

Evaluation of Nutritional Status in Hemodialysis Patients at Kassala Kidney Center, Sudan

Mogahed Salah Ahmed Ali^{1*}, Abdalla Gobara², Mosab Nouraldein Mohammed Hamad³

¹Department of Biochemistry and Nutrition, Faculty of Medicine, University of Kassala, Sudan

²Department of Chemistry, Faculty of Education, Dalanj University, Dalanj, 53312 Sudan

³Excellence Research Center, Elsheikh Abdallah Elbadri University, Berber, Sudan

*Corresponding Author: Mogahed Salah Ahmed Ali

Department of Biochemistry and Nutrition, Faculty of Medicine, University of Kassala, Sudan

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Abstract: Malnutrition is a common complication in chronic kidney disease (CKD) patients on hemodialysis, increasing morbidity and mortality. Limited data exist regarding the nutritional status of Sudanese hemodialysis patients. To assess protein–energy malnutrition (PEM/PEW) in hemodialysis patients at Kassala Kidney Center using biochemical and anthropometric markers. This case-control study included 140 participants (70 hemodialysis patients, 70 healthy controls). Blood samples were analyzed for albumin, total protein, hemoglobin, calcium, creatinine, urea, sodium, and potassium. Body mass index (BMI) was calculated. Data were analyzed using SPSS v.16, with independent t-tests; $P < 0.05$ was considered significant. Hemodialysis patients had significantly lower BMI, albumin, total protein, hemoglobin, and calcium compared to controls ($P < 0.0001$), while urea, creatinine, sodium, and potassium were significantly elevated ($P < 0.0001$). Based on BMI and albumin, 40% of patients were malnourished. Albumin correlated positively with BMI ($r = 0.707$, $P < 0.0001$) and hemoglobin ($r = 0.561$, $P < 0.0001$). Malnutrition is prevalent among Sudanese hemodialysis patients. Routine nutritional assessment, dietary counseling, and monitoring of biochemical markers are essential to improve patient outcomes.

Keywords: Hemodialysis, Malnutrition, Protein–Energy Wasting, Chronic Kidney Disease, Sudan.

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1. INTRODUCTION

Chronic Kidney Disease and Hemodialysis

Chronic kidney disease (CKD) refers to a persistent impairment in kidney structure or function lasting for more than three months and having significant health consequences. It is commonly identified by a reduction in the estimated glomerular filtration rate (eGFR) to below 60 mL/min/1.73 m² or by evidence of structural kidney damage [1]. The most advanced stage of CKD is end-stage renal disease (ESRD), which occurs when kidney function declines to an eGFR of less than 15 mL/min/1.73 m², necessitating the initiation of renal replacement therapy (RRT) to sustain life [1].

CKD has emerged as an important global health concern. Current estimates indicate that approximately 9–10% of the global population is affected by some degree of kidney dysfunction, representing more than

800 million individuals worldwide [4]. The number of patients progressing to kidney failure continues to increase each year, resulting in a growing demand for dialysis and kidney transplantation. Reports from the United States Renal Data System (USRDS) 2023 indicate that the incidence and prevalence of ESRD are rising steadily, largely due to the increasing occurrence of diabetes mellitus and hypertension, which are the primary causes of kidney failure [3]. In addition, the International Society of Nephrology Global Kidney Health Atlas (2023) emphasizes the unequal availability of dialysis services across the world, particularly in low- and middle-income countries, where access to renal replacement therapy remains limited [8].

Among the various etiological factors, diabetes mellitus accounts for roughly 30–40% of CKD cases worldwide, making it the most significant contributor to

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kidney disease [2, 3]. Other well-recognized risk factors include chronic hypertension, obesity, dyslipidemia, cigarette smoking, aging, and genetic predisposition [1-7]. Without proper management, CKD may gradually progress to ESRD, at which stage dialysis or kidney transplantation becomes essential for patient survival [1-5]. For individuals with ESRD, hemodialysis is the most frequently utilized form of renal replacement therapy [5]. During this procedure, blood is circulated through a dialysis machine where waste products, excess electrolytes, and surplus fluid are removed through a semi-permeable membrane via diffusion and ultrafiltration processes. Although hemodialysis performs several essential functions of the kidneys, it cannot completely replicate the complex metabolic and endocrine roles of normal renal function [5]. Nutritional status plays a critical role in determining the clinical outcomes of patients receiving long-term hemodialysis. Many patients with advanced kidney disease develop protein-energy wasting (PEW), a metabolic condition characterized by the depletion of body protein stores and energy reserves. The development of PEW is multifactorial and is associated with insufficient dietary intake, chronic inflammation, metabolic acidosis, hormonal imbalances, and increased protein breakdown related to uremia and dialysis treatment [6]. Malnutrition is therefore a common complication among dialysis patients, affecting approximately 20–50% of individuals undergoing maintenance hemodialysis worldwide. Poor nutritional status has been strongly linked to impaired immune response, increased susceptibility to infections, delayed wound healing, reduced muscle mass, frequent hospital admissions, and higher mortality rates [6, 7]. Multiple factors may contribute to the deterioration of nutritional status in dialysis patients. These include dietary limitations, reduced appetite caused by uremic toxins, gastrointestinal disturbances, chronic inflammation, and the loss of certain nutrients during dialysis sessions. Furthermore, socioeconomic challenges, lack of nutritional education, and coexisting conditions such as diabetes may further aggravate malnutrition in this patient population [7]. Given these risks, evaluating the nutritional status of individuals receiving hemodialysis is essential for the early identification of malnutrition and the development of appropriate nutritional management strategies. Nutritional assessment in dialysis patients typically involves anthropometric indicators such as body mass index and waist circumference, biochemical markers including serum albumin and lipid profile, as well as dietary intake evaluation [6]. Despite the growing burden of CKD, information regarding the nutritional status of hemodialysis patients in Sudan remains limited, particularly in regional dialysis centers. Therefore, further research is required to better understand the nutritional challenges faced by this population and to guide effective clinical and nutritional interventions. Accordingly, the present study aims to assess the nutritional status of patients undergoing hemodialysis in Kassala locality, Sudan.

3. MATERIALS AND METHODS

3.1. Study Area

Kassala kidney center is located inside Kassala locality – Sudan. It was established in 2005 with a capacity of 22 hemodialysis machines and provide health service for 70 patients.

3.2. Study Design

This is a case control - study conducted in hemodialysis patients.

3.3. Ethical Consideration

The study protocol was reviewed and approved by the Ethics Committee of the University of Kassala. Written informed consent was obtained from all participants prior to their inclusion in the study.

3.4. Study Subjects

Study included 70 patients with renal failure attending Kassala kidney Center for hemodialysis, and 70 healthy subjects as a control group enrolled agree to participate in this study after writing consent (September 2021 to June 2024).

3.4.1. Inclusion Criteria: Hemodialysis patients with age range from 15-70 years.

3.4.2. Exclusion Criteria: Patients with kidney disease but not undergoing hemodialysis.

3.5. Materials

3.5.1. Questionnaire

Information about age, gender, socioeconomic status and demographic and the dietary habit, and duration of disease were obtained by patient interview.

3.5.2. Blood Samples

Five ml of blood samples were taken from the vein for each patient and were collected into two different tubes: plain (serum) for total protein and albumin, calcium, sodium, potassium, urea, creatinine. The serum was separated by centrifugation at 1000 rpm for 20 minutes. EDTA tube (whole blood) for estimation of hemoglobin.

3.5.3. Instruments

Equipment and instrument used in this study include:

- Centrifuge.
- Spectrophotometer.
- Easylyte Na/K analyzer.
- Automatic Pipettes, test tubes, racks, syringes, and cotton.

3.5.4. Chemical Reagents

- Bromocresol green.
- Biruet reagent.
- Drabkin's solution.
- Picrate reagent.
- Urease salicilate.

- Methylthymol blue.

3.6. Methods

3.6.1. Biochemical Measurements

3.6.1.2. Determination of total protein by using Biuret Method

Principle

Protein give and intensive violet-blue complex with copper salts in an alkaline medium Iodide is included as antioxidant, the intensity of the color formed is proportional to the total protein concentration in the sample.

3.6.1.2. Determination of Albumin by Using Bromocresol Green Method

Principle: Albumin in the presence of bromocresol green at slightly acid pH, produces a color change of the indicator from yellow-green to green-blue, the intensity of the color formed is proportional to the albumin concentration in the sample.

3.6.1.3. Determination of Hemoglobin by Using Cyanmethemoglobin Method

Principle: Blood is diluted in a solution containing potassium cyanide and potassium ferricyanide. The latter converts Hb to methemoglobin which is converted to cyanmethemoglobin (HiCN) by potassium cyanide, the absorbance of the solution is then measured in a spectrophotometer at a wavelength of 540nm or in a colorimeter using a yellow green filter.

3.6.1.4. Determination of Blood Urea Nitrogen by Using Urease Method

3.6.1.5. Determination of Creatinine by Using Jaffe Compensated Method

Principle: Creatinine in the samples reacts with picrate in alkaline medium forming colored complex. The complex formation rate is measured in a short period to avoid interferences, serum and plasma sample contain protein that react in non-specific way nevertheless the result can be corrected subtracting affixed value the use of this correction.

3.6.1.6. Determination of Calcium by Using Methyl Thymol Blue Method

Principle: Calcium in the sample reacts with methylthymol blue in alkaline medium forming a coloured complex that can be measured by

spectrophotometry. Hydroxyquinoline is included in the reagent to avoid magnesium interference.

3.6.1.7. Determination of Sodium and Potassium by Using Easylyte Na/K Analyzer Method

Principle: Electrolyte measurements in blood by using flame photometry, in which a sample, diluted with a known concentration of a reference ion (usually lithium or cesium), is aerosolized and passed through a flame which excites the cations. They re-emit the energy as light of different frequencies; the amplitude of this emission is proportional to the ion concentration in the sample.

3.6.2. Anthropometric Measurements:

Anthropometric parameters are reliable and valid measurements that indicate nutritional status in HDP.

The BMI was calculated according to the patient's pre-dialysis weight (kg) divided by height (cm) squared.

3.7. Data Analysis

The data were analyzed using statistical package for social science (SPSS). The independent – samples, t-test was used to compare the means of the cases and controls. The results were presented as mean ± SD. P< 0.05 was considered significant at 95% confidence interval.

4.1. RESULTS

Controls were married (74% and 66%, respectively). Illiteracy was considerably higher among cases (64%) compared with controls (16%), whereas university education was reported only among controls (34%). Regarding occupation, most cases were classified under other occupations (58%) or housewives (40%), while controls had more diverse employment status. A markedly lower monthly income (<1000 SD) was reported among cases (96%) compared with controls (44%). Family size was generally larger among cases, with 76% having more than five family members compared with 52% in the control group.

Table 4.1: Demographic information about study subjects

Demography	Cases N=70	Controls N=70
Marital Status		
Married	74 %	66 %
Single	26%	34 %
Education level		
Illiterate	64%	16 %
Primary	16%	36 %
Secondary	20 %	34 %
University	0 %	

Demography	Cases N=70	Controls N=70
Job		
Student	2 %	10 %
Housewife	40 %	24 %
Employee	0 %	18 %
Other*	58 %	48 %
Monthly income		
Less than 1000 SD	96 %	44 %
1000 but less than 3000SD	2 %	34%
3000 but less than 6000SD	2 %	22%
More than 10000SD	0 %	0%
Family members		
Less than 3 peoples	2 %	10%
3-5 peoples	22%	38%
More than 5 peoples	76%	52%

Most patients had a relatively short duration of disease, with 56% having the disease for 6–12 months, while 40% had the disease for 1–5 years, and only 4% had the disease for 5–10 years. Similarly, the duration of

hemodialysis was predominantly short, where 60% of patients had been on hemodialysis for 6–12 months, 36% for 1–5 years, and 4% for 5–10 years.

Table 4.2: Distribution of the patients according to years with kidney disease and duration of the hemodialysis

Duration of the disease		
6-12 month	1-5 years	5-10 years
56%	40%	4%
Duration of the hemodialysis		
6-12month	1- 5 years	5 - 10 years
60%	36%	4%

The distribution of co-morbidities among the study participants showed that hypertension was the most common condition, affecting 70% of patients. In addition, 14% of patients had diabetes mellitus, while 14% had both hypertension and diabetes. Only 2% of the

participants had no reported co-morbidities. These findings indicate that hypertension is the predominant co-morbid condition among hemodialysis patients, highlighting its important role in the progression of chronic kidney disease.

Table 4.3: Presence of co-morbidities in hemodialysis cases at the Kassala Kidney Center, Sudan

Co-morbidity	Percent
None	2%
Diabetes	14 %
Hypertension/Diabetes	14%
Hypertension	70%

The biochemical parameters showed significant differences between cases and controls. The mean serum potassium level was significantly higher among cases (7.1 ± 1.21 mmol/L) compared with controls (3.9 ± 0.67 mmol/L). Similarly, sodium levels were slightly higher in cases (143.9 ± 5.5 mmol/L) than in controls ($139.6 \pm$

4.21 mmol/L). Moreover, markedly elevated levels of urea (145.84 ± 43.6 mg/dl) and creatinine (9.7 ± 2.69 mg/dl) were observed among cases compared with controls (21.06 ± 7.33 mg/dl and 1.2 ± 0.27 mg/dl, respectively).

Table 4.5: Creatinine, Urea, Sodium and Potassium serum levels (mean \pm SD) in cases and Controls

Parameter Group	Creatinine (mg/dl)	Urea (mg/dl)	Na (mmol/L)	K (mmol/L)
Cases	9.7 ± 2.69	145.84 ± 43.6	143.9 ± 5.5	7.1 ± 1.21
Control	1.2 ± 0.27	21.06 ± 7.33	139.6 ± 4.21	3.9 ± 0.67
P.value	<0.0001	<0.0001	<0.0001	<0.0001

The comparison of biochemical and clinical parameters revealed significant differences between cases and controls. Serum calcium levels were

significantly lower in cases (6.9 ± 1.39 mg/dl) compared with controls (11.5 ± 1.28 mg/dl). Hemoglobin levels were also reduced among cases (9.27 ± 2.61 g/dl) relative

to controls (12.2 ± 1.58 g/dl), indicating the presence of anemia in hemodialysis patients. Similarly, total protein and albumin levels were significantly lower in cases (6.08 ± 1.53 g/dl and 3.91 ± 1.01 g/dl, respectively)

compared with controls (8.15 ± 1.17 g/dl and 5.38 ± 0.69 g/dl). In addition, body mass index (BMI) was lower among cases (19.2 ± 3.06 kg/m²) compared with controls (22.5 ± 1.64 kg/m²).

Table 4.6: BMI, Albumin, Total protein, Hemoglobin, Calcium serum levels in Cases and Control

Parameter Group	BMI (kg/m ²)	Albumin (mg/dl)	Total protein (mg/dl)	Hemoglobin (mg/dl)	Calcium (mg/dl)
Cases	19.2 ± 3.06	3.9120 ± 1.01	6.2608 ± 1.53	9.27 ± 2.61	6.9 ± 1.39
Control	22.5 ± 1.64	5.3802 ± 0.69	8.1542 ± 1.17	12.2 ± 1.58	11.5 ± 1.28
P value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

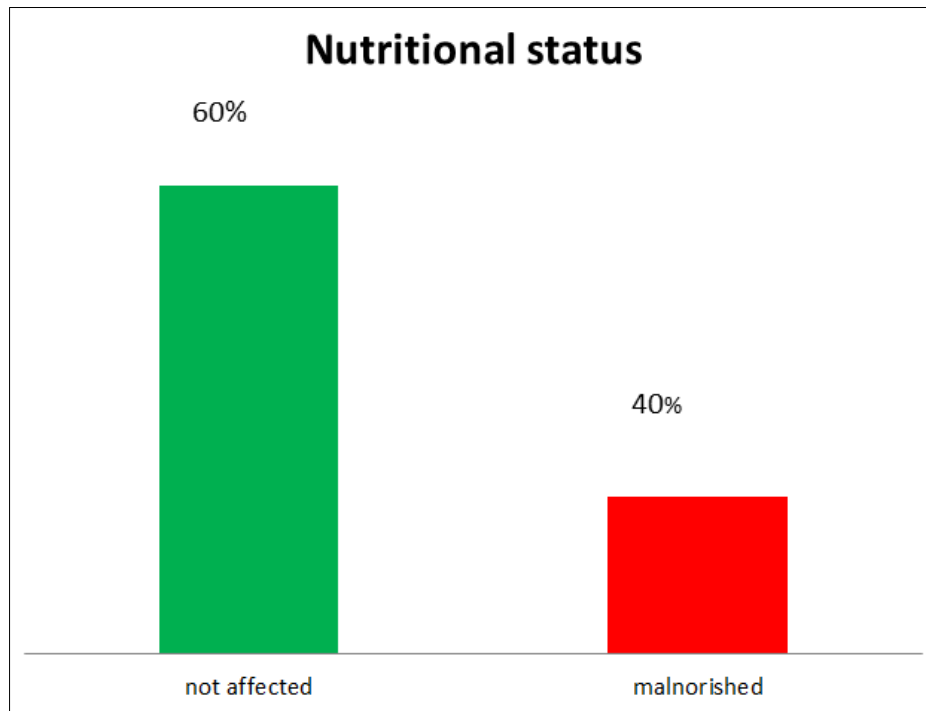


Figure 1: Distribution of the cases according to body mass index and albumin

The prevalence of clinical and biochemical abnormalities among the cases showed that hypocalcemia was the most frequent abnormality, affecting 96% of patients. In addition, 54% of patients were underweight according to BMI values, indicating possible malnutrition among hemodialysis patients.

Hypoalbuminemia and hypoproteinemia were also common, occurring in 48% and 46% of patients, respectively, reflecting impaired nutritional status. Furthermore, anemia was observed in 28% of the patients.

Table 4.6: Frequency of underweight, hypoalbuminemia, hypoproteinemia, hypocalcemia and anemia in cases

Marker	Cases (n= 50) N / %	Normal reference range
Under weight (BMI)	27 / 54%	18.5 – 25 Kg/m ²
Hypoalbuminemia	24 / 48%	3.5 - 4mg/dl
Hypoproteinemia	23 / 46%	6 – 8 mg/dl
Anemia	14 / 28%	8 – 17 mg/dl
Hypocalcemia	48 / 96%	10 – 13 mg/dl

Correlation analysis revealed a strong positive correlation between BMI and total protein ($r = 0.707$, $p = 0.0001$) as well as a moderate positive correlation with calcium ($r = 0.403$, $p = 0.004$). Disease duration showed significant negative correlations with hemoglobin ($r = -0.433$, $p = 0.002$) and calcium ($r = -0.416$, $p = 0.003$),

while a positive correlation was observed with creatinine ($r = 0.281$, $p = 0.048$). Albumin demonstrated significant positive correlations with total protein ($r = 0.450$, $p = 0.001$) and hemoglobin ($r = 0.561$, $p = 0.0001$). In addition, total protein was positively correlated with hemoglobin ($r = 0.319$, $p = 0.024$).

Table 4.7: correlation of BMI, duration of disease, albumin, total protein, hemoglobin, calcium, creatinine, urea

Variable	BMI	Disease duration	Albumin	Total protein	hemoglobin	Calcium	Creatinine	Urea
BMI	R <i>p</i>	-0.14 0.333	0.707*** 0.0001	0.271 0.057	0.403** 0.004	-0.090 0.536	-0.158 0.273	0.229 0.110
Duration of disease	R <i>p</i>		-0.243* 0.089	-0.163* 0.258	-0.433** 0.002	-0.416** 0.003	0.281* 0.048	-0.67 0.441
Albumin	R <i>p</i>			0.450** 0.001	0.561** 0.0001	-0.038 0.792	-0.262 0.115	0.088 0.541
Total protein	R <i>p</i>				0.319* 0.024	0.086 0.553	-0.086 0.555	0.268 0.060
Hemoglobin	R <i>P</i>					0.185 0.199	-0.370* 0.008	0.029 0.840
Calcium	R <i>p</i>						-0.140 0.333	-0.041 0.778
Creatinine	R <i>p</i>							-0.065 0.652
Urea	R <i>P</i>							

*= weak correlation **= moderate correlation ***= strong correlation

4.2 DISCUSSION

Protein–energy wasting (PEW), previously referred to as protein–energy malnutrition (PEM), is a common and serious complication of chronic kidney disease (CKD), particularly among patients undergoing maintenance hemodialysis. PEW is strongly associated with increased hospitalization, cardiovascular morbidity, and mortality in end-stage renal disease (ESRD) patients [1-12]. The Kidney Disease: Improving Global Outcomes (KDIGO) 2024 guideline emphasizes that routine and comprehensive nutritional assessment is an essential component of care in advanced CKD and dialysis populations [1]. In Sudan, data regarding malnutrition among hemodialysis patients (HDP) are limited. This study represents the first assessment of PEW among HDP in Kassala City using a multidimensional protocol incorporating biochemical markers (albumin, total protein, hemoglobin, calcium, creatinine, sodium, potassium, and urea) alongside anthropometric measurement (BMI). The National Kidney Foundation Kidney Disease Outcomes Quality Initiative (KDOQI) 2020 nutrition guideline recommends that nutritional status should not be evaluated using a single parameter but rather through a comprehensive approach [6]. The demographic findings demonstrated that most HDP belonged to low socioeconomic strata, characterized by illiteracy, unemployment, and poor income. Socioeconomic disadvantage is recognized as a determinant of poor dietary quality, limited healthcare access, and adverse clinical outcomes in CKD populations [4-10]. These factors may have contributed to the higher prevalence of malnutrition observed among cases. Body mass index (BMI) was significantly lower in HDP compared with healthy controls. According to the World Health Organization (WHO), a BMI <18.5 kg/m² is classified as underweight [11]. Several dialysis cohort studies have demonstrated that low BMI is associated with increased mortality risk in ESRD patients [3]. However, BMI alone

may underestimate muscle wasting due to fluid shifts and sarcopenia in dialysis patients [12]. Therefore, BMI should be interpreted in conjunction with biochemical and clinical parameters. Serum albumin levels were significantly lower among hemodialysis patients compared with controls. Hypoalbuminemia remains one of the strongest predictors of mortality in dialysis populations [12]. Nevertheless, KDIGO guidelines caution that serum albumin is influenced by inflammation, infection, hydration status, and comorbid conditions and should not be used as an isolated marker of nutritional status [1]. Calcium levels were significantly lower among HDP compared with healthy subjects. Disturbances in calcium metabolism in CKD are primarily due to reduced renal 1 α -hydroxylase activity, resulting in decreased synthesis of active vitamin D and subsequent secondary hyperparathyroidism. These abnormalities form part of CKD–mineral and bone disorder (CKD-MBD), which is strongly associated with vascular calcification and cardiovascular morbidity [7]. These findings align with current KDIGO CKD-MBD recommendations [7]. Hemoglobin levels were significantly lower in hemodialysis patients, confirming the high prevalence of anemia in ESRD. Anemia in CKD results primarily from insufficient erythropoietin production, iron deficiency, chronic inflammation, and reduced red blood cell survival. The KDIGO 2021 anemia guideline recommends individualized use of erythropoiesis-stimulating agents and iron therapy to optimize hemoglobin levels and improve patient outcomes [8]. In this study, 40% of HDP were classified as malnourished based on combined serum albumin and BMI criteria. Although substantial, this prevalence may differ from reports in other Sudanese regions due to methodological differences. The International Society of Renal Nutrition and Metabolism (ISRNM) recommends diagnostic criteria for PEW that include biochemical markers, body mass, muscle mass, and dietary intake parameters to

improve diagnostic accuracy (12). Studies utilizing combined assessment methods provide more reliable prevalence estimates than those relying solely on anthropometric measures [6-12]. Comorbid conditions and socioeconomic factors may further contribute to malnutrition among HDP. Diabetes and cardiovascular disease increase catabolic stress and dietary restrictions, thereby accelerating nutritional deterioration [2-4]. Finally, poor adherence to dietary and fluid restrictions was observed among many participants. Non-adherence in dialysis patients has been widely documented and is associated with low educational level, inadequate counseling, and absence of specialized renal dietitians [6-10]. The lack of a dedicated dietitian at Kassala Kidney Center may contribute to insufficient nutritional education and follow-up. Structured multidisciplinary nutritional programs have been shown to improve adherence and biochemical outcomes in dialysis populations [6].

5.1. CONCLUSION

The level of nutritional markers were significantly decreased in hemodialysis patients. The percentage of malnutrition is 40% were malnourished. Low educational level, low monthly income and presence of co-morbid diseases may aggravate the risk of malnutrition in HDP.

5.2. Recommendations

- Additional biochemical measurement, such as: lipid profile, vitamins, and minerals can be used to give a more comprehensive indication of PEM.
- Routine assessment of the nutritional status of HDP is mandatory for their health.
- More areas of Sudan with large number of patients are needed to replicate our findings.

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