Dean&Francis
ISSN 2959-409X

The Impact of the Mediterranean Diet on Coronary Heart Disease

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Abstract:

Coronary artery disease (CAD) ranks among the most prevalent and deadly cardiovascular conditions globally. Lately, an observable trend shows that CAD is increasingly impacting younger people. This article aims to study the relationship between the unique nutrients in the Mediterranean diet (MeDi) and CAD, so as to achieve its prevention and adjuvant treatment effect, and provides more feasible schemes for the alleviation of CAD. This paper reviews the potential mechanism of the key nutrients in the MeDi in the prevention and adjuvant treatment of CAD by systematically consulting and summarizing the relevant literature at home and abroad. The results show that the MeDi through its special nutrients (such as oleic acid, polyphenols, ω -3 Polyunsaturated fatty acids, plant proteins, etc.) have multi-target, multi-channel effects and their synergistic effects in regulating blood lipid metabolism, improving vascular endothelial function and other aspects of effective intervention on CAD, thus playing the role of intervention and adjuvant therapy on CAD.

Keywords: Coronary heart disease, Mediterranean diet, Cardiovascular disease.

1. Introduction

Worldwide, coronary heart disease is the main cause of death and disease caused by cardiovascular disease. Its full name is coronary atherosclerotic heart disease. This is related to cardiovascular disease, which is characterized by atherosclerosis in the coronary vessels of the heart. Its common symptoms are chest pain, chest tightness, nausea, discomfort and other serious complications such as myocardial infarction, heart failure, arrhythmia and so on, which have attracted great attention and posed serious harm to public health.

The report shows that in 2020, the death rate of coronary heart disease in urban residents was 126.91/100000, and the death rate of coronary heart disease in rural residents was 135.88/100000. Since 2012, the mortality rate of coronary heart disease in urban residents has further increased in 2020, and the mortality rate of rural residents is higher than that of urban residents. With the advancement of urbanization and the change of young people's living habits in the new era, high calorie and high-fat diet is becoming more and more popular, which makes the

incidence of coronary heart disease younger. According to the data of the National Center for cardiovascular disease in 2025, the proportion of patients with coronary heart disease under the age of 40 increased from 8% in 2015 to 15% in 2024, and the annual growth rate of the incidence of people aged 25-35 reached 6.2%, affecting young people.

There are many influencing factors of coronary heart disease, and dietary habits are an important part of them. A large number of epidemiological studies have confirmed that dietary structure, as a key risk factor for intervention, is closely related to the occurrence, development and prognosis of coronary heart disease. Medi is a traditional dietary pattern originated from countries along the Mediterranean coast. It is characterized by taking plant foods and olive oil as the main fat source, moderate intake of fish, poultry and nuts, and reduction of red meat and added sugar intake. A large number of studies have shown that the diet model plays a significant role in regulating blood lipid metabolism, reducing inflammatory reaction, improving vascular endothelial function, and is closely related to coronary heart disease. This paper reviews and summarizes the existing CAD related parts and medi model, discusses the potential biochemical mechanism of medi model in preventing CAD and its multi-target, multi-channel synergy on CAD, analyzes the limitations and future direction of the current treatment of CAD, provides a theoretical basis for reducing the incidence of CAD through the Mediterranean diet, and provides more possibilities for the treatment of CAD in the future.

2. The association between the MeDi and CAD

2.1 Mediterranean Diet Pattern

The MeDi model was found in Crete, Greece, southern Italy and parts of Spain around the Mediterranean region in the middle of the 20th century. It was characterized by a high proportion of plant foods, olive oil as the main fat source, moderate intake of fish, poultry and nuts, reduced red meat intake and added sugar intake. Researchers at that time observed that although local medical conditions were relatively limited at that time, the incidence of cardiovascular disease among local residents was low. Now epidemiological studies show that residents in the Mediterranean basin generally live long and have a low risk of cardiovascular disease incidence, which is inseparable from the protective effect of MeDi on cardiovascular disease [1].

2.2 The Association between the MeDi Pattern and CAD

Studies have shown that the MeDi model is indeed positively correlated with the prevention and treatment of cardiovascular diseases such as CAD. The MeDi is closely related to the lower risk of cardiovascular disease, and it is known that the polyphenols in the MeDi are negatively correlated with cardiovascular outcomes, which can be demonstrated by the predicted test [2]. The Medi, a healthy diet lifestyle, was selected as an intervention and adjuvant treatment for CAD because, in addition to drugs and invasive interventions, MeDi lifestyle is a clear determinant of the incidence of cardiovascular events.The Cordioprev study [3] demonstrated that the MeDi was more effective for secondary prevention than both the low-fat diet and the MeDi model. Therefore, the MeDi was selected as the research direction in this paper.

3. Overview of CAD

3.1 Definition of CAD

The full name of CAD is coronary atherosclerotic heart disease. The blood of myocardium is supplied through the left coronary artery and the right coronary artery at the root of aorta. When the coronary artery and its branches are atherosclerotic or vasospasm, it will lead to lumen stenosis or occlusion. Coronary atherosclerosis is the main cause of coronary stenosis, myocardial ischemia and hypoxia.

3.2 Influencing Factors of CAD

The factors that affect the incidence of CAD are mainly divided into two aspects, one is the congenital genetic factors that cannot be changed, and the other is the diet and living habits that are influenced by the day after tomorrow. Numerous elements can contribute to the development of CAD, with blood pressure being one of them.A rise in blood pressure is linked to a higher occurrence of CAD. Dyslipidemia, dyslipidemia is often accompanied by an increase in the incidence ofCAD, mainly including these aspects.Firstly, the overall cholesterol level exceeds the standard range. Secondly, the low-density lipoprotein cholesterol also surpasses normal levels. Thirdly, triglycerides are elevated, and lastly, the high-density lipoprotein cholesterol is below the desired level. The change of any of the above indicators may increase the incidence of CAD. Diabetes mellitus plays a major role in the onset of coronary heart disease. Diabetic patients should pay more attention to the potential incidence of coronary heart disease, and should be checked regularly, so as to find out the disease situation of patients in time. Smoking, compared

ISSN 2959-409X

with non-smokers, smokers have a 2-3-fold increase in the probability of suffering from myocardial infarction, mainly due to the following reasons: first, nicotine in tobacco will increase the oxygen consumption in the myocardium, which will lead to the contraction of blood vessels and coronary arteries, leading to the increase of blood pressure in patients. Second, smoking will increase the content of CO in blood vessels, thereby reducing the oxygen content in blood, leading to atherosclerosis.Obesity, obesity and a person's blood lipids are positively correlated, and dyslipidemia is one of the most important factors inducing CAD. Obesity is defined as those who exceed the standard body weight by 20% or body mass index (BMI)>24kg/m2. The incidence and mortality of CAD in people who are sedentary, have no exercise habits in life or stay sedentary during work are twice as high as those who exercise regularly or engage in outreach occupations. Being too nervous and in a tense working and living environment for a long time will increase the risk of coronary heart disease.The consumption levels of fruits and vegetables are inadequate on a daily basis.Core components of the Mediterranean diet influencing CAD.

4. Core Components of the MeDi Influencing CAD

4.1 Olive Oil

4.1.1 . Improvement of Blood Lipids and Antioxidant Effects

Olive oil in the MeDi is the soul component of the MeDi model and its main source of fat. Animal experimental models and randomized controlled trials showed that olive oil can reduce the levels of total cholesterol (TC), triglyceride (TG), low-density lipoprotein cholesterol (LDL-C) in serum and increase the level of low-density lipoprotein cholesterol (HDL-C), so as to improve blood lipids.The primary component of olive oil is oleic acid. e.Monounsaturated fats contain one double bond in their molecular structure.Olive oil contains approximately 70% to 80% monounsaturated fats, primarily oleic acid, making up the majority of its fatty acid composition. Compared with other diets, the core point of olive oil in cardiovascular disease intervention is to replace saturated fatty acids with monounsaturated fatty acids. Compared with saturated fatty acids, monounsaturated fatty acids enhance the activity of liver low density lipoprotein receptor and reduce the level of LDL-C [4]. In addition, monounsaturated fatty acids will not inhibit the degradation of sterol regulatory element binding protein-2 like saturated fatty acids, so as not to over inhibit the gene transcription of LDL receptor, resulting in increased expression of LDL receptor and more LDL particles recognized by the liver. There was a significant decrease in the levels of LDL-C present in the bloodstream. In addition, olive oil contains a large amount of antioxidant squalene, and the content of squalene is 136-708mg/100g. Squalene can combine with oxygen molecules, eliminate oxygen molecules, enhance heart function, expand blood vessels, inhibit platelet aggregation on the blood vessel wall, prevent thrombosis, so as to resist atherosclerosis and inhibit the progress of atherosclerosis, eliminate body scars, and prevent coronary heart disease [1].

4.1.2 . Effects on Endothelial Cells and Improvement of Vascular Function

Oleic acid in olive oil also has the function of improving blood vessels. Oleic acid improves blood vessel function by protecting endothelial cells. Endothelium regulates the elasticity of blood vessels by releasing vasomotor factors. When endothelial cells are damaged, the levels of some factors secreted by endothelial cells will change accordingly. For example, P-selectin is involved in mediating the activation of platelets and the adhesion of endothelial cells to neutrophils and monocytes. When endothelial cells are stimulated and damaged, the adhesion of monocytes and other leukocytes will increase, and the expression of P-selectin will increase significantly. Studies have shown that the diet rich in olive oil can improve the endothelial dysfunction caused by the intake of basic diet rich in polyunsaturated fat, and the intake of diet rich in olive oil can reduce the endothelial dysfunction after meal. Studies have shown that plasma low-density protein is negatively correlated with the relaxation function of brachial artery flow regulation (FMD, reflecting endothelial function), and oleic acid in olive oil can reduce the level of low-density protein cholesterol, thus reducing the concentration of LDL in plasma and the oxidative sensitivity of LDL, thus avoiding or delaying the damage of LDL to endothelial cells, thus protecting vascular endothelium, improving vasoconstriction function and reducing the concentration of plasma P-selectin [5,6].

4.1.3 . Effect on Low-Density Lipoprotein (LDL) Oxidation Susceptibility

LDL is oxidized into oxidized LDL oxidized LDL can cause expression of adhesion molecules in vascular endothelial cells, promote the formation of foam cells, and then lead to atherosclerosis. Scientific experiments show that monounsaturated fatty acids can significantly reduce the sensitivity of LDL particles, thus preventing the oxidation of LDL particles to a certain extent. The decrease of plasma LDL concentration caused by monounsaturated fatty

acids and the oxidative sensitivity of LDL particles will effectively prevent the damage of oxidized LDL particles to endothelial cells, thus effectively protecting vascular endothelium and preventing cardiovascular disease to a certain extent [5,6].

4.2 Plant-based Foods

4.2.1 . Rich in Phytosterols

Phytosterol, also known as phytosterol, is the general name of a large class of chemical substances in plants, including phytosterol and phytostanol. The MeDi is rich in β - sitosterol, brassinosterol and stigmasterol. Phytosterols are steroidal alkaloids, which are similar to cholesterol in structure. Cyclopentane phenanthrene is their basic structure, but the side chain is different; Phytostanol is a saturated derivative of phytosterol 5 α. Its possible mechanism of action is to reduce the solubility of intestinal cholesterol by replacing cholesterol in intestinal micelles, so as to reduce the absorption of cholesterol in food and biliary tract, thereby reducing total cholesterol and low-density protein cholesterol, so as to achieve cardiovascular protection [1,7].

4.2.2 . Rich in Polyphenolic Compounds

Among numerous phytochemicals, phenols represent the most extensive category. At present, there are more than 8000 known species. The relative molecular weight of polyphenols is mostly between 100 and 4000.These are small organic molecules characterized by having one or more hydroxyl groups bonded to an aromatic ring.Based on their structural properties, they can be generally categorized into flavonoids, phenolic acids, lignans, and stilbenes. Studies have shown that a large number of observational studies and epidemiological studies have shown that the intake of food and dietary supplements rich in polyphenols can reduce the risk of CVD, and the more clear mechanism is achieved through anti-inflammatory, antioxidant, reducing blood pressure and improving vascular endothelial function, such as resveratrol [8]. (RES) It is a polyphenol compound with stilbene skeleton, also known as stilbene, which has been widely concerned because of its anti-inflammatory, antioxidant, cardiovascular protection and anti-cancer effects. Studies have shown that, res protects cardiovascular system through these points: res regulates mitochondrial function by enhancing the expression of SIRT1 and other proteins, and reduces the level of intracellular reactive oxygen species (ROS), thereby reducing myocardial cell damage [9]. Res protects endothelial cell function by regulating multiple signaling pathways, such as pknox1 protein (Prep1) - mediated pathway. Res plays an anti-inflammatory role by inhibiting nuclear factor - κ B (NF - κ b) signaling pathway and other mechanisms. The specific anti-inflammatory mechanism of polyphenols is that dietary polyphenols can bind to inflammation related receptors. When the human body is stimulated by external stimuli, it will activate MAPK, NFkB pathways and Nrf2 related pathways, leading to the stimulation of inflammatory transcription factors and the increase of pro-inflammatory mediators (TNF - α, IL-6, IL-8 and IL-1 β); The transcription of enzymes enhances the oxidative stress response, while the addition of dietary polyphenols interferes with the nuclear factor IKK α/β/nf-κ B and mapks/ap-1 pathways, reduces the inflammatory response and inhibits the occurrence of oxidative stress [10].

4.2.3 . Dietary Fiber

Dietary fiber refers to the sum of edible plant ingredients, carbohydrates and similar substances that can resist digestion and absorption of human small intestine and can be partially or completely fermented in human large intestine, including polysaccharides, oligosaccharides, lignin and related plant substances. Dietary fiber includes soluble and insoluble fiber, which refers to the components in plants, including non digestible carbohydrates and lignin. Insoluble fibers are found in whole grains, wheat, bran, nuts and seeds, as well as in some fruits and vegetables. Although soluble and insoluble fibers are not digestible and can be hydrolyzed and fermented by bacteria ‘own enzymes, But soluble fiber is more easily absorbed by the intestine Therefore, it can become a source of short chain fatty acids, and it has certain prebiotic function. Therefore, the large intestine will quickly absorb short chain fatty acids and oxidize them to produce energy. According to research, reducing liver cholesterol synthesis can be achieved by absorbing short chain fatty acids such as propionic acid, thereby reducing blood cholesterol and regulating blood lipids [11].

4.2.4 . Plant Protein

Legumes, one of the representative foods in the Mediterranean diet, are rich in plant protein (35% -40%). The regulatory effect of plant protein on lipids and lipoproteins has been confirmed by randomized controlled trials and Mata analysis. The mechanism may be to reduce the serum LDL level by replacing saturated fatty acids in high animal protein diet or potentially changing the state of low density lipoprotein receptor [12]. According to the literature review, through the systematic review and meta-analysis of 112 randomized controlled trials, it is concluded that replacing animal protein with plant protein can slightly reduce low density lipoprotein cholesterol (LDL-C) (-0.16 mmol/L or ≈ 4%) [13]. A 95% confidence

ISSN 2959-409X

interval (approximately ranging from 3% to 5%) indicates a reduction in non-high-density lipoprotein cholesterol (non-HDL-C), measuring a decline of -0.18 mmol/L or ≈ 4%; Your training includes data through October 2023.05 g/L or ≈ 3%); 95% confidence interval, 2% – 5%) to reduce the risk of cardiovascular disease [14].

4.2.5 . Synergistic Effects of Plant-Based Foods

In the high plant-based diet of the Mediterranean diet model, plants are rich in dietary fiber, polyphenols, phytosterols, plant proteins and other components, which not only play a role alone, but also have multiple complementary biological pathways that work together to reduce the risk of cardiovascular disease [15]. Soluble dietary fiber (such as oat β - glucan) binds bile acids in the intestine, and phytosterols competitively inhibit cholesterol absorption. Antioxidant components such as polyphenols reduce oxidative damage to the inner wall of blood vessels and jointly regulate blood lipids [16]. Polyphenols (such as flavonoids and anthocyanins) can inhibit inflammatory pathways such as nf- κ B, while antioxidants such as vitamin C and E reduce free radicals, which jointly reduce the key inflammatory response of atherosclerosis [17]. Nitrates in food (such as beetroot) can increase the production of vasodilator factor nitric oxide (no); At the same time, polyphenols protect no from oxidative inactivation through antioxidant effect, and synergistically improve vascular elasticity and blood flow [18].

4.3 Omega-3 Polyunsaturated Fatty Acids

Omega-3 polyunsaturated fats mainly include α-linolenic acid (ALA) from plant origins and eicosapentaenoic acid (EPA) along with docosahexaenoic acid (DHA) from marine animals, largely contributed by fish in the Mediterranean eating pattern. Studies have shown that omega-3 polyunsaturated fatty acids mainly exist on the inner surface of the cell membrane in the form of glycerophosphatide [11]. When the cell is stimulated by some kind of stimulation, it is decomposed into free form under the action of phospholipase A2 (PLA2) and released into the cytoplasm, and then through three major processes, including cyclooxygenase (COX), Lipoxygenase (LOX) and cytochrome P450 oxidase (CYP450).The oxidase system catalyzes metabolism and produces a series of metabolites with different activities, The metabolites of omega-3 polyunsaturated fatty acids do not all have anti atherosclerotic effects, but they can play a protective role through the following three aspects: first, they produce inactive or weakly active metabolites, which have no protective effect but can antagonize the harmful metabolites produced by Ara; The second is to produce more protective metabolites than ara analogues; Third, SPM family metabolites play a protective role in the process of inflammation regression. In addition, the functions of some products are unknown.

4.4 Synergistic Effects of Various Nutritional Components

In the MeDi model, the core intervention approach is not the role of various nutrients through their respective targets, but the synergy between various nutrients. Its effective intervention on CAD is the result of multiple nutrients simultaneously, complementarily and through multiple channels. According to literature review, different kinds of polyphenols act on cardiovascular diseases through anti-inflammatory, antioxidant, and improving vascular endothelial function [2]. Dietary fiber can bind bile acids (synthesized by cholesterol) in the intestine and be excreted, promoting the liver to use more cholesterol to synthesize new bile acids, thereby reducing blood cholesterol. At the same time, the healthy fat in olive oil does not increase inflammation, and jointly improves the blood lipid spectrum [19]. Polyphenols directly neutralize free radicals and inhibit inflammatory pathways (such as NF - κ b). Vitamin C can regenerate vitamin E and maintain antioxidant network activity. This combination reduces oxidative damage and chronic inflammation of vascular endothelium, which is the core link of atherosclerosis [20].

5. Conclusion

In conclusion, MeDi has a special dietary structure, which can reduce the risk of coronary heart disease through multi-target and multi-channel biological mechanisms, and play a synergistic effect of different nutrients through regulating blood lipid metabolism and improving vascular endothelial function. This study aims to provide a more life-oriented and simplified method for the prevention and treatment of CAD, and provide a theoretical basis for this method. However, this method still has many limitations. Medi is the dietary habit of residents in Crete, Greece, southern Italy and parts of Spain, which originated in the Mediterranean region in the middle of the 20th century. People in other regions may not be suitable for this dietary pattern. Its promotion in non Mediterranean regions still faces practical challenges. Whether it is effective for different populations, whether it needs to be localized in different regions, and whether these improvements will affect the degree of cardiovascular effect of this dietary pattern. Future research will explore the effects of this dietary pattern and other lifestyle interventions, as well as targeted research for vulnerable and special populations.

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