Nutritional Strategies for Managing Chronic Kidney Disease during Dialysis Treatment

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Abstract

The urinary system is made up of the kidneys, ureters, urinary bladder, and urethra, which perform the functions of filtration, production, and excretion of urine; remove waste and regulate the volume and composition of the blood; help maintain the acid-base balance of body fluids, supports the body's mineral balance, and helps regulate red blood cell production. Diet and physical exercise influence people's quality of life. Kidney disease (CKD) is characterised by decreased function of the nephron. It comprises two phases: the acute phase, in which the nephron still fulfils its position and is reversible, and the chronic phase, in which the nephron's ability to filter blood is diminished or null and irreversible.

Dialysis treatment is necessary in the chronic phase when the glomerular filtration rate (GFR) is < 15 ml/dL. In the present work, a bibliographic search has been carried out to find evidence of the influence of diet on kidney disease and propose a nutritional assessment protocol. Scientific evidence shows that a nutritionist's well-designed and personalised eating plan before a nutritional assessment improves biochemical parameters, slowing the disease's progression and restoring renal patients' quality of life. The main elements that increase in the blood and poison the body are sodium, potassium, and phosphate. They are cleared through dialysis and are kept in balance with

the diet. The restrictive diets in toxic elements for the kidney, the DASH diet (Dietary Approaches to Stop Hypertension), or culinary techniques to reduce antinutrients are some tools to achieve a phytotherapeutic treatment for CKD.

Keywords: chronic renal failure, renal pathophysiology, hemodialysis, nutritional assessment

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Introduction

The kidney is a paired organ (the left one higher than the right), bean-shaped, with a length of 12 cm, breadth of 6 cm, and thickness of 3 cm, approximately, and weighing 150-170 g in an adult. It is located in the retroperitoneal region at the level of the T12-L3 vertebrae (Biruete et al., 2023).

Three layers of tissue surround each kidney: the capsule renal, fatty, and renal or perirenal fascia.

- The renal capsule is the innermost and consists of a
- Transparent fibrous membrane that protects the kidney from infection.
- The adipose capsule, or perirenal fat, is a layer of fat that protects the kidney from blows and keeps it firm in the abdominal cavity.
- The renal fascia is the most superficial layer, formed by dense connective tissue, which separates the perirenal fat from the pararenal fat.

Figure 1 shows the location of the kidneys within the abdominal cavity, and in its upper part, the adrenal glands can be seen. The renal artery and vein supply them. The bladder, ureters, and urethra are also part of the urinary tract (Castle et al., 2023).

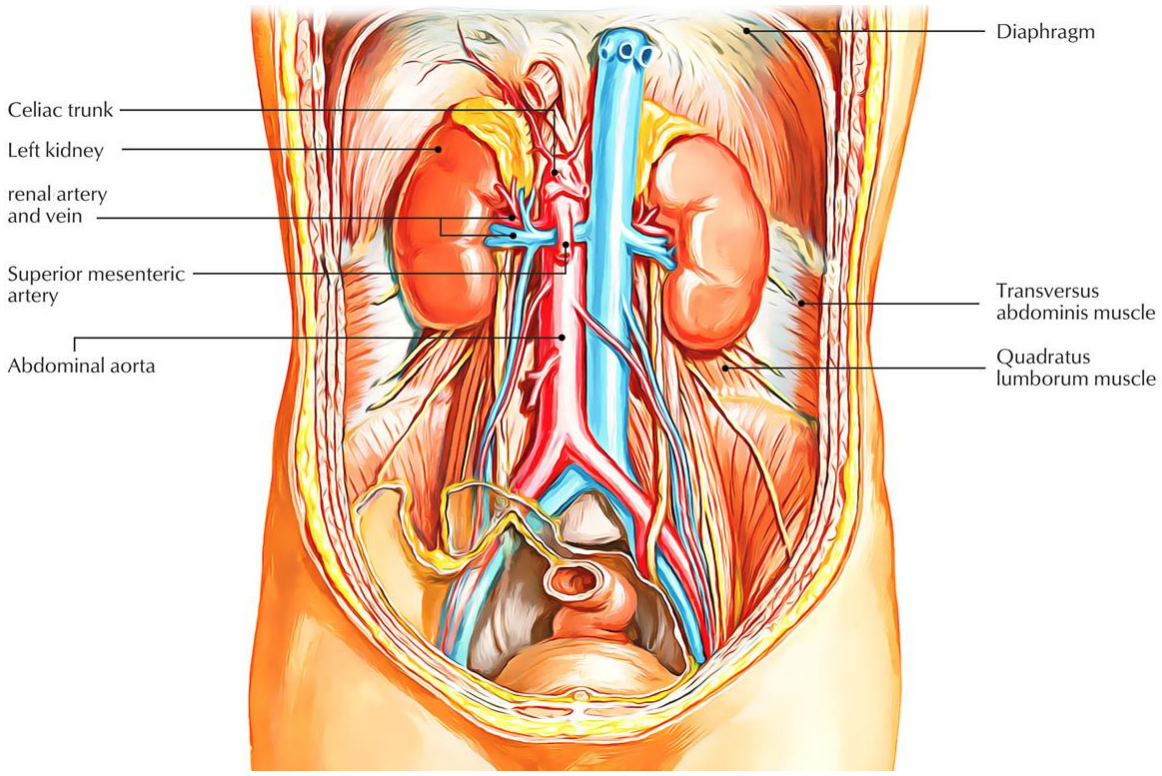

Figure 1. Location of the kidneys in the trunk, in the posterior part of the abdomen, at the level of the T12-L3 vertebrae. Image obtained from www.dolopedia.com

In a frontal section of the kidney, we can see several internal structures (Figure 2): the renal cortex and the renal medulla, which contains the renal or Malpighian pyramids, whose base is directed towards the cortex and its apex, called the renal papilla, is directed towards the hilum. The space between the pyramids is called the renal or Bertin column. The cortex and the renal pyramids form the parenchyma or functional portion of the kidney, within which the functional units, called nephrons, are located. There are approximately one million nephrons, and their number is determined in the fetal stage, no more being generated after birth (Faerber et al., 2023).

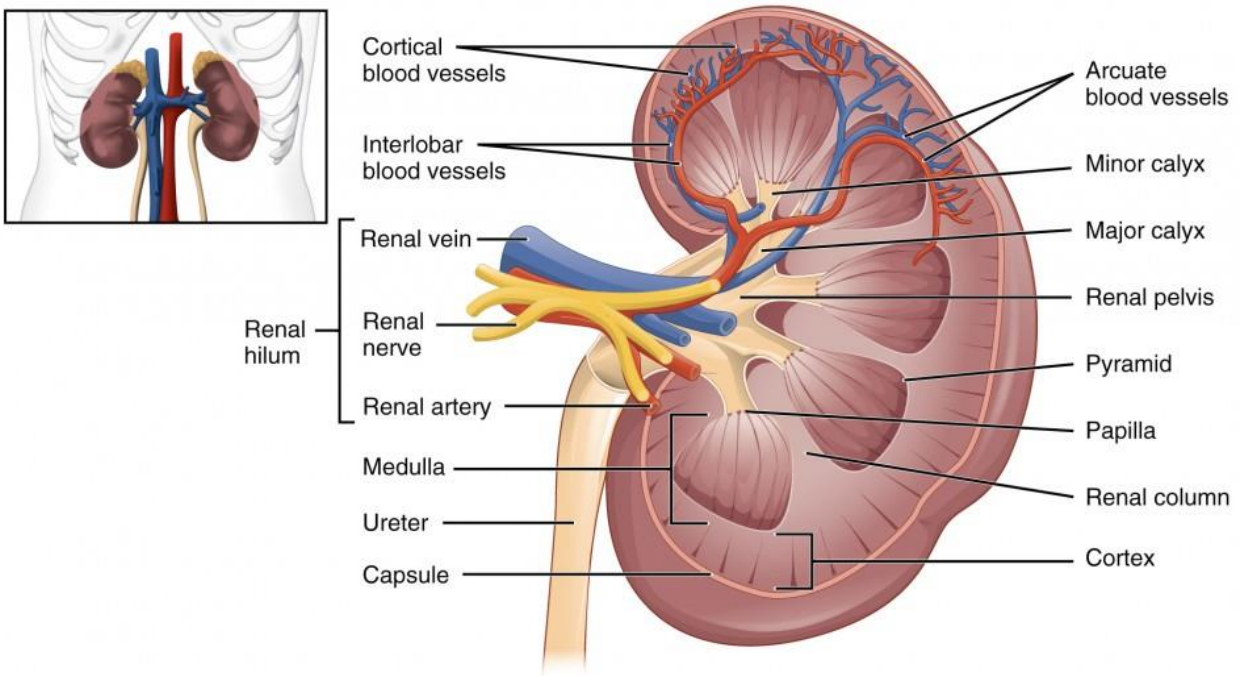

Figure 2. The frontal section of the right kidney shows its main internal anatomical structures. Image obtained from https://courses.lumenlearning.com/suny-ap2/chapter/gross-anatomy-of-the-kidney/

Kidney functions

The kidney functions are various, including excretory, endocrine, metabolic, and homeostatic: they regulate the composition of the extracellular fluid through urine formation, carrying out gluconeogenesis. They are responsible for filtering the blood thanks to the nephrons, which comprise the glomerulus, where filtration occurs, and the tubule system, which returns the necessary substances to the blood and retains waste and excess water, forming urine. ; they eliminate the acid produced by the cells and are responsible for maintaining homeostasis (water balance, salts and minerals such as sodium, calcium, Phosphorus and potassium); regulate the pH of the blood; play a hormonal role in controlling blood pressure, producing red blood cells through the erythropoiesis and maintaining strong and healthy bones through synthesising vitamin D. In case of hypotension and low blood volume, renin is produced (Faerber et al., 2023)

Definition of kidney disease

Chronic kidney disease (CKD) is a clinical syndrome secondary to a definitive kidney function and structure change. It is a failure in the anatomical part of the kidney, the glomerulus, where a decrease or cessation of blood filtering is observed. It is irreversible, evolves slowly, and comprises five stages depending on the glomerular filtration rate (GFR) (Hamidianshirazi et al., 2023):

1. Kidney damage with normal or elevated eGFR: >90mL/min
2. Kidney damage with a slight decrease in eGFR: 60-89mL/min
3. Moderate decrease in eGFR: 30-59 mL/min
4. Severely decreased: 15-29mL/min
5. Kidney failure or dialysis: GFR <15mL/min

Two forms of the syndrome are distinguished: acute renal failure (ARF), which is a homeostatic imbalance, and chronic renal failure (CRF), which is the sustained, progressive and irreversible failure of renal functions (Ammirati & Ammirati, 2020). As a future dietitian nutritionist, in this paper, I will focus on CKD, explaining in detail its nutritional approach in the hemodialysis phase (Kalantar-Zadeh et al., 2023).

The pharmacological treatment of hemodialysis consists of purifying the metabolic waste produced in the digestion of food. The increase in some nutrients, such as sodium, potassium or phosphate, harms the body. The dietitian nutritionist must prescribe dietary restrictions to maintain optimal levels of these elements. Both excess and deficit of hemodialysis, uremic syndrome and comorbidities are contributing factors to malnutrition (Mohamed Hussin & Syed Jamaludin, 2023)

CKD prevalence and epidemiology

The criteria to suspect that there is kidney disease are the presence for at least 3 months of a decrease in GFR (<60ml/min) and kidney damage. Due to its high prevalence, CKD is a public health problem in Spain since it affects 1 in 7 adults. It is more present among men (23%) than in women (7%), and the percentage doubles in those over 65 years of age (37%). Likewise, the risk of suffering from some renal pathology is associated with the presence of other pathologies, such as cardiovascular, malnutrition, hyperlipidemia, triglyceridemia, obesity or diabetes mellitus (DM). Patients needing dialysis as treatment represent 1% but 5% of the health budget. During the

progression of CKD, the number of nephrons decreases, and those that remain experience functional overload to increase glomerular filtration (Moroșan et al., 2023).

CRI Clinic

Knowing the factors that predispose to the disease helps establish prevention and management strategies, both pharmacological and dietary. The Spanish Society of Family and Community Medicine (Inww.semfyc.es) reached a consensus in 2007, signed among 10 societies, after reviewing the literature on the management of CKD (Parker et al., 2023).

The characteristic manifestations are polyuria and nocturia due to urine concentration and manifest with a sensation of thirst. Sodium retention produces hypertension and oedema or hyponatremia. Renal anemia (normocytic and normochromic) and renal osteodystrophy are due to endocrine dysfunctions of the kidney. The number of healthy nephrons is greatly decreased, and uremia occurs due to the work overload and the mechanisms put in place to eliminate toxins. Elimination of <<uraemic toxins>> requires dialysis. Hydroelectric and acid-base balance disturbances occur, where filtration capacity is affected, and the ability to concentrate urine and acids is retained due to decreased glomerular filtration. Other manifestations of CRI can be (Praditpornsilpa et al., 2023):

- Nephrotic syndrome due to infections, drugs, tumors, glomerulonephritis, DM, etc. Intense proteinuria (>3.5g/day) is observed in the laboratory analysis.
- Proteinuria or protein elimination in the urine (>0.15gr/day). It leads to a decrease in plasma proteins, implying a decrease in oncotic pressure and the consequent oedema formation.
- Renal osteodystrophy as a result of decreased hydroxylation of vitamin D_3 (destruction of the parenchyma), consequent increase in parathyroid hormone (PTH), increase in cytokines (IL-1, TNF-α), mineralisation failure (D is not activated$_3$ and presence of metals Al or Fe that make dialysis necessary), rickets/osteomalacia.
- Rickets due to a deficit in serum calcium and phosphate levels. Genes associated with this disease have been identified that encode proteins involved in the metabolism of vitamin D. Prevention is only possible

through nutritional intervention with supplements or food fortification with calcium and vitamin D and sun exposure (Biruete et al., 2023)

Diagnosis and treatment

The disease is asymptomatic, and many patients discover its presence late. Primary care is critical in preventing CKD since various tests are conducted to detect abnormalities in kidney function. Some tests are clinical history, physical examination, blood and urine analysis in which renal function is evaluated, diagnostic imaging (kidney size <9cm indicates chronicity), etc. When the cause is unexplained, the nephrologist is referred, and an invasive diagnostic technique is practised, such as a kidney biopsy (Castle et al., 2023).

Depending on the case, the nephrologist prescribes drugs to control the influencing factors or dialysis if there is chronicity. The primary therapeutic measure is diet since it can delay the destruction of nephrons and the accumulation of nitrogenous waste, reducing uremic symptoms. The dietitian nutritionist can intervene before the onset of kidney disease, maintaining a good cardiovascular condition, which is the main factor in kidney failure. Their intervention throughout renal failure is also crucial, including in phase five of dialysis. Nutrition education in a healthy lifestyle is another powerful tool that aims to change patients' eating habits, including toxic habits and physical inactivity. Various studies highlight the potential of diet in disease management (Faerber et al., 2023).

Nutritional approach to renal patients on dialysis

In the 1960s, dialysis was, for the first time, a therapeutic option for patients with end-stage renal disease (ESRD), but the costs were very high. In the 1980s, it was observed that morbidity and mortality in this group were high, and there was no history of previous CKD. In 2002, the National Kidney Disease Foundation KDOQI (*Kidney Disease Outcomes Quality Initiative*) published a series of clinical practices for caring for patients with kidney disease. It gave a more precise definition of CKD. Dialysis stages were based on GFR <60mL/min/1.73 m^2SC utilising creatinine clearance for more than 3 months. According to the bibliography, malnutrition is the main nutritional problem (Faerber et al., 2023).

In a population of 761 patients in 20 hospitals in Madrid, biochemical and anthropometric parameters were analysed; a prevalence of 80.6% in men and 68.7% in women was found, mainly protein malnutrition in men and caloric malnutrition in women. Some factors that influence

malnutrition on dialysis are found in CKD, such as anorexia, digestive disorders, associated comorbidity, hormonal changes, metabolic acidosis, the uremic environment or uncontrolled diets. Two types of malnutrition are distinguished: type I malnutrition, which presents slightly decreased albumin levels, does not present inflammation, low protein-calorie intake, and C-reactive protein at normal levels. The intervention of the nutritionist dietitian is effective and can reverse the situation. Conversely, type II malnutrition occurs with low albumin levels and presents signs of inflammation associated with elevated C-reactive protein levels. Resting energy expenditure is high, and we would have to increase caloric intake, as we will detail in the nutritional intervention. In this phase, the nutritionist must treat inflammation and malnutrition simultaneously (Table 1) (Hamidianshirazi et al., 2023).

Table 1. Clinical manifestations of CKD, according to (Lopez, 2008)

Manifestation	*Cause*	*Nutritional diet intervention*
Water/sodium disturbances, oedema	Free sodium/water loss, congenital anomalies	Calculation of water needs, assessment of sodium supplements, natural diuretics if there is water retention
Metabolic acidosis	decreases acid excretion	Alkaline diet (low protein diet 0-6-0.8g/kg, essential amino acids)
Arterial hypertension	Increased cardiac output, vascular resistance, hypervolemia	DASH diet (low in salt, high in fruits, vegetables, whole grains, dairy, and low in fat and protein)
Anemia	Erythropoietin deficiency (iron and folic acid deficiency)	A diet high in iron and vitamin B9
Potassium disorders	Kidney overload to remove retained potassium.	Low potassium diet. Maintain at normal levels (3500mg/day)

Osteodistrofia renal	Phosphate retention, metabolic acidosis, 1.25(OH)^2 cholecalciferol deficiency, hyperparathyroidism secondary to hypocalcemia.	An alkaline diet rich in calcium and vitamin D

Process of nutritional care in dialysis (PAN)

Consensus areas (Huarte-Loza et al., 2006) and (Gallar, 2019) propose the following model of nutritional therapy:

Patient-therapist relationship: It is established from a holistic perspective of Nutrition, where we will also include the psychological aspects.

Nutritional assessment: The parameters we mention should not be evaluated separately to carry out a correct nutritional assessment. Several are related to morbidity and mortality, such as albumin, creatinine, body mass index (BMI) or the subjective global assessment questionnaire (VGS). The nutritional assessment, as well as the recommendations and a dietary plan, should be carried out by a dietitian nutritionist (Kalantar-Zadeh et al., 2023).

Anamnesis: We will collect the following data: a reason for the consultation, dietary history, eating habits questionnaires, lifestyles, psychosocial history, medical history, current/previous illness, and allergies)

Physical exploration: corresponds to the doctor and must be performed after dialysis while the patient is at his dry weight. However, the nutritionist must know the signs that can help detect nutrient deficiency. The mucous membranes, hair, nails, appearance of the skin, etc., are observed. Questionnaires such as VGS or DMS can be passed that assess weight change in the last 6 months, change in daily intake,

gastrointestinal symptoms, functional capacity, associated comorbidity, or loss of subcutaneous fat and loss of muscle mass (Mohamed Hussin & Syed Jamaludin, 2023).

Biochemical parameters: An analysis is performed once a week before dialysis, and plasma protein data is observed as albumin, albumin, ferritin and transferrin, with which a nutritional assessment is made, and *somatic* such as serum creatinine, an indicator of muscle mass, and protein intake with values <10mg/dL at the start of dialysis. Creatinine index = ∑ of creatinine eliminated in urine and dialysis. The creatinine breakdown rate calculates protein intake or lean (edema-free) muscle mass (Moroșan et al., 2023).

Anthropometry: Data are collected on height, arm circumference (indicative of muscle mass), skin folds (indicative of fat mass), current/usual weight (ideal weight is estimated and compared with reference tables in the Spanish population), etc. For dialysis patients, as there is oedema in almost all cases, the adjusted weight must be calculated to avoid errors in calculating caloric needs. A stadiometer is required to measure height, a tape measure to measure perimeters, and a plicometer to measure folds. There are different formulas to calculate energy needs, such as the Harris-Benedict formula, which for obese or thin patients should be used with the adjusted weight instead of the current weight as indicated below (Parker et al., 2023):

Adjusted weight for obese: [(Current weight – Ideal weight) x 0.25] + Ideal weight-*adjusted weight for thin*: [(Ideal weight – Current weight) x 0.25] + Current weight

Body composition: can be determined b*y indirect methods* such as anthropometry bioelectrical impedance (BIA), which quickly and non-invasively measures the state of hydration, fat mass, muscle mass and bone mass, or calorimetry. Likewise, it can also be determined by *indirect methods* such as dual-energy X-ray absorptiometry (DEXA), which measures fat mass, fat-free mass, mass, and mineral density and

is more reliable than dual-indirect methods but is also more expensive and therefore not reliable. Usual use: Determining total body Nitrogen is the best method to quantify the body protein content in patients with CKD. It is the reference method for the other methods (Praditpornsilpa et al., 2023).

Other tests: C-reactive protein identifies the presence of inflammation. If its value is high, the existence of inflammation – infection due to risk of malnutrition and cardiovascular risk is ruled out, and the value of albumin will not be observed; a cholesterol level <150mg/dl indicates a nutritional-energy deficit and comorbidity. High-density (HD) cholesterol levels will be assessed; lymphocyte count (<1500/µl) and neutrophils (>2800/µl) in immunity are important parameters, but in dialysis, they are uncertain data; bicarbonate (normal values >22mEq/l) should be measured periodically at the start of dialysis. Acidification due to an increase in HCl induces a loss of amino acids and proteins and low levels of albumin and vitamin D. On the contrary, levels >27mEq/l produce alkalosis that must be avoided.

Data analysis and synthesis: Study the collected data and identify nutritional diagnoses

Goals: nutritional, food, nutritional education and psychological **nutritional intervention**: varied, balanced, adapted, complementary diet. It must be characterised by:

- ✂ Adapt meal times to the dialysis schedule
- ✂ Optimisation of dialysis in terms of quality and quantity.✂ Correction of acidosis to preserve muscle mass. It is treated by increasing the concentration of oral bicarbonate (22-26mEq/l)
- ✂ Prevention/correction of malnutrition due to lack of nutrients or an inflammatory process that must be reversed before treating it.
- ✂ At the nutritional level: calculating energy needs, micro and macronutrient modifications, supplementation.

✂ At the food level: establish route (oral, enteral, parenteral) texture modifications. Correct anemia.

✂ At the educational level: nutritional education and psychological support. Improve the family and social environment during the meal. Perform moderate physical exercise according to physical condition and preferences

✂ Execution of the intervention: preparation of diets and nutritional recommendations` adapted according to objectives, personalisation to adapt to the patient and nutritional education.

Evaluation of the intervention

✂ Establish a monitoring system for early malnutrition and nutritional deficits detection to intervene and reverse the situation. One dietitian nutritionist is needed for every 100-150 patients.

✂ Final assessment of the PAN (objective compliance and patient acceptance). The first contact is made in the first month of inclusion in dialysis with a frequency of 1 visit/month during the 2-3 months following the inclusion of dialysis and every 4-6 months in case of deterioration of the baseline state.

✂ Quality control system

Table 2. Nutritional requirements in dialysis. (HD, hemodialysis; PD, peritoneal dialysis)

carbohydrates	*35 cal/kg/day (30-35 cal/kg/day if >65 years *HD and PD 35 kcal/kg/day > 65 years obesity 30 kcal/kg/day *In PD, quantify glucose absorbed from the peritoneum ([0.89xg/day of dehydrated glucose infused] – 43)

Proteins	*HD 1.2 g/kg/day *DP 1.3 g/kg/day
Fats	*Depends on the type of fat and comorbidities are prescribed at the discretion of the dietitian nutritionist
vitamins - minerals	*B9 (1 mg/day), B6 (10 mg/day), *Vitamin C (50 mg/day), *Vitamin E (800 IU/day), *Vitamin B12 (5 mg/day), *Iron (10-18 mg/day), Zinc and Selenium, *Sodium 2-3 g/day on HD and 2-4 g/day on PD * Potassium approx. 40mg/day in HD and restricted in PD according to laboratory *Phosphorus < 15 mg/day *Calcium 1000-1500 mg/day regularly depending on Phosphorus, parathyrin and Vitamin D
Supplements in malnutrition moderate/severe	*Severe Malnutrition: Carnitine 20 mg/day post intravenous HD for 4 months *Glycemic control *Total parenteral Nutrition, depending on the case
Liquids	*500-700 ml/day or 1000 ml in HD anuria

	*Individualised in DP

nutritional recommendations, *General tips*

✂ Perform moderate physical exercise

✂ Control the amount of protein

✂ Reduce potassium and phosphorus intake

✂ Ensure calcium and vitamin D intake

✂ Control sodium and fluid intake

✂ Control the food groups: milk and dairy products, fruits, vegetables, legumes, meat, fish and eggs.

✂ You can take honey, sweeteners, jam, pastries, and sweets should be avoided.

✂ Fats should come from vegetable oils and butter, bacon, and nuts or the like should be avoided.

Recommendations to reduce potassium

✂ Recommended cooking method: Boiled. Broiling and microwaving do not reduce potassium.

✂ Cut vegetables into very small pieces before washing or using frozen vegetables.

✂ Peel and clean food.

✂ Soak the food several times in water and keep it soaking for as long as possible, changing the water 2-3 times.

✂ Avoid processed products: they contain a lot of salt.

✂ Boil the food twice, changing the water.

✂ Do not use salt in food or salt shaker at the table.

✂ Season the dishes using spices and aromatic herbs.

✂ Consume the fruit in compote without the juice.





III. Objectives

This bibliographical review aims to deepen the knowledge of CKD in the dialysis phase and the nutritional care plan. This general objective is broken down into the following **objectives (Biruete et al., 2023)**:

To evaluate the influence of some macro and micronutrients in developing kidney disease.

Discuss guidelines to prevent or reverse malnutrition.

Design an intervention plan for a CKD patient on hemodialysis and propose a real case study to observe how the PAN is personalised.

Explain culinary techniques to reduce potassium, Phosphorus and sodium.

IV. Methodology

The present work has a double qualitative approach, focused on the variables of nutritional education and nutritional assessment plan, and quantitative, focused on the nutritional requirements of macro and micronutrients. A bibliographic search was carried out to collect information, both from primary sources (books or manuals, articles in scientific journals) and secondary, using a search strategy in the PubMed Mesh thesaurus (https://www.ncbi.nlm.nih.gov/pubmed//).

The inclusion criteria were free full-text articles, reviews, and systematic reviews. Filters from the last 5 years were used between the English and Spanish languages in humans and adults over 45 since it affects dialysis more. On Google Scholar (https://scholar.google.es), A systematic review was found that describes the quality of life of patients undergoing dialysis (Castle et al., 2023).

V. Results

Kidney disease has been widely studied, but as we have seen in the development of this work, dialysis drug treatment was introduced as an option much later, and the influence of food on the development of the disease has continued to be investigated (Hamidianshirazi et al., 2023). The Spanish Society of Dialysis and Transplantation (www.sedyt.org), after a review of 761 patients from 20 hospitals, reached a consensus on PAN in CKD on dialysis and published an article in their journal in 2006 (Huarte-Loza et al., 2006). Many articles have been found that talk about an increase in the prevalence of these patients, and some recognise the intervention of the dietitian nutritionist as very important when it comes to slowing down the progression and comorbidity of the disease (Faerber et al., 2023). The nutritional approach by the dietitian nutritionist must be carried out in conjunction with the pharmacological treatment to obtain positive results on the quality of life of the patient with dialysis CKD.

The predetermining factors are the presence of pathologies such as cardiovascular diseases, among others, as mentioned above. If we talk about specific data, we observe a prevalence three times higher in men (23%) than in women (7%), which increases with age by 37% in people over 65 years of age, a period in which the functioning of the organism, in general, is affected (Kalantar-Zadeh et al., 2023). Renal dysfunction affects the quality of life of the patient, according to the systematic review, due to the predisposing factors of the disease, such as age, sex, pain, a functional decline of the organism, psychological well-being due to the loss of autonomy and the impact on labour productivity and the daily life activities. Suffering from kidney disease leads to a change in diet and culinary technique, as described in this work. The high prevalence of malnutrition (80.6% men and 68.7% women) in older people has to put us on alert to prevent or restore an optimal state of health as far as possible and thus avoid the inflammatory state and morbidity and mortality.

Conclusions

Although dialysis-dependent patients represent a small group of 1%, they constitute a problem for public health and 5% of the health budget is needed. The prevalence in men older than 65 years is more present than in the rest of the subjects, with which we observe that the variables of age and sex influence the disease (Faerber et al., 2023). Suffering from cardiovascular diseases such as hypertension or presenting a failure in any of the kidney's functions is a previous step to contracting kidney disease. A weakening of renal function in blood filtering below 15 ml/min places us in

phase 5 or dialysis, where the nephron cannot recover (Kalantar-Zadeh et al., 2023). The diagnosis of CKD in the dialysis phase is based, in addition to the glomerular filtration rate (GFR), on creatinine levels with values <10 mg/dL at the start of dialysis, albumin, albumin, ferritin or transferrin, among other tests. Diagnostics.

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