2020

The Effects of a Plant-Based Diet on Inflammation of Patients with Cardiac Disease

Rachel L. Butcher
University of Central Florida

THE EFFECTS OF A PLANT-BASED DIET ON INFLAMMATION OF PATIENTS WITH CARDIAC DISEASE

by

RACHEL L. BUTCHER

A thesis submitted in partial fulfillment of the requirements
for the Honors in the Major Program in Nursing
in the College of Nursing
and in The Burnett Honors College
at the University of Central Florida
Orlando, Florida

Spring Term 2020

Thesis Chair: Dr. Maureen M. Covelli, PhD, RN

ABSTRACT

Cardiac disease is the primary cause of death in the United States of America (CDC, 2017). Despite ongoing efforts and investments to improve cardiac health in the United States, most of the population will suffer from cardiovascular diseases. There is a multitude of research supporting that diet can contribute to cardiac disease, but it is less known that diet can greatly contribute to regulation and reversal of cardiovascular disease processes (Huang et al., 2012; Satija et al., 2017; Kim et al., 2019). Existing research supports the efficacy of plant-based diets to manage and reverse certain cardiac diseases (Tuso et al., 2015; Esselstyn, 1999; Ornish 1998; Campbell et al., 1998). Plant-based diets have the potential to save many lives and drastically reduce healthcare costs. The purpose of this literature review is to evaluate current research on plant-based diets as interventions for cardiac disease and to identify the reasoning for underutilization of plant-based diets as intervention with cardiac health within the United States population. A database search of CINAHL Plus, MEDLINE, BIOSIS, Cochrane, Google Scholar, and PubMED was conducted and university librarians were utilized. Inclusive criteria and keyword searches were comprised of coronary artery disease and plant-based diets, cardiac disease and diet interventions, intensive lifestyle changes for reversal of coronary heart disease, plant-based diets and cardiac disease and inflammation, and plant-based diets reducing cardiac inflammation.

DEDICATIONS

To my husband, Brad, for always inspiring me to overcome life's challenges and exceed expectations. I love you.

To my parents for always supporting me in all that I do.

To all the nurses, providers, and healthcare workers who strive to make our world a better, more compassionate place.

ACKNOWLEDGEMENTS

Dr. Covelli, thank you so much for being such an exceptionally supportive thesis chair. Your insight, guidance, and motivation have been invaluable during this process. It has been such a wonderful opportunity to work with you an learn from your expertise.

To my incredible committee member and mentor, Mrs. Neubauer. Thank you for all that you have done for me and for always sharing your wisdom and passion for nursing with me.

To my Aunt and Uncle, Connie and John Tresize. Thank you for inspiring me to research and share plant-based diets with others. I am so thankful for your unconditional love and encouragement.

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INTRODUCTION

Heart disease is the number one "killer" in the United States of America, but over seventy-five percent of heart disease diagnoses can be prevented (Stewart et al., 2017). Over 600,000 Americans die each year due to heart disease, which approximates to one in every four Americans (CDC, 2017). The American Heart Association estimates by 2035 almost half of the population will have cardiovascular disease (CVD) (American Heart Association, 2015). The American Heart Association also predicts by 2035 that healthcare costs of CVD will reach over one trillion dollars with direct medical costs exceeding $748 billion and indirect costs reaching beyond $360 billion (American Heart Association, 2015). CVD includes disorders of the heart such as hypertension, coronary artery disease, stroke, and peripheral vascular disease. Data reported by Center for Disease Control (CDC, 2017) suggest that controllable CVD risk factors such as uncontrolled hypertension, high low-density lipid cholesterol levels, and smoking could significantly reduce cardiovascular disease. The Center for Disease Control has found that almost half of Americans have at least one of these risk factors (CDC, 2017).

It is interesting to note that in regions of countries, such as Africa and rural China, who rely on mostly a plant-based (no animal meat or byproducts) diet to survive, coronary artery disease (CAD) is not an epidemic (Esselstyn, 2001). This phenomenon intrigued Esselstyn, which lead him to become one of the original researchers of plant-based diets as interventions for cardiac disease. In a study conducted by Breslow, it was found that people living in rural China have decades without documentation of a myocardial infarction (Esselstyn, 2001, p.171). Esselstyn asserts that current strategies for management and prevention of CAD rely heavily on medication and surgical intervention that are pressing the limits of what the United States'

healthcare system can afford (Esselstyn, 2001). Once arterial stenosis becomes symptomatic, it often has become over a 70% blockage in the affected artery (Esselstyn, 2001, p.172). At this point, the millions of Americans suffering from this disease are treated by interventions including stent placement, atherectomy, bypass surgery, and angioplasty. The issue with this management strategy is that they only provisionally alter disease progression because they do not treat the juvenile plaques (30-50% blockage), that are more inclined to rupture (Esselstyn, 2001, p.172). Esselstyn's original research is a foundation to current research in this area and has influenced many providers who advocate for plant-based diets as means for managing cardiac disease.

The plant-based diet studies support the significant prevention, improvement, and potential for reversal in cardiac disease (Esselstyn, 1999; Ornish 1998; Campbell et al.,1998). By reducing inflammation and restoring arterial health, plants are shown to be a noteworthy treatment for CAD (Tuso et al., 2015). Further implementation of these plant-based interventions in people with various levels of CAD, or simply seeking prevention may prevent cardiac disease from continuing to an immense threat for Americans (CDC, 2017). A wide variety of plant-based diets can be beneficial to cardiac health and can be customized based on one's nutritional preferences and severity of cardiac disease (Huang et al., 2012; Satija et al., 2017; Kim et al., 2019).

Problem

Plant-based diets demonstrate to not only prevent and manage CAD, but reverse it as well (Tuso et al., 2015; Ornish 1998; Campbell et al., 1998). This could provide an alternative or supportive measure to the heart disease crisis in the United States, as well as an effective measure to reduce health care costs that are exponentially increasing due to heart disease

(Benjamin et al., 2019). Esselstyn emphasized, “Some people think that the plant-based whole foods diet is extreme. Half a million people a year will have their chest opened, a vein taken from their leg and sewn onto their coronary artery. Some people would call that extreme” (Fulkerson, 2011). Research does reflect plant-based diets as successful in preventing and being retrogressive with inflammatory heart diseases (Tuso et al., 2015; Ornish 1998; Campbell et al., 1998). The reasoning for lack of utilization of plant-based diets as intervention with cardiac health is less clear. If more patients are educated on the benefits of plant-based diets with cardiac health, then more can attempt this lifestyle modification to decrease cardiac disease (Huang et al., 2012). Moreover, there are also studies done on a less strict plant-based diet, such as vegetarianism (no animal meats) or increasing plants while decreasing meat, which also indicate prevention of cardiac disease (Kim et al., 2019). It could be proposed to patients that the extent of plant-based diets could be dependent on personal preference, or stage of CAD (if any) in the person attempting this diet (Kim et al., 2019). Modifications to make plant-based diets more accessible and easier to adapt into current lifestyles may also increase compliance in patients (Satija et al., 2017). Plant-based diets have the potential to save many lives and drastically reduce healthcare costs pertaining to cardiac disease (Tuso et al., 2015; Ornish 1998).

Purpose

The purpose of this literature review is to investigate evidence-based research supporting the benefits of plant-based diets including potential biological mechanisms and their effects on cardiac health. This review collates numerous current and original studies to provide a synopsis of components investigated throughout the literature. The effects of a plant-based diet on cholesterol, inflammatory biomarkers, and potential of reversal of cardiac disease have been explored. More specifically, investigation of research on the potential for plants to improve

arterial flexibility and endothelial function was implemented. Factors such as cholesterol, inflammatory biomarkers, and cardiac episodes have been used to measure cardiac inflammation. Motivators and barriers to the underutilization of the plant-based diets for individuals who are at risk or have arteriosclerotic heart disease have been examined.

Methods

A literature review was conducted by analyzing peer-reviewed articles and literature on plant-based diets. Discussion of studies are distinguished as fully plant-based, or a more flexible plant-based approach. The literary review also notes if the populations in the studies are suffering from various cardiac diseases specifically or are a general population. Articles that are not peer reviewed, in languages other than English, or are fifteen years old (unless referenced by a more current study) will be excluded for this review. Databases such as CINAHL Plus, MEDLINE, BIOSIS, Cochrane, Google Scholar, and PubMED as well as university librarians were utilized. Inclusive criteria include coronary artery disease and plant-based diets, cardiac disease and diet interventions, intensive lifestyle changes for reversal of coronary heart disease, and plant-based diets reducing cardiac inflammation.

BACKGROUND

Cardiac Disease Processes

Cardiac disease, coronary artery disease, and cardiovascular disease are disease processes influenced by blood vessels and arteries found throughout the human body. The two major components of most cardiac disease are atherosclerosis and endothelial dysfunction. Coronary artery disease leads to weakening of the mechanical pumping capability of the heart caused by deprivation of oxygen to the heart and body (Huether & McCance, 2017). Atherosclerosis, or narrowing of the arteries, is often the precursor of CAD. Atherosclerosis is derived from arteriosclerosis caused from the accumulation of lipid-laden macrophages within the arterial wall. These inflammatory accumulations create plaque which further perpetuates endothelial damage. Risk factors contributing to atherosclerosis and endothelial injury include smoking, hypertension, diabetes, high levels of low-density lipoproteins, and low levels of high-density lipoproteins (Huether & McCance, 2017). Increased levels of serum markers for inflammation, such as C-reactive proteins, troponin I, and adipokines can also influence endothelial harm (Huether & McCance, 2017). Cellular endothelial destruction creates inflammation in the body further contributing to fatty streaks accumulating in the arteries. These impairments in the arteries lead to ischemia, or deficiency of cellular functioning deriving from lack of oxygen supply (Huether & McCance, 2017). Worsening of ischemia and comprehensive obstruction of arteries cause myocardial damage, or infarction, which can create blood clots and lead to heart attack and stroke (Huether & McCance, 2017).

Coronary artery disease underlies multiple cardiac disease processes. Chronic or uncontrolled hypertension of high blood pressure impacts this as well. Hypertension is defined as

systolic blood pressure of 140 mm Hg or more, or a diastolic blood pressure of 90 mm Hg or more (Huether & McCance, 2017). Blockage caused by CAD and worsened by hypertension lead to heart attacks, strokes (brain attacks), heart failure, and cardiac arrhythmias (Huether & McCance, 2017).Valve diseases of the heart are also deadly effects of CAD which involve leakage of blood instead of one-way blood flow in the heart. Atherosclerosis can also impact other arteries throughout the body, which is known as peripheral artery disease (PAD). Peripheral artery disease decreases circulation to the organs and extremities and can lead to death.

Cholesterol and Inflammatory Biomarkers

A common contributing factor is plaque buildup leading to narrowing arteries, or atherosclerosis. The complexity behind the inflammatory process of atherosclerosis seems to originate by lipids congesting the subendothelial layer of an artery wall (Benjamin et al., 2019). This phenomenon then engenders biologically active species, such as low-density lipoproteins (LDL), thus causing inflammatory molecules to aggravate the arterial wall (Huether & McCance, 2017). Cardiac inflammation, particularly chronic, leads to rupturing of plaques, blood clots, heart attack, and stroke (Piepoli, 2017). Methods to improve lipid levels are utilized in primary levels of intervention to prevent CVD risks. More specifically, LDL levels have been known to have a robust correlation with CVD risks (Piepoli, 2017). For example, reducing LDL levels by 1.0 mmol/L causes a 20 to 25 percent reduction in CVD death (Piepoli, 2017). High-density lipoproteins (HDL) have been hypothesized to be cardioprotective, but this is a controversial topic (Stewart et al., 1993). The link of advantages from naturally higher HDL levels has not yet fully been proven.

Reasoning for why plant-based diets display success when managing cardiac disease ascribes to halting and undoing atherosclerotic factors (Barnard et al., 2019). To further elaborate, plasma lipids involved with dyslipidemia are attributed from a diet high in saturated fats often reflected in CAD. Animal by-products, such as meat and dairy, are leading sources of saturated fats in a standard American diet (Wang et al., 2015). Not consuming these foods is a key-component to plant-based diets. In a study conducted by the University of Toronto, low-density lipoprotein levels were lowered almost 30 percent in four weeks after participants incorporated an increased amount of soluble fiber by eating plant-based and removing meat and dairy from their diets (Jenkins et al., 2005). Increasing consumption of plants decreases the consequences of atherosclerotic alterations by diminution in systolic and diastolic blood pressure, reduction of blood viscosity, increase of potassium in the blood, and weight loss (Yokoyama et al., 2014). Lowering of blood viscosity improves not only blood flow, tissue oxygenation as well (Barnard et al., 2019). Oxidative stress can influence pathogenesis of atherosclerosis, endothelial dysfunction, and cardiovascular diseases (Nebl et al., 2019). Dietary antioxidant intake such vitamin C and vitamin E widely quantifies in fruits and vegetables, which aid in avoidance of adverse effects of oxidative stress. Plant-based diets, rich in antioxidants, are believed to thus assist in hinderance of oxidative damage (Nebl et al., 2019). A diet high in fruits and vegetables can enhance glycemic control by heightening insulin sensitivity (Barnard et al., 2005). Many vegetables, grains, and legumes are high in complex carbohydrates, this inhibits depletion of glycogen from muscles and liver and promotes an increase of overall energy levels (Barnard et al., 2019). Without chronically elevated levels of glucose, as seen in diabetes and atherosclerosis, arteries have improved flexibility and elasticity (Barnard et al., 2019). Arterial flexibility aids in deterrence of injury to the endothelium as seen in inflammation

(Barnard et al., 2019). While fats exhibited in animal by-products weaken arterial compliance, plants strengthen blood viscosity, arterial diameter, and endothelial integrity (Barnard et al., 2019). Even diminutive changes in blood vessels regarding arterial diameter may drastically change blood flow and halt atherosclerotic processes (Barnard et al., 2019). Plant-based diets reflect anti-inflammatory responses in patients with and without coronary artery disease due to decreases of C-reactive protein (Sutliffe et al., 2015). Reduction of inflammation seen in CAD derives from the healing functions of plants. Plant-based diets have increased quantities of antioxidants and lack of pro-inflammatory fats (Barnard et al., 2019). Studies have indicated that red-meat consumption is directly related to progression of C-reactive protein, hemoglobin A1c, and excess iron associated with cardiac disease (Ley et al., 2013). Plant-based diets suggest the possibility to influence cardiovascular health by reducing atherosclerotic inflammation and enhancing endothelial functioning of arteries (Barnard et al., 2019).

Another biological mechanism that impacts healthy cholesterol in plant-based diets is dietary fiber. Dietary fiber improves cholesterol and cardiovascular health by altering cholesterol synthesis, increasing bile acid synthesis, and decreasing bile acid absorption (Smith & Tucker, 2011). In a meta-analysis of dietary modifications, a 2-10 gram per day increase in soluble fiber intake resulted in a -0.057 mmol/L decreases in LDL cholesterol (Fritsche, 2015). The decreased gastric distention combined with viscous gel formation from water absorption in fiber also plays a significant role in cardiac health. The metabolic process from digestion prolongs nutrient absorption, which increases satiety and regulates post-prandial insulinemic and glycemic reactions (Smith & Tucker, 2011). These responses also aid weight loss and lasting weight maintenance, which further reduces cardiac workload (Fritsche, 2015).

Cardiac Pharmacological Interventions

Cardiac medications are commonly used to treat a wide variety of symptoms and to prevent future cardiac destress (Leslie et al., 2018). Angiotensin converting enzyme inhibitors (ACE inhibitors), angiotensin II receptors, and beta blockers for instance are medications that block stress hormones and relieve strain on the mechanical functioning of the heart (American Heart Association, 2015). Calcium channel blockers likewise treat high blood pressure by restricting the natural flow of calcium into heart cells and blood vessels (American Heart Association, 2015). This action discourages the vessels from narrowing and spasming as well as reduces overall heart workload. These medications along with other antihypertensives relax and widen blood vessels to improve blood flow throughout the body. A noteworthy medication class is lipid, or cholesterol medication. Cholesterol contributes to plaque and narrowing of the arteries, this drastically increases risk for strokes and heart attack (American Heart Association, 2015). Statins, fibrates, and bile acid sequestrants are all lipid medications that improve cholesterol. These medications can lower LDL, lower triglycerides, and treat irregularly low levels of HDL, depending on which medication is used (American Heart Association, 2015). Another common cardiac medication class is Antiarrhythmics, which regulate the heart so that it can maintain a regular rhythm and rate. Anticoagulants and platelet inhibitors aid in preventing blood clots, which can significantly reduce heart attack and stroke (American Heart Association, 2015). Diuretics are prescribed to help patients expel excess fluids and sodium from their bodies (American Heart Association, 2015). Diuretics can help treat hypertension and manage heart failure.

Despite cardiac medications often demonstrating effective for primary and secondary levels of intervention, cardiac disease and death continue to increase in the United States (Leslie

et al., 2018). One barrier to better success with cardiac medication can be attributed to lack of adherence (Leslie et al., 2018). Medication used for prevention and management of CVD are regularly intended for life-term use, therefore adherence is particularly essential. Reasoning for lack of adherence includes medication and appointment costs, polypharmacy, undesired side effects, forgetfulness, and lack of knowledge in patients (Leslie et al., 2018). Others argue that lifestyle modifications must also be made to effectively manage or reverse heart disease. Cardiac medications often treat the signs and symptoms, but do not treat the underlying causes of cardiac disease (Leslie et al., 2018).

Plant-based Diets

Plant-based diets are specified as diets primarily involving various forms of plants and limited amounts of animal meats and biproducts (Satija et al., 2017). They are often recommended based on their health benefits, especially pertaining to cardiac health. Studies have shown that plant-based diets can be cost effective and be used as preventative and reparative for cardiac health (Tuso et al., 2015; Ornish 1998). There are a variety of plant-based diets that vary in amounts of animal products consumed or not consumed. A semi-vegetarian diet is one that occasionally involves eating meat or poultry, while a vegetarian diet does not include meat or poultry (Ferdowsian & Barnard, 2009). There are various labels of vegetarian diets, such as ovo-vegetarians (no animal meat or bioproducts besides eggs) and Lacto-ovo vegetarians (same as ovo-vegetarians, but includes other dairy), but those specifics are not always distinguished. There are also pescatarians, or people who eat plant-based but include dairy and fish. Vegan diets are known to be the strictest of plant-based diets, they do not include any animal meats, animal byproducts, or animal related ingredients (Ferdowsian & Barnard, 2009). Another form of vegan diet, known as whole-food plant-based diet (WFPBD), is a diet that has shown the most

drastic improvements in cardiac health, diabetes, and types of cancers (Ornish, 1998). A WFPBD is high in fruits, vegetables, whole grains, legumes, and natural soy products while avoiding animal products, refined carbohydrates, fat, and sugar.

One major barrier for utilization of plant-based diets is lack of education on its benefits. The majority of physicians will discuss medications and life-style modifications with patients, but do not discuss the impact plant-based diets have on morbidity and mortality (Tuso et al., 2015). To edify the health benefits associated with consuming a plant-based diet to patients, practical material on how to consume a plant-based diet must be provided. The following is an example of a seven-day meal plan for a whole-food plant-based diet. It is important to note that this type of plant-based diet utilizes carbohydrates from whole grain starches (at least four to five grams per serving) as a major source for energy. Approximately forty-five percent of each meal should be starches, ten percent from fruits, forty-five percent from vegetables, and plenty of water (Lawler, 2019). The high-fiber component of WFPB diets make it difficult to overconsume on caloric intake, particularly when it involves beans, grains, fruits, and vegetables. With the following diets, any snacks can be added as additional food, especially for highly active people (2,500-3,000 calories per day).

Day 1
Breakfast
Tofu Scramble (Pan-seared tofu, peppers, potatoes, onions) with fresh fruit and almond butter
Lunch
Cauliflower rice bowl with black beans, corn, avocado, and salsa
Dinner
Veggie-topped pizza (no cheese) and a large salad topped with chickpeas
Snacks
Zucchini chips and a smoothie with chia seeds

Day 2
Breakfast
Oatmeal-based muffins and a smoothie with flax seeds
Lunch
Tomato basil soup with whole-grain crackers
Dinner
Veggie stir-fry with tofu
Snacks
Hummus wrap with almonds

Day 3
Breakfast
Oatmeal bars with fresh fruit
Lunch
Greek salad with whole grain pita and hummus
Dinner
Kale and tofu curry
Snacks
Cashew yogurt with berries and two tablespoons of peanut butter

Day 4
Breakfast
Breakfast burrito with whole-grain wrap, tofu, potatoes, peppers, and salsa
Lunch
Veggie burger and large salad
Dinner
Roasted cauliflower with sweet potato fries and kale
Snacks
Carrot sticks with hummus and trail mix

Day 5
Breakfast
Dairy-free yogurt with berries, granola, and sliced almonds
Lunch
Whole-grain tomato sandwich with pesto, olive oil drizzle, and fresh fruit on the side
Dinner
Whole-wheat pasta with roasted vegetables and a spinach salad
Snacks
Roasted chickpeas and green smoothie with flaxseeds

Day 6
Breakfast
Chia seed pudding with fresh berries and almond butter, whole-wheat flaxseed bread
Lunch

Avocado toast and a spring mix salad topped with dried fruit
Dinner
Vegan mushroom enchiladas with baked corn chips and salsa
Snacks
Almonds and cucumber slices with hummus

Day 7
Breakfast
Oatmeal with fresh fruit, almond milk, and chia seeds
Lunch
Quinoa bowl with roasted carrots, sweet potatoes
Dinner
Vegetarian chili topped with avocado slices
Snacks
Whole- wheat toast topped with peanut butter and dried fruit
(Lawler, 2019)

FINDINGS WITH REVIEW OF LITERATURE

Foundational Plant-based Studies

Pioneers of plant-based diet research are Dr. Esselstyn, Dr. Ornish, and Dr. Campbell. Their original work set a foundation for current studies conducted in preventative and restorative cardiac healthcare. Esselstyn (1999), declares that effective plant-based diet prevents coronary artery disease and can reverse it as well. A study by Esselstyn (1999) involved studying patients that had previously had unsuccessful earlier interventions such as bypass surgery. The original group studied consisted of one woman and twenty-three men with serious angiographically reflective CAD. Each patient was nondiabetic, did not have hypertension, and did not smoke. They eliminated oil, dairy (except none-fat), and all animal meats while only using cholesterol-lowering medications on an individualized basis. The main foods consumed in this plant-based diet were whole-gains, legumes, lentils, vegetables, and fruit. The goal of this study was to maintain a total serum cholesterol level of 150 mg/dl, since CAD under these circumstances is rare (Esselstyn, 1999). Adherence was monitored by monitoring lipids biweekly for the first five years, incorporating individualized meetings and support of diet, and several times a year all involved met together to discuss feelings with one another (Esselstyn, 1999). Six patients withdrew from the study within the first two years and continued to have thirteen new cardiac events (Esselstyn, 1999). Of the remaining 18 patients, 11 went under angiographic analysis after five years of the study. Disease arrest was seen in all 11 patients (100%) and regression in 8 (73%) (Esselstyn, 1999). Angina originally recounted in nine patients was eliminated in two and improved in seven (Esselstyn, 1999). The mean cholesterol of the patients reduced from 237 mg/dl to 137 mg/dl during the first five years of this research (Esselstyn, 1999). After seven more years (12 from the original start date) only one other patient dropped the study and the total

mean cholesterol of patients was 145 mg/dl. These patients at the 12-year mark have experienced no progression of CAD, no coronary events, and no interventions (including medications). These findings were exceptionally considerable because they reflected reversal, rather than slowing of coronary atherosclerosis (Esselstyn, 1999).

Ornish's seminal 5-year research (1998) studied 48 patients with CAD in a modified lifestyle group (including plant-based diets) or a control group (usual-care interventions, such as medication). Specific interventions for the lifestyle group included 10% fat whole foods plant-based diet (no animal meats), aerobic exercise, stress management training, smoking cessation, and group psychosocial support (Ornish, 1998). Of the original group, 35 completed the study. The control group demonstrated progression of their disease while the lifestyle modification group reflected reversal of their atherosclerosis and CAD. Ninety percent of the lifestyle modification group had a reduction in angina (chest pain), as well as a 400% improvement in myocardial perfusion (Ornish, 1998). The estimated health-care savings was estimated at $30,000 per patient after only one year at the time the study was conducted (Ornish, 1998).

Campbell is most known for his work titled "The China Study". In this analysis, researchers studied diet and disease process of residents of rural China. In the primarily plant-based Guizhou province, over the course of three years, there were zero deaths attributed to CAD in the population of men under sixty-five studied (Campbell et al.,1998). In rural China during the time of the study, fat intake was approximately half and fiber was three times higher of that consumed in the United States (Campbell et al.,1998). Additionally, animal protein consumption was very low at a 10% intake of American diet and mean cholesterol was averaged at 127 mg/dl compared to 203 mg/dl in adults in America (Campbell et al.,1998). The apolipoproteins

reflecting serum cholesterol levels were positively associated with animal protein intake and inversely associated with plant protein, legume, and vegetable intake in diets of this research (Campbell et al.,1998).

Current Research

The majority of Esselstyn's and Ornish's studies include strict plant-based diets, meaning no animal meats or by-products. The diets followed in these studies emphasize whole foods (not processed) such as grains, legumes, lentils, vegetables, and fruits, with some nuts and seeds. Their patients in the studies also had CAD. Other research has been conducted to further the study of plant-based diets, but with a more flexible approach. In a recent collaborative study, researchers examined different stringencies on plant-based diets in a general population over an almost twenty-year period in middle-aged atherosclerotic risk adults (Kim et al., 2019). The diets in this study ranged from vegetarian (no animal meat), to healthy vegetarian emphasizing whole grains and plants, less healthy plant based still including processed carbohydrates with plants, and diets still including a reduced amount of animal meats. It was concluded that the diets with more plant-based regimes and less animal products were at lower risk of CVD and CVD mortality (Kim et al., 2019). It is noted that fruits and vegetables are adaptive to glycogen storage due to the high levels of carbohydrates. This biochemical response is reduction of blood viscosity, which improves arterial flexibility and endothelial function while increasing vascular circulation and tissue oxygenation (Barnard et al., 2019).

Similar flexible plant-based diet studies conducted on a more diverse population continue to conclude this beneficial trend, although it is highlighted the quality of the plants in the diet play a detrimental role in the prevention of CAD. According to a study conducted by Satija et al.

(2017), a diet rich in healthy and whole plant foods will considerably lower coronary heart disease and inflammation, while a less healthy plant-based diet with added sugars is associated with higher risks of CHD. Further stressing the quality of nutritionally adequate plant-based diets, it can also be considered that specific plants that are not prepared with an excess of oils and sugars are more beneficial to cardiovascular health (Hemler & Hu, 2019). Additionally, it is distinguished that most of the general population do not have to fully exclude animal meat from their diet to improve their cardiac health (Hemler & Hu, 2019).

Kulshreshtha et al. (2014) investigated the genetic implication on cardiac disease. The study examined 490 twins without CVD. Arterial health, such as carotid intima-media thickness was measured in correlation to modifiable factors such as BMI, cholesterol, and diet (Kulshreshtha et al., 2014). It was found that the modifiable factors were independently associated with arterial health. Therefore, the association with cardiovascular health is not confounded solely by genetics. Family history should not fully determine cardiac health. Modifiable factors, such as plant-based diets can reverse the conditions of CAD that familial association contributes to (Hemler & Hu, 2019).

Research by Trapp, Knez, & Sinclair (2010), examined how plant-based vegetarian diets influence oxidative stress. More specifically, antioxidants were studied due to their advantages of lowering damage correlated with oxidative stress by counteracting free radicals. Antioxidants are compounds found in foods rich in vitamin C and vitamin E that diminish free radicals by offering or taking electrons from free radicals (Trapp et al., 2010). Free radicals can contribute to advancement of various types of cancers and cardiovascular disease when they impede regulation of apoptosis, or cell death normal in cellular cycles (Trapp et al., 2010). Although exercise is a factor of a healthy lifestyle, it can also boost oxidative stress in the body (Trapp et

al., 2010). Antioxidant-rich foods encompass a vegetarian diet, which may influence an enhanced antioxidant relationship capable of lessening oxidative stress and CVD. Studies have shown that vegan participants had higher blood concentrations of vitamins C, vitamin E, beta-carotene, and antioxidant enzymes than the omnivore participants (Trapp et al., 2010). Pertaining to oxidative stress influenced by exercise, vegetarians may have an augmented antioxidant defense systems to counter because of their diets incorporating fruits, vegetables, and wholegrains (Trapp et al., 2010). Plant-based diets combined with routine exercise may be able to reduce CAD due to an improved antioxidant levels. Overall adequate literature addressing oxidative stress and antioxidant levels of plant-based diets are lacking, especially pertaining to reactions involving exercise, and additional conclusive studies should be conducted (Trapp et al., 2010).

Further studies continued to show possibility of plant-based diets exhibiting anti-inflammatory factors reflected in biomarkers when compared with a traditional omnivore (meat eating) diet. Haghighatdoost et al. researched effects of a variety of plant-based diets compared with an omnivore diet on distributing quantities of inflammatory biomarkers. Although no significant differences in inflammation were noted in the first six months of plant-based diets, after two years of a vegetarian diet there was an association with lower hs-CRP levels (Haghighatdoost et al., 2017). Sutliffe et al. likewise found correlation between low CRP levels and plant-based diets. The study involved monitoring of over 600 participants on a six-week vegan diet by measuring CRP levels. It was concluded that vegan diets significantly improved health risk factors and reduced systemic inflammation as measured by circulating CRP. Participants with higher initial levels of CRP exhibited the greatest decrease after diet modifications. Gender also played a significant role in inflammatory responses, as it was

exhibited that males in the study with higher initial CRP levels showed to have a greater reduction in CRP than the female participants studied (Sutliffe et al., 2015). Results reflected that, 76.5% of females and 77.4% of males had a greater than 0.5 mg/dL drop in CRP. High levels of fiber content from plants in a vegan diet is plausible for explanation of reduction in CRP levels (Sutliffe et al., 2015). Fiber intake for participants in this analysis was above 49 grams. CRP levels have been shown to be inversely associated with total dietary fiber intake (North et al., 2009). It has been found that individuals with fiber intake levels of 13 grams or greater had a lower risk of elevated CRP (King et al., 2003). Males likewise had more significant decreases in overall body mass index (BMI). Females with higher initial BMIs showed lower decreases in BMI than the males in the study. The relationship between CRP and BMI indicates that CRP alteration may be closely correlated to the amount of fat lost during the vegan diet intervention (Sutliffe et al., 2015). Visceral fat and the resident macrophages in fat may produce pro-inflammatory cytokines, such as TNF-alpha and IL-6 (Sutliffe et al., 2015). Reasoning for the gender differences in CRP alteration may relate to circulating estrogen. Research has shown that estrogen increased adipose tissues' contribution to circulating CRP (Cooke & Naaz, 2004). Further research is necessary to draw appropriate conclusions regarding potential associations between vegetarianism and CRP, particularly IL-6, levels. Research asserts that a plant-based diet might be a useful approach to manage long-term inflammation (Sutliffe et al., 2015; Haghighatdoost et al., 2017; Trapp et al., 2010).

Global Studies

Inflammation and heart disease are likewise not novel in Middle Eastern countries. Research indicates that CAD was later found in Egyptian rulers who were alive in 1500 BCE (Abdelfattah et al., 2013). Computed tomographic analysis done in 2009 on royal female

mummies showed atherosclerotic plaques in abdominal aortas, CAD, and evidence of myocardial infarctions (Abdelfattah et al., 2013). Traditional diets in these ancient rulers consist primarily of animal meats, milk, and carbohydrates such as beer (Abdelfattah et al., 2013). Royalty in ancient Egypt also included a sedentary lifestyle. Along with this evidence of CAD from over 3500 years ago, CAD remains prevalent and increasing in Egypt and other developed Middle Eastern countries today. In addition to genetic factors, it is also seen that lifestyles of Egyptians exhibiting CAD are more sedentary. Diets in this population are high in fat, calories, and low in fruits and vegetables (Abdelfattah et al., 2013). Environmental factors, such as diet, seem to be a reoccurring trend in CAD worldwide.

Huang et al. (2012) completed a meta-analysis of vegetarians and nonvegetarians throughout differing countries. Seven studies with a total of 124,706 members from the United States, Germany, United Kingdom, Japan, and the Netherlands examined cardiovascular mortality and cancer amounts participants. It was found that both causes of mortality were almost ten percent lower than nonvegetarians (Huang et al., 2012). This included a sixteen percent lower fatality rate from circulatory disease and twelve percent lower mortality from strokes (Huang et al., 2012). Vegetarians had an overall twenty-nine percent lower mortality rate from ischemic heart disease and eighteen percent lower rate of cancer overall than nonvegetarians (Huang et al., 2012). Results were attributed to lower serum cholesterol, less cases of diabetes, lower body mass, and lower blood pressure in vegetarians.

Reasoning of Underutilization of Plant-based Diets

A key argument of why plant-based diets are not more commonly prescribed to manage cardiac health is the assortment of cardiac medications readily available in the twenty-first

century (American Heart Association, 2015). Yet despite this capability, one in every four Americans dies of heart disease each year (CDC, 2017). It is projected that in the next fifteen years, one-half of the U.S. population will have cardiovascular disease (CDC, 2017). According to data for the *C*ongressional Budget Office (2019), global costs for medications are exceeding one-trillion dollars a year, and America is the number one consumer at over one-third the total global costs. It is estimated that seventy percent of Americans take at least one prescription drug per day, yet they are not living longer than other citizens of developed countries (CDC, 2017). In a recent study of life expectancy of people in free-market democracies, Americans rank number twenty-eight out of thirty-four (Murray, 2013). There is also an increase in years involving chronic disease during the American lifetime and dietary changes must also be included if we want to adequately treat and prevent cardiac disease (Murray, 2013).

Notwithstanding plant-based diets supporting to not only prevent and reverse CAD with findings being published in the most respected health journals world-wide, it still does not reflect into standard practice interventions (Tuso et al., 2015). Recent research has indicated that this may be due to financial ties of politicians and U.S. dietary committees (Campbell, 2014). Not long ago, it was discovered that members of the U.S Dietary Guidelines Advisory Committee had financial ties to food corporations such as McDonalds, Coca-Cola, and Duncan Hines (Herman, 2010). While policy makers financially benefit from products containing meat, dairy, excess sugars, and oils it is not a question why they would not translate plant-based diets as legitimate interventions for prevention of various diseases. A specific event that reflects this trend occurred in 1977 when the U.S. Senate Committee on Nutrition and Human needs attempted to release plant-based dietary goals in the United States (Herman, 2010). The meat and dairy industry fought back and under union pressure, the proposal of reduced meat consumption

was eliminated from the statement (Herman, 2010). The Senate nutrition committee was dispersed and multiple senators that endorsed the bill lost their election bids (Herman, 2010). Doctors were, and continue to be, the leading cause in prevention and cessation of smoking (Barnard, 2013). Barnard (2013) asserts that “Plant-based diets are the nutritional equivalent of quitting smoking” (p.369). It is the responsibility of health care workers, influencers, and policy makers to unbiasedly continue to study nutrition and its effect on the morbidity and mortality in America. Our patients deserve to be educated on the benefits eating plant-based has on cardiovascular health and provided with nutritional guidelines similar to smoking cessation resources.

DISCUSSION

Summary

Studies and current research support plant-based diets as a considerable method for prevention, improvement, and reversal in cardiac diseases (Tuso et al., 2015; Esselstyn, 1999; Ornish 1998; Campbell et al.,1998). By reducing inflammation and restoring arterial health, plants are shown to be a significant treatment for CAD (Barnard et al., 2019). Plant-based diets have been proven to improve lipid levels, thus reducing cardiac inflammation and CAD (Tuso et al., 2015; Barnard et al., 2019). Plant-based diets reflect anti-inflammatory responses due to decreases of C-reactive proteins (Sutliffe et al., 2015). This biochemical response can change blood flow and halt atherosclerotic processes by reduction of blood viscosity. This process enhances arterial flexibility and endothelial integrity while increasing vascular circulation and tissue oxygenation (Barnard et al., 2019). Plants are high in dietary fiber, which also enhances cholesterol and cardiovascular health by modifying cholesterol production (Smith & Tucker, 2011). While fully nutrient rich plant-based diets reflect the best results with cholesterol, blood pressure, and blocked artery reversal, a variation of plant-based diets can be advantageous to cardiac health. Modification is based on one's nutritional preferences and severity of cardiac disease (Hemler & Hu, 2019; Satija et al., 2017). For example, partial plant-based diet vegetarians were found to have a twenty-nine percent lower mortality rate from ischemic heart disease and eighteen percent lower rate of cancer overall than nonvegetarians (Huang et al., 2012). As asserted by Tuso et al. (2015), "Therefore, food may be medicine and the power of lifestyle management in disease prevention should not be ignored" (p.7).

Recommendations for Application

Although pharmacological treatments may be more widely used to treat cardiac disease, they do not treat the underlying cardiac conditions as well as lifestyle modifications (Kim et al., 2019). Lack of compliance with cardiac medication regimes are common and may be attributed to adverse side effects, cost of medications, and polypharmacy (Leslie et al., 2018). As cardiac disease continues to increase the loss of lives in over half a million Americans each year, health care and prescription cost continue to increase at hundreds of billions of dollars as well (CDC, 2017). Despite the evidence of plant-based diets providing a cost-effective solution to the heart disease crisis in the United States they are still not typically incorporated, or presented in treatment plans (Tuso et al., 2015). Underutilization of plant-based diets may be due to financial ties of politicians and U.S. dietary committees (Campbell, 2014). Others argue that patients may not adhere to the stringencies of a plant-based diet, but like smoking cessation our patients deserve to at least be educated on the proven benefits eating plant-based has on cardiovascular health and provided with nutritional resources. Medical providers can begin to incorporate the benefits of plant-based diets into preventative education. Informed conversations with patients pertaining to the research that supports a diet incorporating fruits, vegetables, minimally processed carbohydrates and less consumption of meats, dairy, and eggs should be had during primary care visits. There are also a variety of plant-based options including whole-foods plant-based, vegan, pescatarian, vegetarian, and even reduction of daily meat consumption. Although those with CAD would benefit most from whole plant foods because it considerably lowers inflammation associated with coronary heart disease, it is distinguished that the general populace may not need to entirely eliminate animal meat from their diet to improve their heart health (Hemler & Hu, 2019).

Research

Lack of finances has also been recognized as a robust barrier to plant food promotion by the plant food industry (Campbell, 2014). A solution may be a public health initiative supporting plant food advocates in food industry sectors to expand plant-based research and make it more readily available to the public in clinical settings. With access to resources from the multimillion-dollar government health budget, cardiac health could thus be drastically improved by producing and marketing plant-based diets more effectively.

Research in plant-based diet would continue to benefit from studies on diverse populations as well as the selection of plant-based options. Although whole-foods plant-based diets have continued to show reversal of cardiac disease, the restrictions of this diet can deter many people from even attempting it. Studies of less strict plant-based diets, such as vegetarianism, should be continued on larger samples of the population without cardiac disease to help promote it as a method of prevention of CAD (Kim et al., 2019; Tuso et al., 2015). In public health initiatives, prevention can be an effective intervention to promote cardiac health and save hundreds of thousands of lives each year (Barnard, 2013).

LIMITATIONS

It should be noted that the original strict plant-based diet studies were conducted on patients with CAD who were still experiencing disease progression before the diet alteration. Also, the more flexible plant-based diet studies are usually conducted on the general population. Many scholarly articles identified in the literature were published prior to 2005, the majority of these studies were excluded from this literary review. Numerous studies measure different inflammatory markers pertaining to cardiac disease, consequently proving difficult to compare results. Sufficient research is still lacking on specific inflammatory responses and how they are impacted by plant-based diets. Current research would benefit from studies examining the potential association by quantifying markers of oxidative stress levels, such as plasma malondialdehyde and hydroperoxides, in participants consuming various plant-based diets. Researchers do not always identify specifics of other modifiable factors tried on participants such as exercise and smoking cessation. Additionally, the margin of studies was conducted on middle-aged to senior population. It would be beneficial to have further research be conducted on younger populations, perhaps evaluating life-long plant-based diets begun at birth.

NURSING IMPLICATIONS

Clinical Application and Public Health Initiatives

Although plant-based diets are not yet incorporated into cardiac treatment plans by providers in America, advocation for the evidence-based advantages will help initiative move in the right direction. Heart disease is exceptionally high in underserved populations, due to lack of finances for resources such as primary care visits and cardiac health screenings. This would be a population that would particularly benefit from plant-based diets as interventions for CAD because they are especially cost-effective (Tuso et al., 2015). Further public health initiatives pertaining to numerous disease processes could utilize plant-based diets since they show possibility to be beneficial to multiple body systems (Hemler & Hu, 2019; Satija et al., 2017; Barnard et al., 2019; Esselstyn, 1999; Ornish 1998).

Along with lack of significant funding for research, availability of easy and practical applications of the variety of plant-based diets are not widely available. Some physicians are implemented plant-based diets to improve quality of life, including cardiac health, and are creating their own handouts to provide to patients. If plant-based diets could be supported by larger industries in the medical field, then patient education could be perfected and made more readily available. Supporting plant-based food sectors could influence government policy makers to consider endorsing the guidelines to incorporate evidence-based finding into cardiac treatment plans (Campbell, 2014).

Education

Nurses and providers play a crucial role in educating patients. Evidence shows that plant-based diets are effective as primary, secondary, and tertiary levels of intervention with cardiac

disease and healthcare professionals should be aware of this. Education on nutrition, especially plant-based diet benefits, should be better incorporated in continuing education as well as initial college education. Nursing and doctoral programs may benefit from incorporating education on complementary and integrative medicine into the curriculum as well. This would increase the variety of treatments plans depending on the varying needs of patients. Nurses and physicians would also be better prepared to educate patients and their families on the effectiveness of plant-based diets and provide them with additional resources. Nurses can provide information resources such as: meal planner websites, registered dietitians, health coaches, cookbooks recommendations, podcasts, and information on other lifestyle modifications. These resources and organizations can provide educational assets such as community groups, books, documentaries, research, and products to healthcare professionals, patients, and their families. Primary care, public health, and cardiac nurses especially should also familiarize themselves with information about plant-based diets and their healing attributes with cardiac disease to better answer questions and concerns that patients may have. Cardiac disease has already taken the lives of so many loved ones, and we owe it to our patients to provides them with all the evidence-based research and resources that we can.

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