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ORIGINAL ARTICLE

Transferrin as a Marker of Malnutrition in Regular Hemodialysis Patients

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Abstract

Background: **Malnutrition has been linked to higher hospitalization rates, decreased physical activity, reduced quality of life, and insufficient dialysis, as well as death and morbidity. 6%−8% of hemodialysis patients have severe malnutrition, compared to 30%−65% of patients who have moderate malnutrition.**

Purpose: **To evaluate transferrin as a marker of malnutrition in regular hemodialysis patients.**

Method: **The material of this work comprised hemodialysis patients who were followed up at Al-Agouza Hospitals. Patients were recruited in the duration between (April 2022) and (Oct 2022). Modified SGA was calculated for all participants according to history, clinical examination, laboratory findings then patients were divided into 3 groups: normal (SGA = 7), mild to moderate (>7 & <35) and severe malnutrition (SGA = 35). The blood samples will be taken before dialysis in a midweek session before anticoagulation to avoid interference with heparin. CBC, CRP, creatinine, Blood urea, S. albumin, Iron profile, ALT, Calcium, phosphorus and Transferrin were assessed.**

Results: **Twenty patients had normal SGA, 53 patients had mild to moderate malnutrition and 7 patients had severe malnutrition. There was statistically substantial variation between the study groups regarding the presence of lower limb edema with higher incidence among severe malnutrition group, a component of modified SGA score, Ferritin, Albumin, ALT and Serum calcium had higher levels among normal control group than the other 2 groups. Also, mild-moderate malnutrition group had higher levels of transferring than severe malnutrition group with statistically significant difference.**

Conclusion: **Serum transferrin can be used as marker of malnutrition in regular hemodialysis patients.**

Keywords: Hemodialysis patients, Malnutrition, Transferrin

1. Introduction

In poor nations, malnutrition—which has two components: protein-energy malnutrition and micronutrient deficiencies—remains a significant health burden. It is the most significant risk factor for disease and mortality on a worldwide scale, notably affecting hundreds of millions of pregnant women and young children.[1]

It is characterized by stunting, wasting, underweight, and micronutrient deficiencies and is described as the insufficient intake or absorption of nutrients necessary to promote growth and avoid chronic or acute illness.[2]

Malnutrition is primarily shown in impoverished nations by deficiencies in iron, iodine, vitamin A, and zinc. These populations often experience a vicious cycle where a high frequency of poor nutrition and infectious illness coexist.[3]

The majority of patients (particularly those in rural regions) have little or no access to professional health care and are never treated in such settings, despite the fact that treatment methods for severe malnutrition have recently improved in efficiency.[1]

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Table 1. Comparison between different groups regarding demographics and baseline characteristics.

	Group A (Number = 20) Number (%)	Group B (n = 53) Number (%)	Group C (n = 7) Number (5)	Test of Significance	P value	
Age (years) mean ± SD	55.7 ± 8.3	53.8 ± 10.08	54.57 ± 6.74	0.96[a]	0.29	NS
In between groups P value	Group A:B = 0.7, Group A:C = 0.24, Group B:C = 0.45					
Sex Number (%):						
Male	13 (65%)	33 (62.3%)	4 (57.1%)	0.14[b]	0.932	NS
Female	7 (35%)	20 (37.7%)	3 (42.9%)			
Hemodialysis duration (years) mean ± SD	5.76 ± 1.27	5.8 ± 1.28	6.3 ± 1.07	2.77[a]	0.069	NS
In between groups P value	Group A:B = 0.7, Group A:C = 0.2, Group B:C = 0.06					
Dry body weight (Kg) mean ± SD	74 ± 11.054	61.056 ± 10.34	57.7 ± 8.014	12.74[a]	0.00001	hS
In between groups P value	Group A:B < 0.001, Group A:C = 0.002, Group B:C = 0.7					
Body mass index (Kg/m^2) mean ± SD	27.12 ± 2.9	22.5 ± 2.2	20.8 ± 1.25	32.81[a]	0.0001	hS
In between groups P value	Group A:B < 0.001, Group A:C < 0.001, Group B:C = 0.18					
Diabetes Number (%)	0	11 (20.8%)	2 (28.6%)	5.4[b]	0.065	NS
Hypertension Number (%)	0	31 (58.5%)	5 (71.4%)	22.23[b]	0.00001	hS
Cardiovascular disease Number (%)	0	17 (32.1%)	3 (42.9%)	9.27[b]	0.01	S
Chronic liver disease Number (%)	0	20 (37.7%)	2 (28.6%)	10.38[b]	0.006	hS
Lower limb edema	1 (5%)	6 (11.3%)	5 (71.4%)	19.6[b]	0.0001	hS

[a] Analysis of variance (ANOVA) test.
[b] Chi-square test; P value < 0.05 is considered significant (S) and <0.01 is highly significant (hS).

The majority of individuals with chronic renal failure have protein-energy deficiency and wasting. This may be the result of a variety of causes, such as changes in the metabolism of protein and energy, hormonal changes, infections, and other concurrent diseases, as well as decreased food intake due to anorexia, nausea, and vomiting brought on by uremic poisoning.[4]

As the only nutrient shortfall that seems to be significantly relevant for public health and that both rich civilizations and low-income nations share, iron insufficiency is a nutritional deficiency of considerable and widespread attention. These two extreme sorts of societies have very different eating patterns and food availability, which suggests that iron is one of the most important nutrients that should be included in most people's diets. It may, however, also suggest subtly that iron shortage may not just be a matter of iron consumption. Iron deficiency may be caused by a variety of things in addition to the amount of iron in a person's diet. So, we must decide if the iron deficit is primary (caused by a low intake of iron in the diet) or secondary (caused by a rise in the demand for iron).[5]

This investigation into the use of transferrin as a sign of malnutrition in individuals receiving routine hemodialysis.

Table 2. Correlation between baseline characteristics, different laboratory investigations and SGA.

	r (Correlation coefficient)	P value[a]	
Age	0.22	0.29	NS
Sex No	−0.074	0.516	NS
Hemodialysis duration	−0.049	0.663	NS
Dry body weight	−0.637	0.00001	hS
Body mass index	−0.765	0.0001	hS
Diabetes	0.352	0.00001	hS
Hypertension	0.327	0.00003	hS
Cardiovascular disease	0.274	0.014	S
Chronic liver disease	0.278	0.013	S
Hemoglobin	0.048	0.676	NS
White blood cells	0.093	0.413	NS
Platelets	0.071	0.533	NS
Alanine transferase (ALT)	−0.754	0.00001	hS
S. albumin	−0.67	0.00001	hS
S. creatinine	−0.284	0.011	S
Urea	−0.091	0.423	NS
Calcium	−0.26	0.02	S
Phosphorus	−0.031	0.785	NS
C-reactive protein	0.171	0.129	NS
S. ferritin	−0.285	**0.01**	**S**
TIBC	−0.05	0.663	NS
Transferrin	−0.87	0.0001	hS

[a] Pearson correlation; r: Correlation coefficient, P value < 0.05 is considered significant (S) and <0.01 is highly significant (hS).

2. Subjects and methods

2.1. Patients' selection

This cross sectional study with analytical component study included 80 hemodialysis patients who were selected from clinics of Al-Agouza Hospitals. Patient's ages were ranged from 30 to 60 years. They all underwent regular hemodialysis, had never switched to a different form of treatment (such as peritoneal dialysis or a transplant), had not needed blood transfusions in the previous four weeks, had not needed hospitalization in the month prior to the study, showed no symptoms of infection or disease activity (collagen vascular disease), and gave their consent to take part. Patients who had received intravenous iron in the preceding month, those with cancer, and those with liver cirrhosis were disqualified from the trial. The local Institutional Review Board gave their approval to the research (under IRB No. MS.20.09.1264). Patients were cared for in accordance with the declaration of Helsinki's principles.

2.2. Grouping

Patients were classified according to the results of modified SGA into 3 groups: Group A: Normal SGA (SGA = 7), Group B: Mild-moderate malnutrition (SGA > 7 &<35), Group C: Severe malnutrition (SGA = 35).

2.3. Methods

2.3.1. Patients

Data were collected from the patients or their sheets: Age, Gender, Duration of hemodialysis, Diabetes mellitus (type − duration −treatment − controlled or not − presence of other diabetic complication), Hypertension (duration −controlled or not), Cardiovascular disease, Hemodialysis filters type and filter surface area, Changes in end dialysis dry weight, Dietary intake (Good appetite, suboptimal solid diet intake, moderate decrease, hypocaloric liquid intake), Gastrointestinal symptoms (anorxia, nausea, vomiting, diarrhea).

2.3.2. Physical examination

Anthropometric measurement (weight, height, body mass index (BMI), body surface area (BSA), Waist circumference). Signs of muscle loss (using skin pinch technique): Lost normal fullness of temple, clavicle, scapula, ribs, quadriceps, knee and interosseus in comparison to the other side.

2.3.3. Laboratory work-up

The blood samples will be taken before dialysis in a midweek session before anticoagulation to avoid interference with heparin. CBC, CRP, Serum creatinine and Blood urea, S. albumin, Iron profile, ALT, Calcium (Cat. no.# 05061482190), phosphorus (Cat. no.# 03183793122) and Hemodialysis adequacy based on: Urea reduction rate (URR), single pooled Kt/v (spKt/v) were assessed.

2.3.4. Transferrin levels

Human Transferrin was assessed using ELISA Kit (cat.no# E3273Hu).

2.3.5. Modified SGA

According to the data from history, clinical examination and laboratory findings, modified SGA score was calculated and patients were divided into groups accordingly.

2.3.6. Dialysis prescription

The hemodialysis patients received dialysis three times per week, 4 h per session with a dialysate Mg concentration of 0.5 mmol/l using bicarbonate dialysate (sodium 105 mmol/l; bicarbonate cartridge; potassium, 2 mEq/l; Ca, 1.5 mmol/l; and Mg, 0.5 mmol/l) on FRESENIUS 4008 B and 4008 S (Fresenius Medical Care, Hamburg, Germany) Dialysis Machine.

2.3.7. Statistical methods

Statistical analysis was conducted utilizing SPSS (version 21, Chicago, IL, USA). The following statistical tests will be used: χ^2 test: to compare categorical data. Student t-test: to compare normally distributed quantitative data between 2 groups. Mann-Whitney test: to compare abnormally distributed quantitative data between 2 groups. Analysis of Variance (ANOVA): to compare normally distributed data between more than 2 groups. Kruskal-Wallis: to compare abnormally distributed qualitative data between more than 2 groups. Correlation coefficient: to find the correlation between variables of quantitative data (For parametric data, Pearson correlation is used, while for non-parametric data, Spearman correlation).

3. Results

The study included 80 hemodialysis patients with mean age 53.47 ± 9.76 and male predominance (62.5%). They were maintained on hemodialysis for mean 6.67 ± 1.52 years and mean dry body weight 64 ± 11.8. They had mean BMI 23.5 ± 3.1 kg/m^2 and

Table 3. Comparison between different groups regarding SGA components.

	Group A	Group B	Group C	*P* value[a]	
Weight change:					
No	20 (100%)	12 (22.6%)	0	0.0001	hS
Minor	0	34 (64.2%)	0		
5–10% weight loss	0	6 (11.3%)	0		
10–15% weight loss	0	0	0		
>15% weight loss	0	1 (1.9%)	7 (100%)		
Dietary intake:					
Normal	20 (100%)	0	0	0.0001	hS
Sub-optimal solid diet	0	29 (54.7%)	0		
Full liquid diet	0	24 (45.3%)	0		
Hypo-caloric liquid	0	0	0		
Starvation	0	0	7 (100%)		
Gastrointestinal manifestations:					
No	20 (100%)	0	0	0.0001	hS
Nausea	0	30 (56.6%)	0		
Vomiting	0	19 (35.8%)	0		
Diarrhea	0	4 (7.5%)	0		
Severe anorexia	0	0	7 (100%)		
Functional capacity:					
None	20 (100%)	0	0	0.00001	hS
Difficulty with little activity	0	27 (50.9%)	0		
Difficulty with ambulation	0	20 (37.7%)	0		
Light activity ridden	0	6 (11.3%)	0		
Bed/chair	0	0	7 (100%)		
Co-morbidities:					
Healthy with no comorbidity	20 (100%)	0	0	0.0001	hS
Mild comorbidity	0	0	0		
Moderate comorbidity/age>75	0	36 (67.9%)	0		
>4 years HD/severe	0	17 (32.1%)	0		
Severe multiple co-morbidities	0	0	7 (100%)		
Loss of fat stores:					
None	20 (100%)	0	0	0.00001	hS
Moderate	0	21 (39.6%)	0		
Severe	0	32 (60.4%)	7 (100%)		
Muscle wasting:					
None	20 (100%)	0	0	0.00001	hS
Mild	0	20 (37.7%)	0		
Moderate	0	4 (7.5%)	0		
Moderately severe	0	0	0		
Severe	0	29 (54.7%)	7 (100%)		

[a] Chi-square test; *P* value < 0.05 is considered significant (S) and <0.01 is highly significant (hS).

Table 4. Comparison between different groups regarding CBC criteria and iron indices.

	Group A (Number = 20) Number (%) mean ± SD	Group B (*n* = 53) Number (%) mean ± SD	Group C (*n* = 7) Number (5) mean ± SD	Test of Significance[a]	*P* value	
Hemoglobin (g/dL)	11.37 ± 1.3	10.4 ± 1.23	10.01 ± 1.4	3.29	0.043	S
In between groups p	Group A:B = 0.53, Group A:C = 0.24, Group B:C = 0.4					
White blood cells ($^{a}10^3/mm^3$)	16.15 ± 7.2	6.01 ± 3.1	7.01 ± 2.2	1.278	0.28	NS
In between groups p	Group A:B = 0.25, Group A:C = 0.67, Group B:C = 0.99					
Platelets ($10^3/mm^3$)	201.8 ± 100	201.5 ± 73.	218.8 ± 82	0.14	0.86	
In between groups p	Group A:B = 1, Group A:C = 0.88, Group B:C = 0.86					
Ferritin (ng/mL)	1062 ± 530	515.5 ± 230	414.1 ± 210	5.09	0.008	hS
In between groups p	Group A:B = 0.009, Group A:C = 0.008, Group B:C = 0.93					
TIBC (mcg/dL)	229.4 ± 108	297.17 ± 121	186.4 ± 53.6	1.64	0.202	NS
In between groups p	Group A:B = 0.376, Group A:C = 0.867, Group B:C = 0.33					
Transferrin (mg/dL)	276.5 ± 57	185.8 ± 37.3	100.28 ± 6.9	56.3	**0.0001**	**hS**
In between groups p	Group A:B = 0.0001, Group A:C = 0.0001, Group B:C = 0.00001					

TIBC, total iron binding capacity.

[a] Analysis of variance test (ANOVA); *P* value < 0.05 is considered significant (S) and <0.01 is highly significant (hS).

Table 5. Comparison between different groups regarding other laboratory investigations.

	Group A (Number = 20) Number (%) mean ± SD	Group B (n = 53) Number (%) mean ± SD	Group C (n = 7) Number (5) mean ± SD	Test of Significance[a]	P value	
Alanine transferase (ALT) (iu/L)	28.3 ± 3.27	24.19 ± 4.9	9.14 ± 1.46	48.87	0.0001	hS
In between groups p	Group A:B = 0.002, Group A:C = 0.0001, Group B:C = 0.0001					
S. albumin (g/dL)	3.87 ± 0.37	3.4 ± 0.39	2.25 ± 0.24	48.25	0.001	hS
In between groups p	Group A:B = 0.0001, Group A:C = 0.0001, Group B:C = 0.00001					
S. creatinine (mg/dL)	19.6 ± 4.2	8.7 ± 1.8	9.02 ± 1.04	1.99	0.14	NS
In between groups p	Group A:B = 0.13, Group A:C = 0.49, Group B:C = 0.99					
Urea (mg/dL)	117.5 ± 25	108.6 ± 29.2	100 ± 20.4	1.26	0.29	NS
In between groups p	Group A:B = 0.44, Group A:C = 0.33, Group B:C = 0.72					
Calcium (mgdL)	9.4 ± 1.09	8.84 ± 0.8	8.87 ± 0.76	3.73	0.028	S
In between groups p	Group A:B = 0.023, Group A:C = 0.28, Group B:C = 0.99					
Phosphorus (mg/dL)	3.9 ± 1.6	4.3 ± 1.75	3.3 ± 1.36	1.45	0.24	NS
In between groups p	Group A:B = 0.59, Group A:C = 0.69, Group B:C = 0.28					
C-reactive protein	8.7 ± 3.9	13 ± 6.7	14.14 ± 7	0.68	0.51	NS
In between groups p	Group A:B = 0.52, Group A:C = 0.69, Group B:C = 0.98					

[a] Analysis of variance test (ANOVA); P value < 0.05 is considered significant (S) and <0.01 is highly significant (hS).

variable prevalence rates of multiple co-morbidities and lower limb edema was observed in 12 patients.

3.1. SGA components of the patients

SGA score was composed of 7 items. Each items had 5 grades and the sum of the grades in the 7 items was 35. Each patient had a score of 35 according to the results of the different items. The patients then were divided into: normal (SGA≤7), mild (SGA >7, <21), moderate (SGA ≥21,<35) and severe (35). Most of the patients (66.3%) had mild to moderate degree of malnutrition.

We divided the patients into 3 groups: Group A: Normal SGA; Group B: Mild-moderate malnutrition; Group C: Severe malnutrition.

There was no statistically substantial variation between the 3 groups regarding age, sex distribution and hemodialysis duration. Prevalence of hypertension and cardiovascular diseases was higher with statistically substantial variation among severe malnutrition group while chronic liver disease prevalence was higher among mild-moderate malnutrition group. There was statistically substantial variation between the study groups regarding presence of lower limb edema with higher incidence among severe malnutrition group (Table 1).

There was no correlation between SGA and age, sex or hemodialysis duration. There was inverse correlation between dry body weights or body mass index and SGA. There was positive correlation between presence of co-morbidities and SGA. There was inverse correlation between ALT, albumin, creatinine and SGA levels with statistically substantial variation. There was inverse correlation between serum calcium and SGA levels with statistically significant difference. There was inverse correlation between s.ferritin, transferring and SGA levels with statistically significant difference (Table 2).

Table 6. Multivariate analysis of predictors for malnutrition.

	B estimate	Exp (B)	95% confidence interval		P value[a]	
Dry body weight	−0.111	0.895	0.386	2.073	0.796	NS
Body mass index	−0.44	0.644	0.016	25.345	0.814	NS
Hypertension	22.53	0	0.000	0.001	0.996	NS
Cardiovascular	23.65	0	0.000	0.001	0.997	NS
Chronic liver disease	25.58	0	0.000	0.001	0.997	NS
ALT	0.605	1.83	0.223	15.009	0.03	S
Albumin	−7.115	0.001	0.000	1353.36	0.007	S
Calcium	−2.155	0.116	0.000	596.007	0.621	NS
S. ferritin	−0.001	0.999	0.996	1.002	0.52	NS
Transferrin	−0.039	0.962	0.803	1.152	0.001	hS

[a] Binary Logistic regression; P value < 0.05 is considered significant (S) and <0.01 is highly significant (hS).

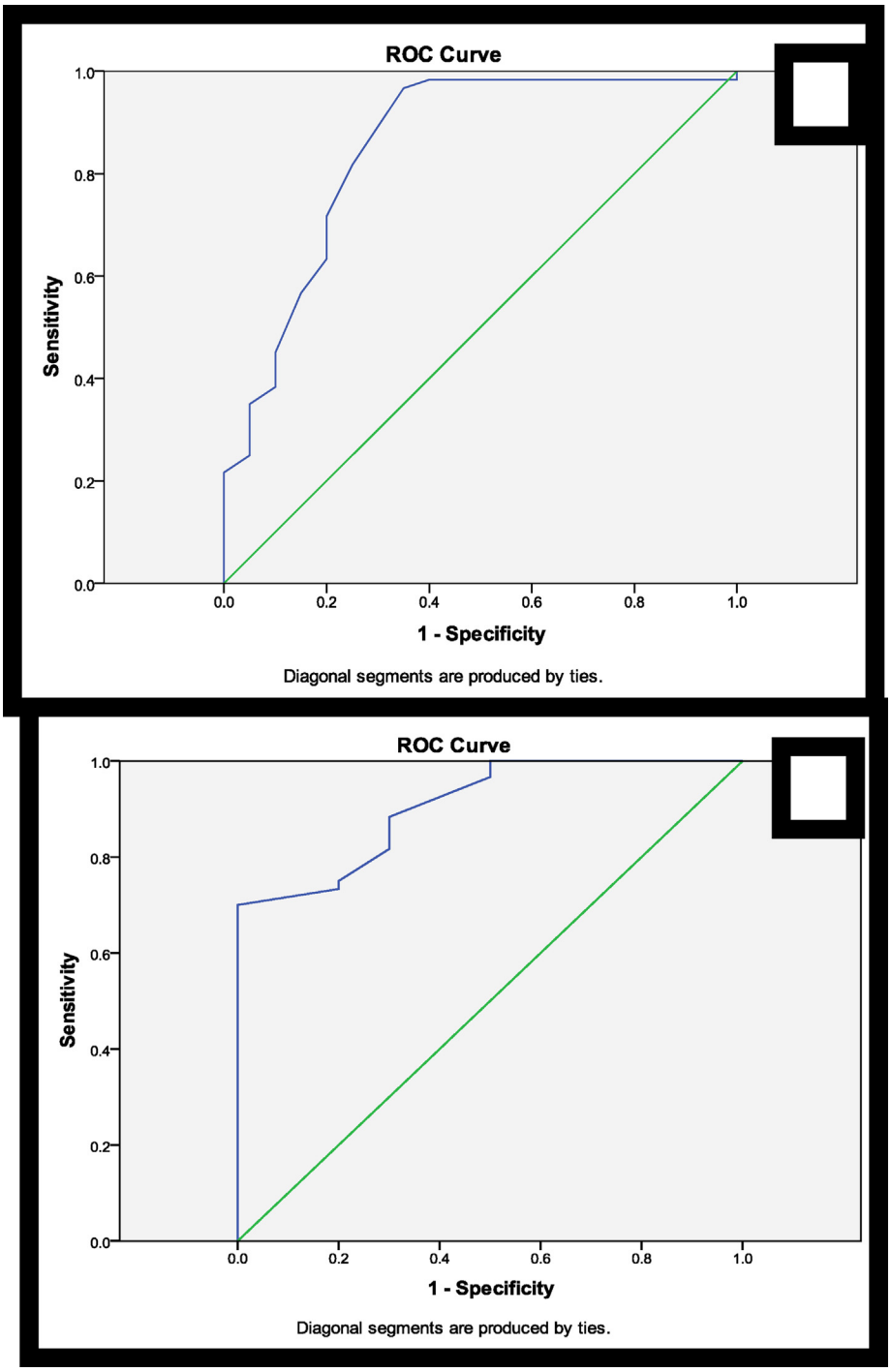

Fig. 1. A: ROC curve to specify accuracy of albumin; B: ROC curve to specify accuracy of transferrin in prediction of malnutrition.

There was statistically substantial variation between the 3 groups regarding each component of SGA score (Table 3).

Hemoglobin, white blood cell count and platelet count were comparable between both groups. Serum ferritin was higher among normal group than the other 2 groups which were comparable. The studied groups were comparable regarding TIBC. Ferritin had higher levels among normal control group than the other 2 groups. Also, mild-moderate malnutrition group had higher levels of transferring than severe malnutrition group with statistically substantial variation (Table 4).

ALT had the highest values among normal group and the lowest values among the severe malnutrition group with statistically substantial variation

Table 7. Correlation between transferrin levels and baseline characteristics and laboratory investigations.

	r (Correlation coefficient)	*P* value*	
Age	0.145	0.2	NS
Sex No.	0.078	0.489	NS
Hemodialysis duration	−0.096	0.398	NS
Dry body weight	0.603	0.00001	hS
Body mass index	0.724	0.00001	hS
Diabetes	−0.29	0.009	hS
Hypertension	−0.289	0.009	hS
Cardiovascular disease	−0.27	0.013	S
Chronic liver disease	−0.183	0.104	NS
Hemoglobin	−0.013	0.907	NS
White blood cells	−0.082	0.471	NS
Platelets	−0.026	0.817	NS
Alanine transferase (ALT)	0.787	<0.001	hS
S. albumin	0.633	<0.001	hS
S. creatinine	0.218	0.052	NS
Urea	0.188	0.096	NS
Calcium	0.212	0.06	NS
Phosphorus	0.04	0.727	NS
CRP	−0.133	0.238	NS
S. ferritin	0.177	0.116	NS
TIBC	0.083	0.464	NS

*Pearson correlation; r: Correlation coefficient, level of significance<0.05.

between the 3 groups. Albumin levels were higher among normal group than the other 2 groups and also higher among mild-moderate malnutrition group than severe group. S. creatinine and urea were comparable between the 3 groups. Serum calcium was higher among normal group than the other 2 groups which showed comparable results. The 3 groups were comparable regarding serum phosphorus and CRP (Table 5).

The factors with statistically significance in the univariate analysis related to incidence of malnutrition were entered in binary logistic regression to adjust the confounders with R = 0.645 and adjusted R = 0.955. ALT, albumin and serum transferring kept their statistically significance (Table 6).

At cut-off value equal to 3.7, s albumin has 81.7% sensitivity and 25% specificity in predicting malnutrition. At cut-off value equal to 235, s transferrin has 96.5% sensitivity and 50% specificity in predicting malnutrition, (Fig. 1).

There was positive correlation between dry body weight, body mass index and serum transferrin. There was negative correlation between serum transferrin and presence of different co-morbidities as hypertension, diabetes and cardiovascular disease. These correlations had statistically significance. There was statistically substantial positive connection between albumin, ALT and serum transferring. Otherwise, there was no statistically substantial correlation between transferring and other laboratory investigations (Table 7, Figs. 2 and 3).

The factors with statistically significance in the univariate analysis related to incidence of malnutrition were entered in binary logistic regression to adjust the confounders with R = 0.645 and adjusted R = 0.955. ALT, albumin and serum transferring kept their statistically significance.

4. Discussion

The present study's objective was to assess the role and accuracy of transferrin as a biomarker of malnutrition among hemodialysis patients and its relation to the degree of malnutrition.

In the current study, mean value of dry body weight was 64 ± 11.8 Kg and BMI was 23.5 ± 3.1 kg/m^2. There was statistically significant difference between different grades of malnutrition regarding dry body weight and also BMI and this was reflected by the strong significant inverse correlation between dry body weight, BMI and SGA score (r = −0.64, −0.76;*P*=<0.001 resp.). **Ghorbani *et al.*,**[6] proved these association in his study and BMI kept his statistically significance in both univariate and multivariate analysis as a predictor of presence and severity of malnutrition also his patients had higher BMI in total. On the other hand, **Rosenberger *et al.*,**[7] did not find statistically substantial variation between well-nourished and malnutrition patients regarding BMI; He depeneded in his classification on lean body weight.

A 45% of the included patients in this study had at least1 co morbidity with hemodialysis with variable incidence rate as diabetes were present in 16.3% of the patients, cardiac diseases had 25% incidence rate, chronic liver disease was diagnosed in 27.5% of the patients and hypertension had the highest prevalence (45%). There was statistically significant difference between the 3 groups regarding the incidence rate of each disease and there was moderate statistically significant correlation between the incidence of these diseases and SGA. In accordance to the current study, Regarding laboratory findings and its relation to the presence of degree of malnutrition, hemoglobin levels were lower with statistically significant difference among severe malnutrition group than the other 2 groups (*P* = 0.043) while the 3 groups were comparable regarding white blood cells counts and platelets. However, there was no statistically significant correlation between SGA and hemoglobin levels in total. In accordance to the current study, **Rezeq *et al.*,**[8] found strong association between SGA and hemoglobin levels. Also, **Kadiri *et al.*,**[9] reported strong relationship between nutritional status and hemoglobin leves. In contrary **Gunalay *et al.*,**[10] did

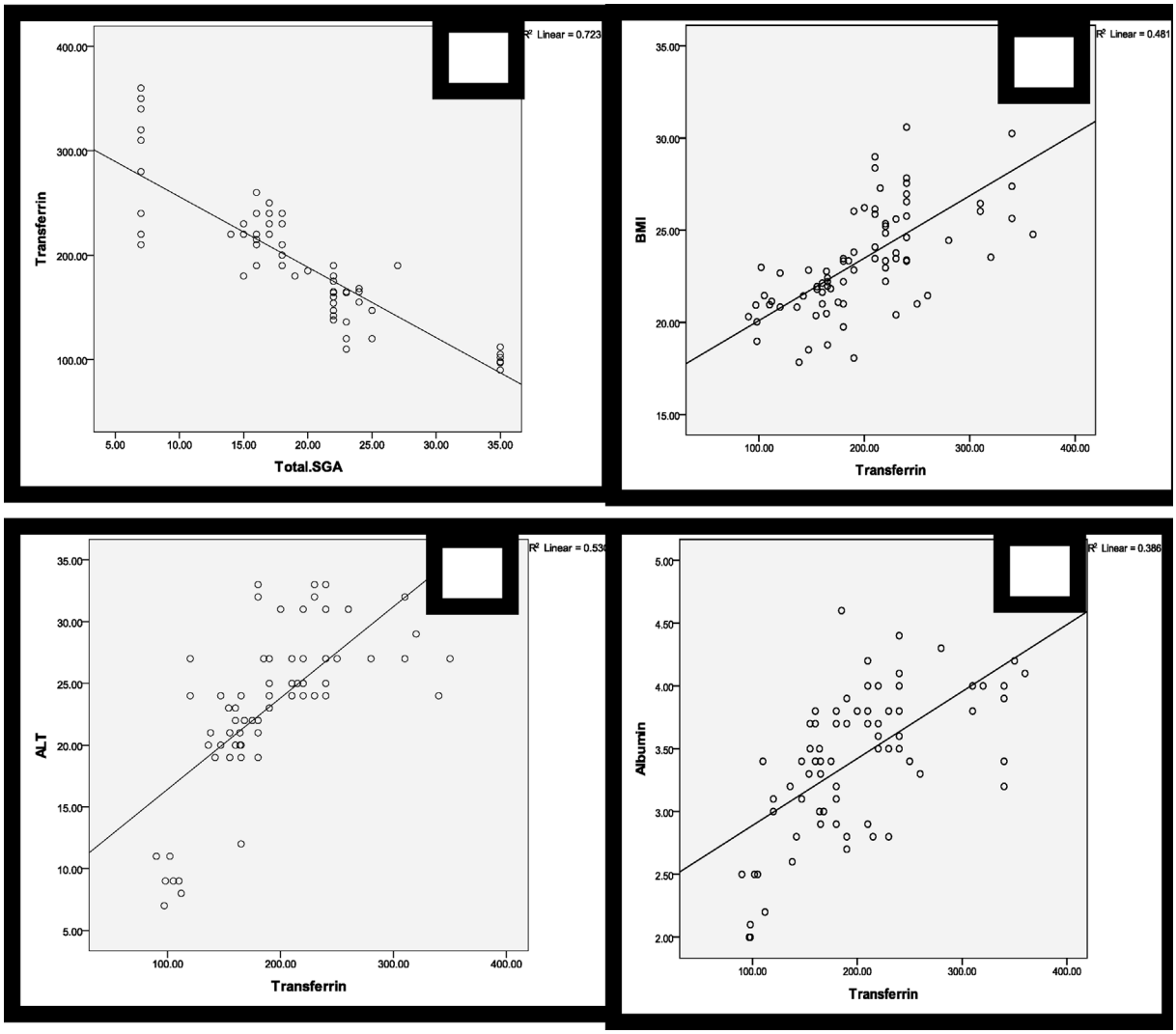

Fig. 2. A: Inverse correlation between SGA and Transferrin; B: Positive correlation between transferrin and body mass index; C: Positive correlation between transferrin and ALT; D: Positive correlation between transferrin and albumin.

not find significant correlation between hemoglobin and nutritional status.

Numerous variables, including decreased erythropoietin production, hyperparathyroidism, acute and chronic inflammatory diseases, aluminum toxicity, and shortened red blood cell life span, might alter hemoglobin levels in HD patients. This is why there is variation across studies.

There were no statistically significant differences between the 3 groups regarding s. creatinine and urea but there was statistically significant correlation between s. creatinine and SGA. **Freitas *et al.*,**[11] similarly reported presence of significant correlation between malnutrition and creatinine but not urea. Post dialysis serum creatinine showed statistically significant correlation to malnutrition and mortality in a study by **Kanno *et al.*,.**[12]

Serum calcium was lower among malnutrition group than normal patients however it did not differ significantly according to disease severity. The correlation between serum calcium and SGA was inverse and of statistically significance. Serum phosphorus levels were comparable with no statistically significant correlation between serum phosphorus and SGA. On the other hand, **Rezeq *et al.*,**[8] did not find any correlation between SGA and serum calcium or phosphate levels.

These biochemical indicators, such as serum albumin, hemoglobin, and cholesterol levels, are often employed to evaluate the general population's nutritional condition. **Espahbodi *et al.*,**[13] the observed biochemical markers and malnutrition were not significantly correlated.

We evaluated the correlation between transferrin and baseline demographics and associated medical

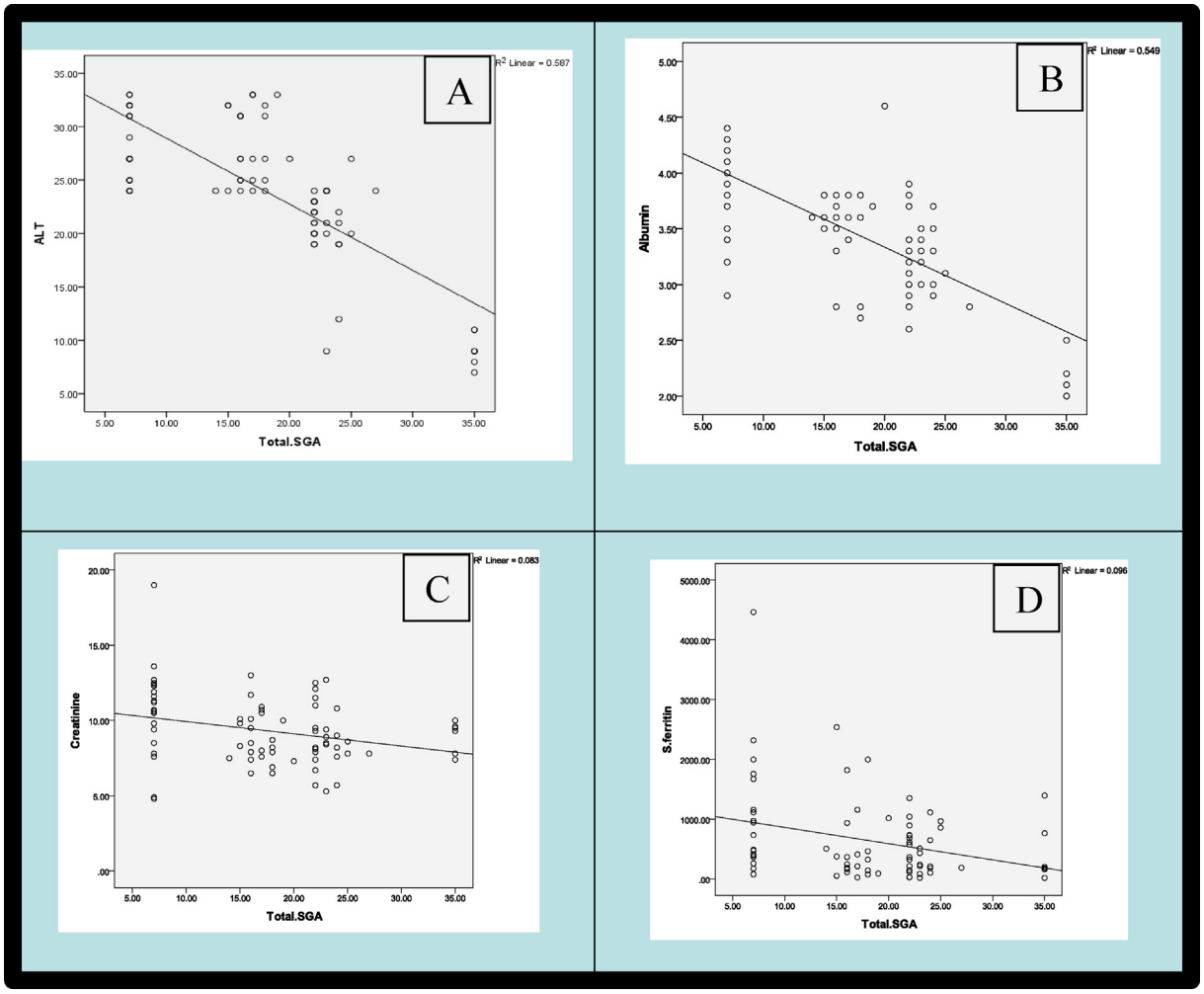

Fig. 3. A: Inverse correlation between SGA and ALT; B: Inverse correlation between SGA and albumin; C: Inverse correlation between SGA and s.creatinine; D: Inverse correlation between ferritin and SGA.

disorders. There was no difference between both genders and no age differences were found regarding transferrin levels. **Zhao *et al.*,**[14] came in agreement with us and reported no age or sex differences in serum transferrin levels. There was statistically significant correlation between transferrin and BMI. In agreement with the current study, **Alam *et al.*,**[15] reported strong relation positive relation between transferring and BMI.

Also, there was correlation between diabetes and low transferrin levels similar to **Zhao *et al.*,**[14] who found negative correlation between transferrin and incidence of diabetes. In the current study, there was also significant correlation between transferrin and hypertension against what was reported by **Zhao *et al.*,**.[14] On analysis the correlation between transferrin and other biochemical properties, there was no statistically significant correlation except with albumin and ALT. No correlation was found between transferrin and hemoglobin. In contrary to the current study, **Zhao *et al.*,**[14] reported significant correlation between hemoglobin and transferrin but he also found significant correlation with serum albumin. in Ikeda-Taniguchi study, transferring and total iron binding capacity were correlated to serum albumin[16].

The study had the advantage of being performed on relatively large sample size and included different grades of malnutrition. Also, we included in the analysis different parameters which may be related to the incidence of malnutrition and these factors were analyzed using univariate analysis then were adjusted for confounders in multivariate analysis. The study had some limitations as lack of randomization. We did not perform serial measurements of serum transferrin and we did not evaluate the relation to improvement or the effect of any intervention.

Authorship

All authors have a substantial contribution to the article.

Conflict of interest

Authors declare that there is no conflict of interest, no financial issues to be declared.

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