

Researches on the Pharmacological Effects of Eicosapentaenoic Acid

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Abstract

Fish oils are the most common source of omega-3 polyunsaturated fatty acids (n-3 PUFAs), mainly eicosapentaenoic acid (EPA). It has been pointed out protective effects and beneficial effects of EPA on body weight reduction, heart health, blood lipid profile, cardiovascular diseases and other diseases. Based on its biological activities, EPA may be developed to a complementary and alternative medicine through further research. In this paper, the pharmacological effects of EPA were summarized by reviewing the recent related literatures.

Keywords: Eicosapentaenoic acid; Pharmacological effects; Research progress

Introduction

In the late 1970s, Dyerberg *et al.* [1] highlighted the cardio protective effect of dietary omega-3 polyunsaturated fatty acids (n-3 PUFAs) for the first time. As the decades passed, n-3 PUFAs have been developed as dietary supplements, and it is now widely accepted that n-3 PUFAs are incorporated as structural components into cell membrane phospholipids in the blood and tissues, and they mediate an array of biological effects [2,3].

Eicosapentaenoic acid (EPA) is typical omega-3 polyunsaturated fatty acids found in fish and fish oils, and it is derived from another n-3 PUFA, α -linolenic acid (α -LNA) (Figure 1) [4-6]. Many reports have shown that EPA has protective roles against many diseases. This paper reviewed the main pharmacological effects of EPA, which provided reference to further study and develop EPA.

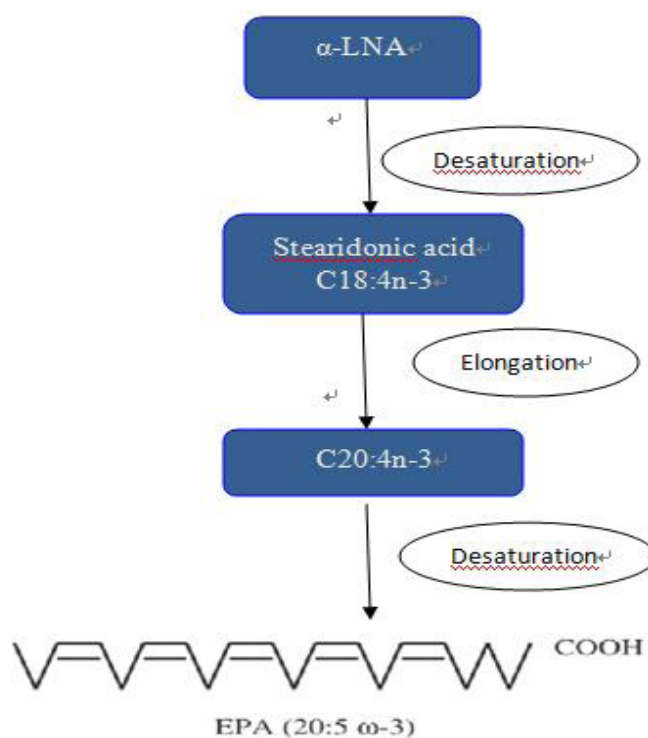


Figure 1: The formation of EPA. EPA is derived from α -LNA. α -LNA, α -linolenic acid

The pharmacological effects of EPA

Anti-lipogenic effect

Obesity is considered as an important public health disease, along with at least three of the following: abdominal obesity, hypertension, hyperglycemia, reduced plasma high-density lipoprotein (HDL), cholesterol and elevated plasma triglyceride (TG). Given the side effects and limitations of pharmacologic therapies, it is greatly needed to develop nutritional interventions which may not only prevent or treat obesity but also inhibit its associated diseases. Some studies reported that n-3 PUFAs had positive effects on body weight reduction [7,8]. Furthermore, the effect of EPA supplementation on overweight has been scarcely investigated and its therapeutic effects have been confirmed.

In a review of randomized controlled trials, Monique J LeMieux *et al.* [9] investigated the possible mechanisms to explain the anti-lipogenic effect of EPA. The results showed that supplementation with EPA in the high fat diet could prevent diet-induced obesity and insulin resistance. Both glucose homeostasis and metabolic profile were ameliorated by reducing adipose tissue inflammation, and this was done possibly through the reduction of lipid accumulation, prostaglandin (PG) synthesis and adipocyte size (Figure 2). A clinical trial showed that the supplementation with EPA combination with α -lipoic acid at lower doses (300mg/day) could promote fat mass reduction and weight loss in healthy overweight women following an energy-restricted balanced diet [10].

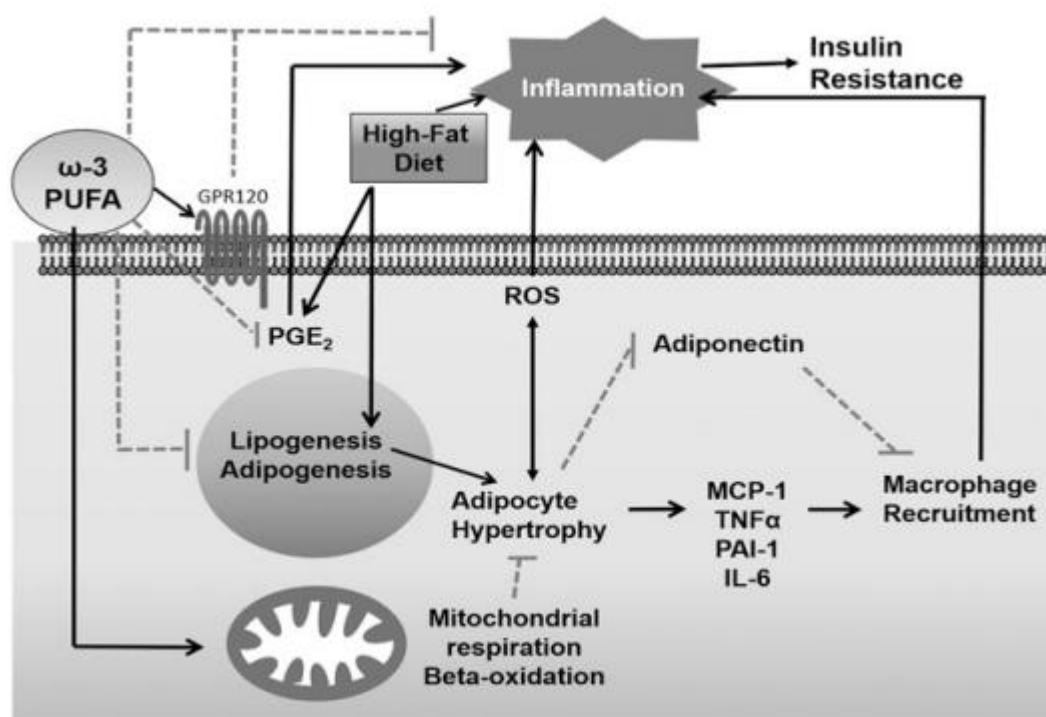


Figure 2: Model illustrating plausible mechanisms mediating anti-inflammatory and adipocyte hypertrophic effects of EPA. We showed here that EPA is able to ameliorate glucose homeostasis and metabolic profile in part by reducing adipose tissue inflammation, possibly via reduction in PG synthesis and reduced lipid accumulation and adipocyte size. GPR120, G-protein coupled receptor 120; MCP-1, monocyte chemoattractant protein 1; PAI-1, plasminogen activator inhibitor-1; ROS, reactive oxygen species

Cardioprotective effect

Although increasing evidence have showed that consumption of EPA could decrease risk of the cardiovascular disease (CVD), the detailed mechanisms of the cardio protective effect of EPA are not fully studied.

Elevated triglyceride (TG) levels is an important risk factor for coronary heart disease (CHD). It has been known that high dose fish oil reduces or maintains TG levels, so nutritional interventions may be effective to reduce CHD risk. One such intervention is the consumption of EPA [11-13]. Kathy Musa-Veloso *et al.* [14] had previously reported that the fasting TG levels could be reduced at a fixed intake of EPA in the dose of 200–500 mg/day, which may have significant public health benefits.

In recent years, some studies have identified home oxygenase-1(HO-1) is an inducible defense mechanism in the treatment of cardiovascular disease [15,16]. Seung Eun Lee *et al.* [17] focused on the contribution of EPA to the induction of HO-1 gene expression mediated by NF-E2-related factor 2 (Nrf2) in human endothelial cells. Their data suggested that EPA protects against H_2O_2 -induced endothelial cells death by activating the Nrf2/ARE (antioxidant response element) /HO-1 axis through the p38 signaling pathway. Taken together, EPA is an effective agent for the prevention of cardiovascular disease.

Anti-tumor effect

Recently, the antitumor effect of EPA has been attracting more and more attention. EPA has been considered to inhibit the growth and development of colon, breast and liver cancer and leukemia *in vivo* and *in vitro* [18]. Furthermore, many studies have demonstrated that EPA could induce apoptosis in cancer cells and have suggested mechanisms for this biological function [19-21].

Hepatocellular carcinoma (HCC) is known for its low cure rate and high death rate, and it is the third most common cause of death from cancer; surgery could only treat the small fraction of patients. So, it is very necessary to find effective agents for the treatment of HCC [22,23]. Yuanyuan Zhang *et al.* investigated the underlying antitumor activity and mechanisms of EPA in HepG2 cells. They found that the proliferation of HepG2 cells has a dose-dependent manner with EPA concentration, and had no significant effect on the viability of normal liver cells. In addition, EPA induced apoptosis, which was mediated by ROS (reactive oxygen species)-Ca²⁺-JNK (Jun N-terminal kinase) mitochondrial pathways [24].

Generally, many patients with esophageal squamous cell carcinoma (ESCC) may develop distant metastases or local tumor recurrence within a short period after curative surgery. Recently, taking omega-3 polyunsaturated fatty acids, especially EPA, have taken on increased importance, because EPA, as a kind of nutritional aid therapies for ESCC, it could improve the state of esophageal cancer patients receive medical attention [25]. In order to examine whether EPA has anticancer activity in the esophagus, Mizoguchi K *et al.* performed a DNA fragmentation assay and a WST-1 assay to investigate the effect of EPA on the apoptosis and proliferation of KYSE180 and TE11 cell lines, respectively. They concluded that cell growth was suppressed by EPA in a dose-dependent manner. Moreover, apoptosis-related proteins, including caspase-3, -7, -9 and poly(ADP-ribose)-polymerase(PARP) were activated, which may be an important mechanism to explain the induction of apoptosis [26].

Liver protection

Epidemiological and clinical trials have demonstrated the suppressive effect of n-3 polyunsaturated fatty acids on hepatic lipid accumulation and inflammation, which mainly by regulating transcription factors [27]. In addition, many efforts have been made to find novel therapeutic strategies for non-alcoholic steatohepatitis (NASH). Kuniha Konuma *et al.* [28] had employed melanocortin 4 receptor-deficient (MC4R-KO) mice to demonstrate that EPA treatment effectively reduced hepatic steatosis, along with marked prevention of the development and progression of liver fibrosis, which thereby suggested a clinical implication for the treatment of NASH.

Although combination therapy with ribavirin and pegylated interferon, which is recommended as a standard regimen for pediatric and young adult patients with chronic hepatitis C (CHC) worldwide [29-32], high ribavirin doses increase the risk of hemolytic anemia [33]. Suzuki M *et al.* [34] selected 12 CHC patients who received the combination therapy to evaluate the efficacy of EPA on ribavirin-induced hemolytic anemia, and they found that the hemoglobin levels were significantly improved in the EPA group at 8 and 16 weeks, contributing to avoiding ribavirin-related anemia.

Bone protection

Excessive stress induces chondrocyte apoptosis through p38 and p53 signaling pathways. The level of chondrocyte degeneration is correlated with the pathogenesis of osteoarthritis (OA), the most common chronic joint disease [35-37]. At the molecular level, Shuhei Sakata *et al.* evaluated the effects of EPA on OA and found that EPA dramatically inhibited sodium nitroprusside (SNP)-induced chondrocyte apoptosis by suppressing phosphorylation of p38 mitogen-activated protein kinase (MAPK) and p53, caspase 3 and poly(ADP-ribose) polymerase cleavage, and expression of matrix metalloproteinases (MMPS) (Figure 3) [38].

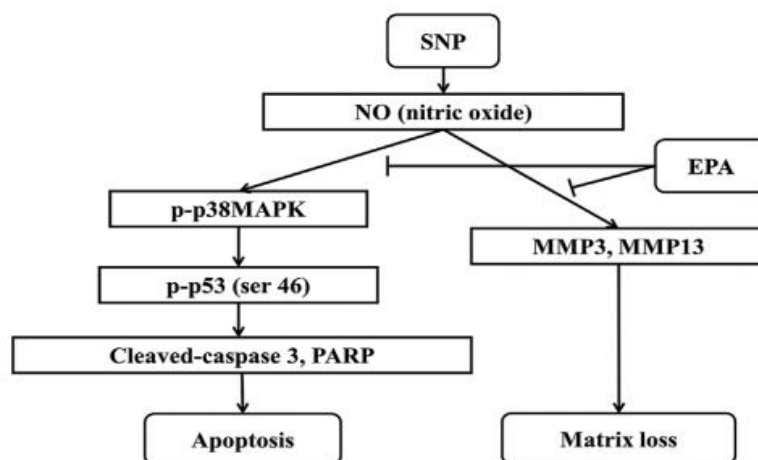


Figure 3: Diagram of the proposed signaling cascade involved in the inhibitory effect of EPA on the progression of osteoarthritis (OA). EPA prevented SNP-induced chondrocyte apoptosis and matrix loss by inhibiting phosphorylation of p38 MAPK and p53, caspase 3 and PARP cleavage and expression of MMP3 and MMP13. SNP, sodium nitroprusside; MMP, Matrix metalloproteinase; P-P38 MAPK, the phosphorylation of p38 Mitogen-activated protein kinase; P-P53(ser46), the phosphorylation of p53 at ser46; PARP, poly(ADP-ribose)-polymerase

Anti-hyperlipidemic effect

Hypertriglyceridemia (HTG) is increasing throughout the world, which might contribute to cardiovascular health. In hyperlipidemic adults, ingestion of dietary enrichment with n-3 PUFA may improve the blood lipid profile [39,40].

Elvira Verduci *et al.* [41] recruited 13 children with primary hyperlipidemia to explore whether supplementation with the mixture of DHA and EPA has positive effect on the reduction of blood lipid profile. The results showed an effect size of +2%, -8% and -12% for (high-density lipoprotein cholesterol) HDL-C, the ratio of total cholesterol/HDL-C and TGs, respectively, which suggested that this therapy was feasible. Another clinic research demonstrated that EPA + docosahexenoic acid (DHA) were required to achieve significant effects on hyperlipidemia when doses were ≥ 2 g/day. The level of TGs could be reduced by 25–30%, with greater effects (up to 45%) on subjects with higher baseline TG levels [42].

Conclusion

In conclusion, based on the relevance of many results, accumulated studies have suggested that EPA intake may positively affect pathological processes and be associated with a significant reduction in the risk of various diseases, including obesity, cardiovascular disease, cancer, hyperlipidemia and so on. EPA, as the alternative chemotherapeutic agents, has recently received more and more attention.

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