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Protective Effects of Tea Polyphenols on Alcoholic Liver-injured Mice and Alcoholic Stomach-injured Mice

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Abstract: The aim of this review is to investigate the protective effects of tea polyphenols on alcoholic liver injury and gastric injury and their potential mechanisms. Alcoholic liver injury and gastric injury are serious health problems caused by chronic excessive alcohol consumption, involving complex pathological mechanisms such as oxidative stress, inflammatory responses, abnormalities in immune regulation, apoptosis, disorders of lipid metabolism and fibrosis. Tea polyphenols, a class of polyphenolic compounds derived from tea, have been shown in several studies to have significant protective effects against these impairments due to their potent antioxidant and anti-inflammatory properties. This paper presents a comprehensive analysis of existing studies on tea polyphenols in the treatment of alcoholic liver injury and gastric injury, including their mechanisms of action such as antioxidant, anti-inflammatory, modulation of lipid metabolism, promotion of tissue repair, protection of the mucosal barrier, and modulation of intestinal flora. Despite the potential for clinical applications of tea polyphenols, current studies have limitations, including low bioavailability and stability issues. Future research should focus on improving the stability and bioavailability of tea polyphenols, conducting clinical studies to validate their safety and efficacy, and exploring the use of tea polyphenols in combination with other therapeutic agents. This paper provides a scientific basis for the use of tea polyphenols in the prevention and treatment of alcoholic liver injury and gastric injury and points out directions for future research.

Keywords: Tea polyphenols; Alcoholic liver injury; Gastric injury.

1. Introduction

With the accelerated pace of life in modern society, unhealthy dietary habits and lifestyles, especially long-term excessive alcohol consumption, have become one of the major factors leading to liver and gastric mucosal damage worldwide. Alcoholic Liver Disease (ALD) is a liver disease caused by long-term excessive alcohol consumption, and its pathological process involves oxidative stress, inflammatory response, apoptosis and fibrosis. Similarly, the direct damage of alcohol to gastric mucosa leads to the destruction of gastric mucosal barrier function and triggers gastric injury. These diseases place a heavy burden on social health care systems, as well as seriously affecting the quality of life of patients.

Green tea polyphenols (GTP), a class of natural polyphenolic compounds derived from tea, have attracted widespread attention for their potent antioxidant, anti-inflammatory, anti-tumour and cardiovascular protective biological activities. Studies have shown that tea polyphenols may exert their biological activities by regulating various signalling pathways, such as nuclear transcription factor Kappa B (NF-κB), epidermal growth factor receptor (EGFR), and adenylate-activated protein kinase (AMPK).

In recent years, studies on tea polyphenols in the prevention and treatment of alcoholic liver injury and gastric injury have gradually increased. Studies show that tea polyphenols significantly reduce rat serum aminotransferase levels with alcoholic liver disease, attenuate pathological changes in the liver, and have a certain protective effect on alcoholic liver injury. In terms of gastric injury, tea polyphenols can improve gastric mucosal damage, reduce gastric fluid secretion, maintain normal gastric acid value, and enhance gastric mucosal protective factors by regulating related gene expression, which has a certain inhibitory effect on alcoholic gastric injury in mice[1].

However, although studies have shown that tea polyphenols have potential protective effects on alcoholic liver injury and gastric injury, their specific molecular mechanisms and clinical application value still need to be further explored. The aim of this review is to comprehensively analyse the relevant studies in recent years to explore the protective effects of tea polyphenols on alcoholic liver injury and gastric injury and their possible mechanisms of action, with a view to providing a scientific basis for the application of tea polyphenols in the prevention and treatment of alcoholic liver injury and gastric injury.

2. Biological Activities of Tea Polyphenols

Tea polyphenols are a class of polyphenolic compounds in tea with significant biological activities, which are diverse and include, but are not limited to, antioxidant, anti-inflammatory, anticancer, hypolipidemic, glucose regulating, bacteriostatic, and antiradical activities. These biological activities make tea polyphenols potentially valuable in the prevention and treatment of many diseases.

2.1. Antioxidant activity

The antioxidant activity of tea polyphenols is one of its best known biological activities. Tea polyphenols exert their antioxidant effects through a variety of mechanisms, including scavenging reactive oxygen/nitrogen species, chelating transition metals, and inhibiting the oxidation of lipids, proteins and DNA. In addition, tea polyphenols enhance cellular antioxidant capacity by inhibiting pro-oxidant enzymes, inducing endogenous antioxidants, and acting synergistically with vitamins[2]. In green tea, the antioxidant capacity of tea polyphenols is shown as EGCG > EGC > ECG > EC, with EGCG (epigallocatechin gallate)

having the strongest antioxidant activity.

2.2. Anti-inflammatory effects

The anti-inflammatory effects of tea polyphenols are mainly achieved through the regulation of inflammation-related signalling pathways. Studies have shown that tea polyphenols can down-regulate the expression of inflammatory factors associated with atherosclerosis (AS), such as inhibiting the inflammatory response by regulating the NF-κB signalling pathway. In addition, tea polyphenols can exert anti-inflammatory effects by affecting several AS-related inflammatory signalling pathways in cells, such as the MAPK/NF-κB signalling pathway, the NF-κB/Notch signalling pathway, and the miRNA signalling pathway.

2.3. Anticancer activity

The anticancer activity of tea polyphenols involves several molecular mechanisms, including intervention in signal transduction pathways, inhibition of tumour cell proliferation and induction of apoptosis. Tea polyphenols inhibit the activity of AP-1 induced by procarcinogens through the JNK pathway and regulate the activity of NF-κB by reducing the phosphorylation of inhibitory protein IκB, selectively blocking the signal transduction pathway of tumour cells, thus destroying the tumour-control growth regulation mechanism [3].

2.4. Regulation of blood lipids and blood sugar

Tea polyphenols can regulate blood lipid levels, inhibit oxidative modification of LDL, improve endothelial function, as well as maintain plaque stability, thus effectively preventing atherosclerosis. In addition, tea polyphenols can also improve insulin resistance, reduce blood glucose and lipid levels, and have a positive regulatory effect on metabolic syndrome[4].

3. Pathological Mechanisms of Alcoholic Liver Disease and Gastric Injury

Alcoholic Liver Disease (ALD) and gastric damage are serious health problems caused by chronic excessive alcohol consumption, and their pathogenesis involves multiple interacting biological processes.

3.1. Pathological Mechanisms of Alcoholic Liver Disease (ALD)

The development of ALD is a complex process involving multiple factors such as oxidative stress, inflammatory response, abnormalities in immune regulation, apoptosis, disturbances in lipid metabolism and fibrosis.

3.1.1. Oxidative stress

Alcohol metabolism produces large amounts of reduced coenzyme I (NADH) and reactive oxygen species (ROS), leading to redox imbalance and lipid peroxidation, thus damaging hepatocytes.

3.1.2. Gut microbiological alterations

Alcohol intake can damage the intestinal mucosal barrier and increase intestinal permeability, leading to bacterial and endotoxin (e.g., lipopolysaccharide, LPS) translocation, which triggers hepatic inflammatory responses[5].

3.1.3. Inflammatory and immune responses

Alcohol activates Kupffer cells and hepatic stellate cells (HSCs) in the liver, producing inflammatory factors such as TNF-α and IL-6, exacerbating liver injury

Lipid metabolism disorder: Alcohol intake promotes liver injury.

3.1.4. Disorders of lipid metabolism

Alcohol intake promotes fatty acid synthesis and inhibits its oxidative decomposition, leading to lipid deposition in the liver and the formation of a fatty liver.

3.1.5. Apoptosis

Alcohol and its metabolites can directly damage hepatocytes and activate the apoptosis signalling pathway, leading to hepatocyte apoptosis.

3.1.6. Fibrosis

long-term alcohol consumption leads to persistent inflammation and cellular damage in the liver, activates hepatic stellate cells, promotes extracellular matrix deposition, and eventually develops into liver fibrosis and cirrhosis.

3.2. Pathological mechanism of gastric injury

3.2.1. Direct cytotoxicity

Alcohol directly destroys the epithelial cells of gastric mucosa, increases the permeability of cell membrane, and leads to cell damage and death.

3.2.2. Abnormal gastric acid secretion

Alcohol stimulates gastric acid secretion and increases the acidity of gastric juice, causing chemical damage to the gastric mucosa.

3.2.3. Inflammatory response

Alcohol can activate the inflammatory cells under the gastric mucosa, release inflammatory mediators, and aggravate gastric mucosal inflammation.

3.2.4. Oxidative stress

ROS produced by alcohol metabolism damage gastric mucosal cells, leading to cellular dysfunction.

3.2.5. Destruction of mucosal barrier:

Alcohol destroys the gastric mucosal barrier, including the mucus-bicarbonate barrier and the epithelial cell barrier, which makes the gastric mucosa more vulnerable to damage.

3.2.6. Reduced blood flow

Alcohol can constrict gastric mucosal blood vessels, reduce gastric mucosal blood flow, and affect the nutritional supply and repair of mucosal cells.

4. Protective Effects of Tea Polyphenols on Alcoholic Liver Damage and Gastric Injury

4.1. Antioxidant effects

One of the key mechanisms by which tea polyphenols protect the liver and gastric mucosa is through their antioxidant effect. In a rat model of alcoholic liver disease, tea polyphenols have been shown to significantly reduce serum aminotransferase levels and attenuate pathological changes in the liver. These findings suggest that tea polyphenols may offer a protective effect against alcoholic liver injury. This indicates that tea polyphenols may offer protection against alcoholic liver injury[6]. Furthermore, tea polyphenols have been shown to boost superoxide dismutase (SOD) activity in the liver and decrease malondialdehyde (MDA) levels, thereby reducing oxidative stress and lipid peroxidation while safeguarding hepatocytes from oxidative damage.

4.2. Anti-inflammatory effects

Tea polyphenols have been shown to reduce the inflammatory response of the liver by inhibiting the production of inflammatory mediators. This is achieved by reducing the levels of tumour necrosis factor alpha (TNF-α) and interleukin 6 (IL-6). In animal models, tea polyphenols demonstrated a notable reduction in inflammatory factor levels in the serum of mice with gastric injury induced by HCl/ethanol, as well as a reduction in the infiltration of inflammatory cells in the gastric mucosa.

4.3. Regulation of lipid metabolism

Disturbed hepatic lipid metabolism due to alcohol intake is another key factor in ALD. Tea polyphenols can regulate lipid metabolism in the liver, reduce lipid deposition in hepatocytes and improve fatty liver lesions. Studies have shown that tea polyphenols reduce lipid deposition in the liver by decreasing fatty acid uptake by the liver through lowering fatty acid translocase (FAT/CD36) protein levels[7].

4.4. Promote gastric mucosa repair

Tea polyphenols can promote the repair and regeneration of gastric mucosa. Studies have shown that tea polyphenols can up-regulate the expression of genes related to the proliferation of gastric mucosal epithelial cells, such as endothelial nitric oxide synthase (eNOS) and neurogenic nitric oxide synthase (nNOS), which can promote the repair of gastric mucosa.

4.5. Protecting gastric mucosal barrier

Tea polyphenols can enhance the gastric mucosal barrier function and prevent apoptosis of gastric mucosal cells. In the gastric injury model, tea polyphenols upregulate the expression of gastric mucosal barrier-related proteins, such as the tight junction protein occludin, to enhance the gastric mucosal defence ability.

4.6. Regulation of intestinal flora

Tea polyphenols regulate the structure of the intestinal flora, promoting the growth of beneficial bacteria and inhibiting the growth of harmful bacteria., so as to improve the intestinal microenvironment and reduce the damage of alcohol on gastric mucosa.

5. Limitations of Clinical Applications of Tea Polyphenols and Directions for Future Research

5.1. Limitations

5.1.1. Bioavailability problem

The bioavailability of tea polyphenols in the body is relatively low, which limits their clinical therapeutic effect. After oral administration, most of the tea polyphenols are not absorbed in the small intestine, but enter the large intestine to be decomposed by microorganisms, and only a small amount can enter the blood circulation directly.

5.1.2. Stability

Tea polyphenols are susceptible to environmental factors such as temperature, light, humidity, etc. during storage and processing, leading to a decrease in their stability, which affects their effectiveness and safety in clinical applications.

5.1.3. Dosage determination

The optimal therapeutic dosage of tea polyphenols has not been clearly defined, and the response of different individuals to tea polyphenols may vary, which increases the complexity of clinical application[8].

5.1.4. Insufficient clinical studies

Although laboratory studies have shown that teat polyphenols have a variety of biological activities, relatively few clinical studies have been conducted on teat polyphenols, especially large-scale, multi-centre clinical trials, which limits the wide application of teat polyphenols in the clinical setting.

5.2. Future Research Directions

5.2.1. Improvement of bioavailability

Future research can explore new formulation technologies, such as nanotechnology, liposome encapsulation, etc., to improve the bioavailability and stability of tea polyphenols.

5.2.2. Dose effect studies

More clinical studies are needed to determine the optimal therapeutic dose of tea polyphenols, as well as their efficacy and safety in different diseases

5.2.3. Mechanistic studies

In-depth studies on the mechanism of action of tea polyphenols, especially its role in anti-inflammatory, antioxidant and anticancer effects, will help to better understand its potential for clinical application

5.2.4. Combined therapeutic strategies

exploring the combined therapeutic strategies of tea polyphenols with other drugs or natural products may improve the therapeutic effects and reduce side effects

5.2.5. Long-term effects and safety

long-term studies are conducted to assess the long-term effects and safety of teatoxin, especially when used at high doses or for long periods of time

5.2.6. Interdisciplinary studies

Encourage interdisciplinary studies that incorporate knowledge from the fields of nutrition, pharmacology, and molecular biology to fully understand the potential for clinical applications of tea polyphenols[9].

6. Conclusion

The Studies have shown that tea polyphenols have significant protective effects on the liver and gastric mucosa through multiple pathways, including antioxidant, anti-inflammatory, modulation of lipid metabolism and protection of the mucosal barrier. Although tea polyphenols show potential for clinical applications, limitations such as low bioavailability and stability issues still exist.

Future research directions should include improving the bioavailability and stability of tea polyphenols, conducting clinical studies to validate their safety and efficacy, and exploring the combined use of tea polyphenols with other therapeutic agents. Through these studies, tea polyphenols are expected to be a strong candidate for the prevention and treatment of alcoholic liver injury and gastric injury.

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