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THERAPEUTIC APPROACH IN THE MANAGEMENT OF PERITONEAL DIALYSIS; PLANT-BASED DIET AND ASSOCIATED PARAMETERS, A COMPREHENSIVE REVIEW

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Abstract

Peritoneal dialysis (PD) has remained a cornerstone in renal replacement therapy since 1794, leveraging the peritoneal membrane to effectively filter toxins and excess fluid. Offering patients flexibility and autonomy, PD allows for treatment at home or amidst daily routines. However, persistent challenges such as PD-related infections and catheter insertion obstacles necessitate ongoing strategies like biocompatible solutions and improved catheter designs to mitigate risks. Concurrently, patient education and telemedicine play pivotal roles in enhancing PD management.

In recent years, the surge in veganism, a lifestyle advocating for the elimination of animal exploitation, has been notable. Vegan diets, characterized by plant-based foods and the exclusion of animal products, hold promise for various health benefits, particularly in chronic kidney disease (CKD) management. While studies suggest potential advantages such as delaying the need for dialysis and improving cardiovascular health in CKD patients, the impact of vegan diets on end-stage kidney disease (ESKD) patients undergoing PD remains uncertain.

PD patients encounter diverse challenges, including volume overload and constipation, which can be addressed through dietary modifications such as sodium restriction and increased fiber intake. Vegan diets, typically low in sodium and rich in fiber, may offer advantages in managing these complications. Additionally, they have been associated with benefits like weight loss, improved gut health, and reduced inflammation, which could potentially benefit PD patients.

However, concerns regarding nutrient deficiencies, particularly in vitamin D and vitamin B12, highlight the need for careful monitoring and supplementation in vegan diets. Further investigation is warranted to assess the suitability of vegan diets for PD patients comprehensively. Nutrition education and counseling are crucial for optimizing dietary choices and enhancing outcomes in PD patients. Understanding the intricate relationship between vegan diets and PD outcomes is imperative for delivering holistic care to this patient population.

Keywords: Chronic Kidney Disease (CKD), Diet and Dialysis, Kidney Disease, Metabolic Parameters, Plant-Based Diet, Renal Nutrition, Therapeutic Approach

Introduction

With a legacy dating back to 1794, peritoneal dialysis has been a trusted and enduring treatment option for over a century, offering a proven approach to patient care (Misra & Phadke, 2019). Peritoneal dialysis (PD) is a treatment for end-stage kidney failure that utilizes the peritoneal membrane, a thin layer of tissue lining the abdomen, as a filter to remove excess fluid and toxic waste from the blood, replacing the function of kidneys (ASKARI *et al*., 1959)(Chaudhary, 2011). This process involves infusing the dialysis solution into the peritoneal cavity through a catheter, allowing solutes to diffuse and excess fluid to be removed from the blood (ASKARI *et al*., 1959).

PD provides several advantages over other forms of renal replacement therapy, primarily due to its flexibility and independence (Navaratnarajah *et al*., 2021). It can be performed in the comfort of a patient's home, at work, or while traveling, making it a convenient choice for many individuals (Mehrotra & Piraino, 2020). Moreover, the therapy can be carried out continuously uninterrupted (CAPD) or overnight using a cycler machine (CCPD) (Kathuria & Twardowski, 2023). This flexibility allows patients to adapt their dialysis schedules to their daily lives.

In 2018, the United States had around 58,500 individuals on peritoneal dialysis (PD), accounting for 10.6% of the dialysis population. PD patients experience elevated death rates and a considerable burden of concurrent diseases, particularly heart disease (CVD), which accounts for 41% of deaths. In view of the widespread occurrence of risk factors such as high blood pressure and diabetes in PD patients, dietary intervention with a whole food plant-based diet (WFPBD) may help reduce mortality and improve outcomes.

One of the key benefits of PD is that it allows for more frequent and gradual dialysis, which can lead to better blood pressure control, fewer dietary restrictions, and improved preservation of residual renal function (C. H. Chen *et al*., 2020). Also, since PD does not need needles, patients often find the process less invasive and more manageable, with the ability to perform treatments independently (Oza-Gajera *et al*., 2022).

Despite these benefits, PD has its distinct challenges. One of the most major risks is PD-related infections, such as peritonitis (J. H. C. Chen *et al*., 2018), which can arise due to the presence of the catheter and the exchange process (Regunath *et al*., 2023). Peritonitis can lead to technique failure and potentially need a transfer to hemodialysis. Furthermore, the procedure requires the insertion of a catheter into the peritoneal cavity, which can be a barrier for some patients (Zeiler & Granata, 2021). PD can also change the peritoneal membrane over time, causing changes in therapy to keep efficacy (Morelle *et al*., 2021).

To address these challenges, various strategies have been proposed (Kendrick & Teitelbaum, 2010), including the use of more biocompatible solutions that are gentler on the peritoneal membrane, as well as improvements in catheter design to reduce the risk of infection (Cullis *et al*., 2021). Enhanced patient education and support are also crucial for ensuring that individuals on PD can manage their therapy effectively (Brown *et al*., 2020). The use of telemedicine and remote patient monitoring has appeared as a significant innovation in PD management, allowing healthcare providers to offer real-time support and oversight (Pungchompoo & Udomkhwamsuk, 2021).

Veganism is a lifestyle and philosophy that seeks to eliminate animal abuse and brutality for diet, fashion, or any other purposes (Mota-Roja *et al*., 2023). In 1944, Donald Watson and his wife

Dorothy Morgan coined the term “vegan”, marking the beginning of animal rights and environmental sustainability, to describe non-dairy vegetarians and led to the formation of the Vegan Society (Wrenn, 2022). A 100% plant-based diet is a vegan diet that eliminates all animal-derived foods (H.-J. Hsu *et al*., 2021; Rosenfeld, 2018). The society's definition highlights the ethical and environmental considerations of veganism, stressing the promotion of cruelty-free and sustainable options that benefit humans, animals, and planet.

Those who follow a vegan lifestyle avoid using animal products or by-products in various aspects of life, including food, clothing, and personal care products. A vegan diet excludes all animal products, including meat, dairy, honey, and other by-products of animal husbandry (Kalantar-Zadeh *et al*., 2020).This philosophy is founded on the principal that animals have inherent values and should be treated with respect and dignity, rather than being abused for human gains. The rise in veganism can be attributed to growing awareness of animal welfare, environmental sustainability, and health benefits (Silva Souza *et al*., 2020).

Vegan diets frequently contain high amounts of dietary fiber, magnesium, folic acid, vitamin C, and iron, while having a reduced amount of saturated fat, cholesterol, and omega-3 fatty acids (Butola *et al.*, 2021). However, poorly planned vegan diets may lead to nutrient deficiencies, especially in vitamin B12, which can be managed with supplements or fortified foods (Gibbs & Cappuccio, 2024).

What is a vegan diet?

Veganism is a thought that looks to exclude all forms of cruelty to animals for food, clothing, or any other purpose. The term "vegan" was coined by Donald Watson in 1944 to describe a non-dairy vegetarian, and it was later refined by Leslie Cross in 1951 to mean living without exploiting animals. The Vegan Society defined veganism in 1979 as a philosophy and way of living that promotes animal-free alternatives for the benefit of humans, animals, and the environment (Dutkiewicz & Dickstein, 2021).

Veganism extends beyond diet to all areas of life, such as clothing, entertainment, and personal care products. Vegans avoid exploiting animals for any purpose, often driven by compassion. A vegan diet is diverse, including fruits, vegetables, nuts, grains, seeds, beans, and pulses, (Koeder & Perez-Cueto, 2024) and can provide health benefits like lowering heart disease risk, preventing type 2 diabetes, and decreasing certain cancers (Wang *et al.*, 2024).

While there is debate about the nutritional health of a vegan diet, proponents argue that nutrients found in animal products can be replaced by those in plant-based foods and supplements (Klapp *et al*., 2022). A balanced and nutritious diet is essential, particularly for protein, vitamins, minerals, and the management of conditions such as vitamin D deficiency (Awuchi *et al.*, 2020).

Common misconceptions about vegan diet

Despite growing popularity, misconceptions about veganism persist, such as the idea that vegans lack sufficient protein (Evans *et al*., 2022). However, a well-planned vegan diet can provide all necessary nutrients through plant-based sources like beans, nuts, seeds, and tofu (Alcorta *et al*., 2021). Study showed that CKD3-4 patients who adhered to carefully planned vegan diet rich in legumes and whole grains for 13 months maintained optimal nutritional status with no nutrient deficiency (Cases *et al.*, 2019).

Another misconception is that veganism is expensive and restrictive. Many affordable and tasty plant-based ingredients, such as fruits, vegetables, grains, and legumes, are available, and more restaurants are offering vegan options (Koeder & Perez-Cueto, 2024).

Veganism is sometimes seen as being for animal lovers or elite groups, but it is a social justice movement that aims to end speciesism and human supremacy, with growing global influence (Roeder, 2021). Vegan substitutes for animal products can be expensive, but there are many naturally vegan foods that are more affordable than animal products (Alcorta *et al*., 2021).

What are the rationales for considering vegan diet for peritoneal dialysis?

The rationale for recommending a vegan diet to individuals undergoing peritoneal dialysis (PD) arises from the potential therapeutic advantages that plant-based diets can propose in managing chronic health conditions, here in context with CKD and end-stage kidney disease (ESKD) (Carrero *et al*., 2020). Several studies showed positive results of vegan diet with CKD (Kim *et al*., 2019; Świątek *et al*., 2023; Wu *et al*., 2023b; Yin *et al*., 2023). Higher proportion of plant based protein intake is linked to reduced CKD related mortality (Cases *et al*., 2019). A study of middle aged adults found that a healthy plant based diet reduced the risk of CKD (Kim *et al*., 2019). Plant based diet have gained significant attention recently due to their potential to promote overall health and wellbeing. Emerging studies showed their beneficial effecting reversing and stopping CKD progression as secondary prevention (Zarantonello & Brunori, 2023).

Whole food plant-based diets are gaining interest as preventive and therapeutic opportunities for various chronic health issues, and their application to individuals on PD is under investigation (Freeman & Turner, 2024).

One important aspect of plant-based diets is their potential to improve mortality rates and address usual challenges faced by PD patients, like constipation, fluid retention, sodium retention, hypertension, and metabolic acidosis (Carrero *et al*., 2020). Plant-based diets have shown a correlation with improved survival rates and may provide targeted solutions to issues prevalent in the PD population (Dupuis *et al*., 2021).

Moreover, plant-based diets can offer nutritional benefits for PD patients, such as preventing protein overconsumption typical in Western diets and providing sufficient protein intake without compromising health (Alcorta *et al*., 2021). Research shows that those undergoing dialysis, including PD patients, can keep adequate protein levels with plant-based diets, which can aid in regulating protein homeostasis and compensating for peritoneal protein loss (Liebman & Joshi, 2022).

In addition, plant-based diets have been associated with a reduction in the production of uremic toxins, due to their higher fiber content and lower protein content, helping individuals with kidney disease, including those on PD. These diets may also help prevent risks linked to hyperfiltration from excess protein intake, a concern for individuals with kidney disease.

What is the scientific research and clinical experience with vegan diet for peritoneal dialysis?

Adopting a plant-based diet (vegan) has been shown to have a beneficial effect on peritoneal dialysis outcomes (National Kidney Foundation, 2013). Vegan diets are becoming more popular as a preventative and therapeutic approach for various chronic health issues, including CKD (Carrero *et al*., 2020). A vegan diet is a great option for patients with advanced CKD, characterized by an estimated glomerular filtration rate eGFR of less than 60mL/min, as it is a low protein plant-based diet (Zarantonello & Brunori, 2023). A study showed that vegans had a lower risk of developing CKD suggesting protective effects against kidney health problems (Liu *et al*., 2019).

However, the suitability and safety of vegan diets for patients with end-stage kidney disease (ESKD) undergoing peritoneal dialysis (PD) remain uncertain. PD patients face high mortality rates and many comorbidities, particularly cardiovascular disease (Davies, 2013). A study of older patients (>70 years) with end-stage CKD, found that a vegan diet delayed the need for dialysis by almost a year, without increasing mortality risk and reduced hospitalization rates. Suggesting that vegan diet may be a useful strategy for patients awaiting transplantation or dialysis access maturation (Brunori *et al*., 2007).

Volume overload is common in peritoneal dialysis (PD) patients and significantly affects survival. Bioimpedance spectroscopy studies show that volume overload persists even after years of PD treatment. Patients with prominent levels of volume overload at one month have a 59% increased risk of mortality (Van Biesen *et al*., 2019). Sodium restriction is key to managing volume overload, and plant-based diets, which are typically lower in sodium, can help control it. Vegans consume less than half the sodium compared to omnivores (Kristensen *et al*., 2015). A vegan diet also proves more helpful in lowering blood pressure than other vegetarian diets (K. W. Lee *et al*., 2020). However,

careful planning is needed to avoid excessive sodium from processed foods and to keep adequate protein and energy intake. Plant foods also have more water, needing reduced fluid intake to support proper volume (Liebman & Joshi, 2022).

In 1918, Dr. Franz Volhard discovered patients having plant-based diets with low protein intake experienced significant body urea nitrogen level reduction (Volhard, 2019). A study in Taiwan studying patients with high uric acid levels found that those who followed vegan diet had 31% lower risk of developing CKD compared to non-vegans (Wu *et al*., 2023a). Moreover, lowered levels of SNA, as well as CUTC-serum phosphate and serum sodium, were noticed in opposition to higher levels of urea NCC in patients who took meat protein in comparison with those who took in soy protein in the process of examination of diabetic nephropathy (Azadbakht & Esmaillzadeh, 2009). A recent controlled trial randomly assigned 45 individuals to either a vegan or meat-rich diet for three weeks. The results showed that the vegan group had a significantly lower potential renal acid load and an indirect index of diabetic acid load (DAL), compared to the meat-rich group. Suggesting vegan diet as an effective way to reduce the risk of DAL and related metabolic acidosis (Müller *et al*., 2021). For another study, the impact of soy on factors of phosphorus and other markers in PD patients was examined. As a result, a reduction in plasma coagulation factor IX activity (a risk factor for thrombosis) was observed (Imani *et al*., 2009). Eating a plant-based diet and avoiding processed foods with added phosphates can help reduce the amount of phosphate absorbed by the body. This is because a plant-based diet provides phosphate in a less easily absorbed form, and processed foods with added phosphates are a common source of excessive phosphate intake (McCarty & DiNicolantonio, 2014). The researcher examined the effect of walnuts on phosphorus and other specific renal markers. Other specific cardiovascular risk factors were also included. Daily walnut intake, functioning within the framework of the corresponding diet, did not alter phosphorus, potassium, parathyroid hormone, or fibroblast growth factor 23 concentrations and reduced markers of cardiovascular risks (Sanchis *et al.*, 2019).

Constipation is a common issue for peritoneal dialysis (PD) patients and can lead to serious complications such as reduced dialysate flow and a higher risk of peritonitis (A. Lee, 2011). The average fiber intake for PD patients is low, around 8-9 grams per day (Xu *et al*., 2019), compared to the recommended 25-38 grams (Kendrick & Teitelbaum, 2010). Increasing dietary fiber intake, either through supplements or plant-based diets, has been endorsed as first-line treatment for constipation in PD patients (Ramos *et al*., 2022). Vegan diets, which are naturally high in fiber (Allès *et al*., 2017), can improve constipation and may also help reduce inflammatory markers (Marrone *et al*., 2021).

Maintaining weight is also a challenge in PD patients. In a retrospective study, peritoneal dialysis patients gained 10kg over 2 years, due to increased calorie intake along with dialysate glucose absorption (Jolly *et al*., 2001). Plant-based diets tend to lead to a healthier weight. Research shows that people who eat mostly plants tend to weigh less than those who eat a lot of meat. The more plant-based your diet is the lower your body mass index is likely to be, with vegans typically having the lowest BMI (Fraser, 2009; Najjar & Feresin, 2019). Vegan diets have been shown to be effective for weight loss (Selinger *et al*., 2023). Additionally, plant-based diets improve the health of gut bacteria and enhance sensitivity to insulin (Najjar & Feresin, 2019).

Dysbiosis, or an imbalance in the microbiome, can lead to negative health outcomes such as increased levels of endotoxins and uremic toxins (Rysz *et al*., 2021), which may contribute to inflammation and cardiovascular disease, especially in individuals on peritoneal dialysis (PD) (Lambie *et al*., 2021). A vegan diet may positively affect the microbiome, offering benefits such as decreased production of harmful substances like trimethylamine-N-oxide (TMAO) and increased production of beneficial short-chain fatty acids (Lombardo *et al*., 2022).

Research shows that vegan diets may help CKD prevention and management. Yet, the impact of vegan diets on ESKD patients on PD is less understood. People with advanced CKD are vulnerable to a range of nutritional problems like malnutrition, PEW, and imbalances in essential electrolytes (Zarantonello & Brunori, 2023). Protein-energy wasting (PEW) in continuous ambulatory peritoneal

dialysis (CAPD) patients is significantly associated with poor health-related quality of life (HRQoL), predominantly when PEW is severe (Orozco-González *et al*., 2022). In a study, only 34% of CKD patients with stages 3-5 achieved their low protein diet (LPD) goals. Additionally, most of these patients (about 85%) had inadequate daily calorie intake despite routine dietary counseling, leading to muscle wasting and malnutrition in these patients (H. J. Hsu *et al*., 2021).

Protein homeostasis is crucial in PD, where peritoneal protein loss is a significant concern. Some studies report low levels of albumin in dialysis patients who were having vegetarian diet versus those were on non-vegetarian diet (Ou *et al*., 2016; Viswanathan *et al*., 2002). A plant-based diet with very low urea and nitrogen content resulted in reduced albumin and urea extraction (Di Iorio *et al*., 2013). In PD, daily albumin loss ranges from 5-8 g, usually compensated by improved liver albumin synthesis—a process hindered via inflammation and chronic acidosis (Rippe & Öberg, 2016). Reduced inflammation and improved acidosis from plant-based diets may offset potential declines in total protein intake (Cases *et al*., 2019).

Vitamin D deficiency is common among PD patients (Shah *et al*., 2005), which can be a concern for strict vegans. Since vegan diets lack vitamin B-12, supplementation is necessary (Crowe *et al*., 2011). A vegan diet promotes vascular and bone health. Being rich in fiber and vitamin K1, a vegan diet also tends to have lower phosphorous levels and a reduced risk of metabolic acidosis, which may help prevent vascular calcifications and support strong bones (Di Micco *et al*., 2019). Results from the case study showed that vegetarian diets may influence nutritional status and cardiovascular parameters among CKD patients on dialysis. Vegetarians in comparison with omnivores have light bodies with a lower body mass index, serum phosphate, urea, creatinine, vitamin D, uric acid, and stabilized protein catabolic rates (Ou *et al*., 2016).

The object of the study was to evaluate the nutritional status of vegetarians on dialysis versus non-vegetarians. Vegetarians have normalized protein catabolic rates, BMI, and mid-arm circumference. They needed more erythropoietin agents to keep similar hematocrit concentrations, serum albumin and pre-albumen concentrations, and muscle strength. Subjective global assessment scores and activities of daily living showed no difference (WU *et al*., 2011).

Comparing standard low-protein diets and vegan diets, both have equal urine urea excretions in patients with mildly reduced renal functions. Special vegan diets had lower urine hydrogen excretion and serum bicarbonate concentrations when compared with usual protein diets. Those who were consuming a vegan diet observed their serum phosphorus and potassium were within tolerable limits and there was no evidence of malnutrition (Barsotti *et al*., 1996).

Despite these efforts, counseling and public awareness are important. To understand the impact of nutrition education, a study was conducted in peritoneal patients to improve their nutrition status biomarkers, the study included three study groups: nutrition education only, milk-based supplements, and education with soy-based supplements. Revealed nutrition education either combined or not combined with protein supplements was associated with increased protein intake and nutritional status (Duong *et al*., 2019).

Are there risks and safety concerns with a vegan diet for peritoneal dialysis?

Vegan diets have seen gaining interest as a preventive and therapeutic approach for various chronic health conditions like CKD (Rhee *et al*., 2023). Vegan diets are safe and enable greater protein reduction in CKD patients (Torreggiani *et al*., 2023). A significant distress with recommending plant-based diets to PD patients is the risk of hyperkalemia (St-Jules & Fouque, 2024), a common issue due to reduced kidney function and potassium-based dialysate solutions (Lindner *et al*., 2020). The bioavailability of potassium depends on its form in the diet, and plant-based diets can lead to more effective potassium management through cellular uptake and excretion henceforth fear of hyperkalemia often leads to dietary restrictions, including avoidance of plant-based foods, which are naturally high in potassium. With careful monitoring and management of potassium intake, however, plant-based foods can be safely included in the diet of PD patients(Barsotti *et al*. , 1996).

Hyperphosphatemia is a concern for peritoneal dialysis (PD) patients, although limited data exists on the relationship between phosphorus levels and outcomes. High phosphorus levels have been linked to increased all-cause mortality, and while intervention many PD patients use phosphorus binders, which can cause adverse events and add to the pill burden (Wheeler & Winkelmayer, 2017). Dietary phosphorus sources have received attention. For a given dietary phosphorus load, a plant-based diet provides lower levels of phosphorus, but due to processing and treatment phosphorous levels increase (Calvo & Uribarri, 2013). A study investigated diet with 70% plants and 30% plants. Diets holding 70% plant protein were safe, well tolerated, and lower urine phosphorus excretion and were an alternative to phosphate binders (Moorthi *et al*., 2015), but more studies on PD patients are needed.

Protein malnutrition is another concern, as plant-based diets can be lower in protein than animal-based diets (Misconceptions & Dietary, 2022). PD patients also face peritoneal protein loss (5–8 g/day), typically compensated for by liver synthesis (Blumenkrantz *et al.*, 1981). PD patients face elevated risk for PEW and undernutrition, with a median prevalence of 36% (Carrero *et al*., 2018). Concerns exist that plant-based diets may not provide sufficient protein or energy, especially for strict vegans. Nonetheless, research suggests vegetarian diets are workable for those on dialysis, with patients able to achieve adequate protein intake without deficiency (Verzola *et al*., 2020). However, vegans in the general population usually meet the recommended daily intake of protein (Mariotti & Gardner, 2019). Data on protein intake and albumin levels in those who eat plant-based diets and are on dialysis are limited and mixed. Some studies found lower albumin levels in vegetarians, while others found no relationship. One study showed higher albumin levels in PD patients with higher plant protein intake (Liebman & Joshi, 2022).

Adult vegetarians typically receive sufficient protein and amino acids from their diets. There may be a small risk of insufficient protein intake for some vegans, especially without protein-rich foods like legumes, nuts, seeds, or protein analogs of animal foods. In developed countries, vegetarians can keep adequate amino acid intake with a varied diet. Future research should focus on comparing the overall nutrition quality and long-term health effects of plant-based versus animal-based protein-rich foods (Mariotti & Gardner, 2019).

Nutritional adequacy has been seen in plant-based diets for PD patients who ensure the intake of all essential amino acids, such as through a mix of cereals and legumes (Awuchi *et al*., 2020). Nevertheless, close monitoring and intervention are crucial for all PD patients, regardless of dietary patterns, to address potential issues such as vitamin D deficiency and protein homeostasis (Joshi *et al*., 2021).

Conclusion

In conclusion, a vegan diet can offer significant benefits for individuals undergoing peritoneal dialysis, including lower risk of cardiovascular disease, improved blood pressure control, and a diverse intake of vitamins and minerals. A well-planned vegan diet can provide essential nutrients while also promoting a lower intake of saturated fats and cholesterol, potentially improving patient outcomes.

However, careful consideration must be given to the specific dietary needs of PD patients, particularly in managing protein, potassium, and vitamin D levels. Vegans with PD may require added supplementation for nutrients such as vitamin B12 and iron. Close monitoring by healthcare professionals, including nephrologists and dietitians, is essential to ensure patients support best nutritional status and avoid complications such as hyperkalemia or protein malnutrition.

Overall, a balanced and carefully structured vegan diet, guided by experienced healthcare providers, can be a workable and beneficial choice for patients on peritoneal dialysis. It has the potential to enhance patient well-being and quality of life, provided that individual dietary needs and medical conditions are appropriately managed.

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