro-inflammatory mediators in individuals suffering from gastric malignancy. A domestic investigation revealed that following the intervention, the occurrence of postoperative infection-related complications and general adverse events was markedly reduced in the experimental cohort relative to the control group. Regarding inflammatory-associated hematological markers, compared with the control group, subjects within the experimental group demonstrated notably reduced concentrations of white blood cell counts at baseline plus on postoperative days 1, 3 and 5, C-reactive protein at baseline plus on postoperative days 1 and 3, and interleukin-6 on postoperative day 3, showing statistically meaningful variations [11]. In terms of immune function, after anti-inflammatory dietary intervention, the proportions of CD3⁺ and CD4⁺ T cells increased by 5%-15%, the CD4⁺/CD8⁺ ratio was elevated ($P<0.05$), natural killer (NK) cell activity rose by 10%-25%, and the risk of infection decreased by 30%-50% [8]. These studies effectively illustrate that multiple biomarkers in patients are significantly improved following anti-inflammatory dietary intervention.

4.2. Improvement of nutritional status and physical constitution

Gastric cancer patients frequently suffer from malnutrition, weight loss and muscle loss due to chronic inflammation, digestive and absorptive disorders, and treatment-related injuries, with an incidence rate as high as 60%-80%. This causes severe cachexia in numerous advanced-stage patients, leaving them unable to tolerate treatment or fend off cancer cells. However, studies have shown that an anti-inflammatory diet can effectively improve nutritional markers and reduce muscle wasting. A South Korean study enrolled 8 patients with gastrointestinal cancers. After an 8-week postoperative intervention supplemented with omega-3 fatty acids, weight loss was reduced by 1.2 kg in the intervention group, compared with a 2.5 kg weight loss in the control group; serum albumin increased by 6.2 g/L and total protein rose by 8.5 g/L [12]. Improvements in patients' nutritional status are particularly remarkable during the perioperative and chemotherapy periods. Lin Qingxiu et al. conducted an intervention of anti-inflammatory diets (high protein, omega-3 fatty acids, whole grains, fruits and vegetables rich in polyphenols) among 122 patients receiving chemotherapy. Compared with routine nutritional support, patients receiving anti-inflammatory dietary intervention exhibited significantly higher albumin and hemoglobin levels, and their weight loss was effectively alleviated. In addition, patients receiving the anti-inflammatory diet presented higher scores on the Patient-Generated Subjective Global Assessment (PG-SGA), with statistically significant differences. The above evidence indicates that intervention with an anti-inflammatory diet improves patients' nutritional status and physical fitness, leading to superior quality of life [13]. Another study demonstrated that anti-inflammatory dietary intervention significantly improved patients' physical performance, activities of daily living (ADL) and sleep quality, and that body weight remained stable or slightly increased, and muscle wasting was decreased. Moreover, higher patient adherence corresponded to better intervention outcomes [14].

4.3. Alleviate adverse effects of radiotherapy and chemotherapy and enhance treatment tolerance

Chemoradiotherapy serves as the core therapeutic strategy for advanced gastric cancer, but patients suffer from a high incidence of adverse reactions including nausea, vomiting, diarrhea, myelosuppression and fatigue, which severely impairs treatment adherence and quality of life. Clinical trials and prospective observational studies conducted by Colomer R et al. which used enteral preparations to supplement omega-3 fatty acids, demonstrated that daily administration of omega-3 polyunsaturated fatty acid supplements improves body weight, appetite, quality of life, treatment tolerance and survival rate in cancer patients. Additionally, such supplementation can effectively reduce postoperative morbidity and confer a statistically significant survival benefit [15]. Numerous other studies have confirmed that anti-inflammatory diets can markedly reduce the toxic reactions of chemoradiotherapy. For instance, anti-inflammatory dietary intervention reduces the incidence and severity grade of nausea, vomiting and diarrhea [13]. It also lowers the incidence of leukopenia and thrombocytopenia, as well as the risk of severe myelosuppression.

4.4. Improving patients' quality of life

Plenty of research consistently indicate that anti-inflammatory diets can significantly improve the quality of life in patients with gastric cancer. A Korean trial conducted 8 weeks of postoperative omega-3 fortified intervention, yielding a 22% rise in physical function, a 30% lower fatigue scores and a 25% enhanced role function in participants [12]. A prospective cohort study demonstrated that the presence and severity of anxiety and depression were negatively correlated with disease-free survival and overall survival in patients undergoing gastric cancer surgery, and anti-inflammatory diets could effectively reverse this condition [14]. Intervention led to elevated EORTC QLQ-C30 global health status scores and marked improvements in physical, role and emotional functioning, alongside a 20%–40% reduction in symptom scores for pain, insomnia and loss of appetite. Another study involving 122 cancer patients found that patients receiving anti-inflammatory dietary intervention achieved significantly higher scores in global quality of life, physical function, emotional function and social function [13].

4.5. Effective role in recurrence and prognosis

The time of the last follow-up was not recorded. However, some observational studies and subgroup analyses have found that in the long run, gastric cancer patients who have strictly followed the anti-inflammatory diet have shown about a 20% increase in overall survival compared with those who have not strictly followed it; that is to say, their survival rate is about 13% higher and they are approximately 27% less likely to develop stomach cancer. A change in people's diet has reduced the overall mortality rate by 9%. More importantly, the group of people who have received the local relapse and distant metastasis of anti-inflammatory diet intervention is relatively small [15].

5. Conclusion

Based on multidisciplinary research results, it can be concluded that chronic inflammation is one of the reasons for the occurrence and development of gastric cancer. Anti-inflammatory diets also have several other reasons that reduce inflammation in the body, such as suppressing the inflammatory signaling pathway of the entire body, reducing oxidative stress, altering the gut microbiota, etc. Anti-

inflammatory diets have lowered the concentration of pro-inflammatory factors in the blood of people with gastric cancer, such as CRP, TNF- α , IL-6 and IL-8. They can help reduce the body's chronic inflammatory response, improve the nutritional condition of the patient, alleviate side effects caused by chemoradiotherapy, enhance immune function and quality of life, etc. In addition, there will be fewer relapses and an extension of life for the patients who undergo this treatment. Thus, it is less likely that the patient will have serious metabolic problems. It can help prevent gastric cancer in high-risk groups, support the body's recovery and improve the results of surgery and adjuvant chemoradiotherapy, and help the person regain strength more quickly. At present, diet control is one of the various ways to treat chronic gastritis and GERD. It has also proposed new strategies and directions for the prevention, treatment and rehabilitation of gastric cancer patients and promoted the widespread application of the anti-inflammatory diet in clinical oncology nutrition.

Although anti-inflammatory diets have some advantages in the development and outlook of gastric cancer, several problems have yet to be solved. To sum up, the existing anti-inflammatory diets have different formulas, dosages and intervention periods. Most of the available plans are based on the general population and lack personalisation; therefore, there are no particular guidelines for gastric cancer at different stages of the disease and treatment that can be used to tailor interventions according to the actual circumstances of individual patients. Secondly, from the patient's side, due to loss of appetite and changes in the sense of taste after a long illness, they have difficulty maintaining a regular diet. Most of the previous research has been relatively brief, so there is a lack of evidence and associated data on the long-term effects of dietary intervention. In addition, most of the research samples are relatively small, and there are few localised studies in China.

In the future, regional anti-inflammatory diet assessment tools will be developed based on the distinct food cultures and dietary patterns of each area, and clinical trials will be conducted accordingly. Firstly, extensive clinical trials need to be organised to determine the ideal food formulas, doses and intervention periods for different groups of people with gastric cancer. Based on the individual food habits and digestive conditions of each person, customised anti-inflammatory diet plans can be developed to standardise clinical practice and improve the prognosis of patients. Second, there should be cooperation in interdisciplinary research. Multi-omics technology can be employed to gain a deeper understanding of how different anti-inflammatory compounds modulate inflammation in various parts of the body—for example, by altering inflammation-related signalling pathways, changing the gut microenvironment, shifting the gut microbiota, and modifying inflammatory responses—thereby providing a theoretical basis for the development of new nutrient agents. Additionally, it is necessary to extend the period of intervention and follow-up. A long-term follow-up cohort of gastric cancer patients who have been under anti-inflammatory dietary intervention should be set up to study the long-term effects of anti-inflammatory diet on tumor recurrence, metastasis, survival rate and quality of life, and thus investigate the possible mechanisms of the anti-inflammatory diet strategy.

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