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Could Uric Acid to High-Density Lipoprotein-Cholesterol Ratio be Considered as a Marker of Hemodialysis Sufficiency?

Ürik Asit Yüksek Yoğunluklu Lipoprotein-Kolesterol Oranı, Hemodiyaliz Yeterliliğinin Bir Belirteci Olarak Kabul Edilebilir Mi?

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Abstract

Aim: Hemodialysis (HD) is one of the most widely utilized renal replacement therapies in individuals with end-stage chronic kidney disease (CKD). The purpose of this study was to compare the Uric acid to HDL cholesterol ratio (UHR) levels of well-treated HD patients to those of those who had inadequate HD therapy.

Material and Method: In the research, 60 participants had sufficient HD, and 24 had insufficient HD. 31 men (52%) and 29 women (48%) had adequate HD, whereas 17 men (71%) and seven women (29%) did not. Data on HD patients were acquired from patient files and the institution's database. A URR value of more than 70% designated the sufficient HD group, whereas less than 70% defined the insufficient HD group. Furthermore, laboratory data, such as the UHR of the study groups, were compared.

Results: The UHRs for adequate and inadequate HD were 0.160±04 and 0.20±0.07, respectively. The UHR of patients with insufficient HD was substantially greater than that of the subjects with sufficient HD (p=0.004). Besides, UHR was substantially and positively connected with urea before HD (r=0.37, p=0.001), urea after HD (r=0.39, p=0.001), serum creatinine before HD (r=0.48, p0.001), serum creatinine after HD (r=0.45, p0.001), and negatively correlated with URR (r=-0.29, p=0.008), according to correlation analyses. In individuals with chronic renal disease, a UHR value higher than 0.16 exhibited 67% sensitivity and 57% specificity in detecting inadequate HD.

Conclusion: We propose that UHR, in addition to URR, might be used to determine HS sufficiency in CKD patients undergoing HD therapy.

Keywords: Hemodialysis, uric acid to HDL cholesterol ratio, urea reduction ratio

Öz

Amaç: Hemodiyaliz (HD), son dönem kronik böbrek hastalığı (KBH) olan bireylerde en yaygın kullanılan renal replasman tedavilerinden biridir. Bu çalışmanın amacı, iyi tedavi edilen HD hastalarının Ürik asit / HDL kolesterol oranı (UHR) düzeylerini, yetersiz HD tedavisi almayanlarınkilerle karşılaştırmaktı.

Gereç ve Yöntem: Araştırmada 60 katılımcının HD'si yeterli, 24'ünün HD'si yetersizdi. 31 erkek (%52) ve 29 kadın (%48) yeterli HD'ye sahipken, 17 erkek (%71) ve yedi kadın (%29) değildi. HD hastalarına ilişkin veriler, hasta dosyalarından ve kurumun veri tabanından elde edildi. URR değerinin %70'in üzerinde olması yeterli HD grubunu, %70'in altında olması ise yetersiz HD grubunu tanımlamıştır. Ayrıca, çalışma gruplarının UHR'si gibi laboratuvar verileri karşılaştırıldı.

Bulgular: Yeterli ve yetersiz HD için UHR'ler sırasıyla 0,160±04 ve 0,20±0,07 idi. Yetersiz HD'si olan hastaların UHR'si, yeterli HD'si olan deneklerden önemli ölçüde daha yüksekti (p=0.004). Ayrıca UHR, HD öncesi üre (r=0,37, p=0,001), HD sonrası üre (r=0,39, p=0,001), HD öncesi serum kreatinin (r=0,48, p0,001), serum Korelasyon analizlerine göre HD sonrası kreatinin (r=0.45, p0.001) ve URR ile negatif korelasyon (r=-0.29, p=0.008). Kronik böbrek hastalığı olan bireylerde, 0,16'dan yüksek bir UHR değeri, yetersiz HD'yi saptamada %67 duyarlılık ve %57 özgüllük sergilemiştir.

Sonuç: HD tedavisi gören KBH hastalarında HS yeterliliğini belirlemek için URR'ye ek olarak UHR'nin kullanılabileceğini öneriyoruz.

Anahtar Kelimeler: Hemodiyaliz, ürik asit HDL oranı, üre düşüş oranı

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INTRODUCTION

Hemodialysis (HD) is one of the most widely utilized renal replacement therapies in individuals with end-stage chronic kidney disease (CKD). Urea reduction ratio (URR) and normalized treatment ratio (Kt/V) are two indicators used to calculate HD dosage (1). Inflammation is critical in the progression of CKD. According to the scientists, inflammatory markers and indicators of oxidative stress are higher in patients with grade 3-5 CKD than in healthy participants (2). Furthermore, inflammation is linked to the development of CKD (3). Many inflammatory markers have been investigated and discovered to be elevated in the HD population. C-reactive protein (CRP), tumor necrosis factor (TNF)-alpha, and adiponectin are examples (4; 5). Therefore, effective HD has a pivotal role in decreasing the inflammatory burden in CKD.

Uric acid is the byproduct of purine metabolism. The uric acid elevation is linked to oxidative damage and inflammation (6). Subjects with high uric acid levels are more likely to develop CKD (7). It also rises in people with diabetes with inadequate metabolic control (8; 9). The uric acid to HDL-cholesterol ratio (UHR) has recently been proposed as a potential metabolic and inflammatory measure in specific situations. It was hypothesized that UHR predicted metabolic syndrome better than any other metric (10).

Furthermore, it was linked to HbA1c levels in type 2 diabetes patients (11). Furthermore, individuals with non-alcoholic fatty liver disease had greater UHR levels than healthy controls (12). Because metabolic syndrome, type 2 diabetes, and non-alcoholic fatty liver disease are all illnesses with a low-grade chronic inflammatory burden, UHR has been acknowledged as a metabolic and inflammatory marker. Therefore, in the present study, we aimed to determine UHR levels of the sufficiently treated HD patients according to URR level and compare them to those who received poor HD treatment.

MATERIAL AND METHOD

Study Design

A total of 84 subjects enrolled in the study; 60 were in the sufficient HD group and 24 in the insufficient HD group. There were 31 (52%) men and 29 (48%) women in the sufficient HD group, while there were 17 (71%) men and 7 (29%) women in the insufficient HD group. The mean age of the subjects in sufficient and insufficient HD groups were 62±15 and 58±14 years, respectively. This study was designed retrospectively, and after approval from the institutional review board, the data about HD patients were obtained from the patient's files and the institution's database. A sufficient HD group was determined with a URR value greater than 70%. The subjects with a URR value equal to or below 70% were grouped as insufficient HD subjects. The age and gender of the sufficient and insufficient HD groups were recorded. Urea, creatinine, and potassium (K) levels were recorded before and after dialysis. Complete blood count parameters, leukocyte count (WBC), hemoglobin (Hb), hematocrit (Htc), and platelet count (Plt) of the study groups were obtained. Fasting plasma glucose, alanine transaminase, sodium (Na), phosphorus (P), bicarbonate (HCO3), parathyroid hormone (PTH), total cholesterol, LDL cholesterol, HDL cholesterol, triglyceride, c-reactive protein (CRP), serum iron, iron-binding capacity, and ferritin levels were also obtained and recorded. In addition, KTV and URR levels were calculated. UHR was calculated by simple division of serum uric acid by HDL cholesterol. Data from the sufficient and insufficient HD groups were compared. All procedures were carried out under the ethical rules and the principles of the Declaration of Helsinki. Our study was approved by the XXX University Non-Interventional Clinical Researches Ethics Committee (Date: 20.05.2021, Decision No: 16318).

Statistical Analyses

The SPSS software (SPSS 18.0 for Windows, IBM Co., Chicago, IL, USA) is used to conduct the statistical analyses. The distribution of the variables between study groups was analyzed with the Shapiro-Wilk test. Variables with normal distribution were expressed as mean ± standard deviation (SD) and compared with independent samples t-test. Variables without normal distribution were expressed as median (min.-max.) and compared with the Mann-Whitney U test. A comparison of categorical variables was conducted with the X2 test. Pearson's correlation analysis test revealed a possible correlation between study variables. Receiver operative characteristics (ROC) analysis is used to observe the sensitivity and specificity of UHR in determining HD sufficiency. A p-value lower than 0.05 was considered statistically significant.

RESULTS

Age was not significantly different among the study groups (p=0.21). Gender was also not statistically different among study groups.

Urea before HD (p=0.11), K before HD (p=0.15), Na (p=), Ca (p=0.97), total protein (p=0.52), albumin (p=0.31), FPG (p=0.73), HCO3 (p=0.35), total cholesterol (p=0.08), HDL cholesterol (p=0.12), CRP (p=0.13), WBC (p=0.053), Plt (p=0.88), PTH (p=0.95), serum iron (p=0.42) and iron binding capacity (p=0.08) of the sufficient and insufficient HD groups were not statistically different.

Serum creatinine before (p=0.01) and after (p<0.001) HD, urea after HD (p<0.001), K after HD (p=0.02), P (p=0.01), uric acid (p=0.01) and ferritin (p=0.03) levels of the sufficient and insufficient HD groups were statistically different. **Table 1** and **Table 2** show the general data and laboratory findings of the study population. **Table 3** demonstrates descriptive statistics.

Table 1. Demographic characteristics of the patients

	n	%
Age (year)		
Min-Max	23-88	
Mean±SD	60,75±14,3	
Gender		
Female	36	(42,9)
Male	48	(57,1)
Dialysis way of entry		
Permanent right subclavian catheter	7	8,3
Right AVF	19	22,6
Right Femoral catheter	1	1,2
Permanent right femoral catheter	1	1,2
Right juguler catheter	5	6,0
Left AVF	51	60,7
Primary etiological cause		
Idiopathic	16	19,0
Atrophic kidney	1	1,2
Diabetes Mellitus	14	16,7
Diabetes Mellitus + hypertension	17	20,2
Diabetes Mellitus + hypertension + Nephrolithiasis	2	2,4
FMF	2	2,4
FMF + Amyloidosis	2	2,4
Glomerulonephritis	3	3,6
Hypertension	13	15,5
Hypertension + Nephrolithiasis	1	1,2
Cystic kidney disease	1	1,2
Contrast nephropathy	1	1,2
Nephrolithiasis	3	3,6
Nephrotic syndrome	1	1,2
Polycystic kidney	3	3,6
Renal cancer	1	1,2
Systemic lupus erythematosus	1	1,2
Tuberculosis	1	1,2
Wegener granulomatosis	1	1,2

AVF: Arteriovenous fistula, FMF: Familial Mediterranean Fever

Table 2. Laboratory data of the study population

Laboratory Findings	Minimum-Maximum	Mean- Std. Deviation
Urea (Dialysis entrance)	6-206	125,61±32,19
Urea (Dialysis exit)	9-96	33,39±14,96
Creatin (Dialysis entrance)	3,39-14,6	7,89±2,37
Creatin (Dialysis exit)	0,81-6,6	2,64±1,15
Potassium (Dialysis entrance)	3,7-7,03	5,46±0,7
Potassium (Dialysis exit)	2,15-5,03	3,6±0,47
Ferritin	9,4-1867	633,05±481,48
PTH	17-2000	505,44 ±358,99
CRP	0,21-84	9,63±11,35
Uric acid	3,8-9,2	5,83±1,09
HDL	20-76	37±9,9
KTV	0,86-20,8	1,89±2,11
URR	49-86	74,26±6,34

PTH: Parathormone, CRP: C-Reactive Protein, HDL: High-Density Lipoprotein, URR: Urea reduction ratio KTV(Kt/V): normalized treatment ratio

Table 3. Descriptive analysis of patients.

Descriptive Statistics

		Median	Mean	Std. Error	Std. Deviation	Min.	Max.
Age	F	64.500	61.882	2.475	14.432	23.000	82.000
Age	M	61.000	59.980	2.034	14.383	26.000	88.000
Dialysis time (month)	F	16.000	16.029	0.143	0.834	15.000	17.000
Dialysis time (month)	M	16.000	16.160	0.108	0.766	15.000	17.000
Uric acid	F	5.400	5.582	0.162	0.945	3.800	7.600
Uric acid	M	5.900	5.998	0.163	1.152	4.000	9.200
CRP	F	5.000	6.986	1.137	6.633	0.210	35.000
CRP	M	7.020	11.437	1.899	13.426	0.880	84.000
HDL	F	40.000	41.000	1.862	10.857	20.000	76.000
HDL	M	34.000	34.240	1.153	8.156	21.000	60.000
LDL	F	93.000	101.676	6.118	35.675	38.000	184.000
LDL	M	73.000	76.180	3.665	25.916	25.000	159.000
T.KOL	F	164.000	170.706	7.800	45.482	101.000	289.000
T.KOL	M	138.500	139.560	4.769	33.722	79.000	219.000
KT/V	F	1.830	2.371	0.561	3.269	1.250	20.800
KT/V	M	1.535	1.566	0.036	0.256	0.860	2.100
URR %	F	79.000	77.265	0.905	5.276	66.000	86.000
URR %	M	73.000	72.220	0.884	6.248	49.000	85.000

CRP: C-Reactive Protein, HDL: High-Density Lipoprotein, URR: Urea reduction ratio KTV(Kt/V): normalized treatment ratio. Min.: Minimum, Max.: Maximum

The UHR of the sufficient and insufficient HD groups were 0.16±0.04 and 0.20± 0.07, respectively. UHR of the subjects with insufficient HD was significantly higher than that of the sufficient HD group (p=0.004). **Table 4** reveals independent sample statistical results.

Correlation analyses revealed that UHR was significantly and positively correlated with urea before HD (r=0.37, p=0.001), urea after HD (r=0.39, p=0.001), serum creatinine before HD (r=0.48, p<0.001), serum creatinine after HD (r=0.45, p<0.001), and inversely correlated with URR (r=-0.29, p=0.008). **Table 5** indicates correlation analyses.

In ROC analysis, a UHR value greater than 0.16 had 67% sensitivity and 57% specificity in determining insufficient HD in patients with chronic kidney disease (**Figure**).

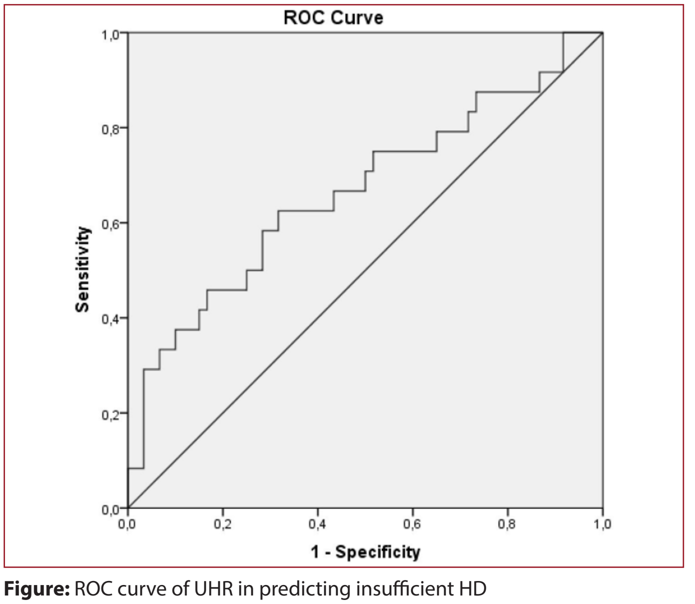

Figure: ROC curve of UHR in predicting insufficient HD

Table 4. Statistical analysis of independent samples test results.

Independent Samples Test

	Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
			t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
AGE	0,005	0,947	1,267	82	0,209	4,375	3,452	-2,493	11,243
			1,303	45,049	0,199	4,375	3,358	-2,388	11,138
ureaentrance	0,211	0,647	-1,617	82	0,110	-12,450	7,700	-27,768	2,868
			-1,659	44,844	0,104	-12,450	7,504	-27,566	2,666
Creaentrance	3,193	0,078	-2,678	82	0,009	-1,4791667	0,5524128	-2,5780916	-0,3802417
			-2,342	33,215	0,025	-1,4791667	0,6316584	-2,7639687	-0,1943647
Kexit	0,066	0,798	-2,425	82	0,017	-0,2677500	0,1104071	-0,4873849	-0,0481151
			-2,251	36,710	0,030	-0,2677500	0,1189556	-0,5088413	-0,0266587
UA	7,604	0,007	-2,670	82	0,009	-0,6760000	0,2531996	-1,1796947	-0,1723053
			-2,236	31,122	0,033	-0,6760000	0,3023790	-1,2926076	-0,0593924
HCO3	2,720	0,103	0,935	82	0,353	0,5768333	0,6171685	-0,6509113	1,8045780
			1,077	59,117	0,286	0,5768333	0,5355606	-0,4947767	1,6484434
HDL	0,189	0,665	1,567	82	0,121	3,700	2,362	-0,998	8,398
			1,563	42,210	0,126	3,700	2,367	-1,077	8,477
Chol	1,103	0,297	1,788	82	0,077	17,733	9,916	-1,993	37,460
			2,005	55,197	0,050	17,733	8,846	0,008	35,459
UHR	5,392	0,023	-2,950	82	0,004	-0,04175	0,01415	-0,06990	-0,01360
			-2,471	31,133	0,019	-0,04175	0,01690	-0,07620	-0,00730

UA: Uric Acid, HCO3: Bicarbonate, HDL: High-Density Lipoprotein, UHR: Uric acid to HDL cholesterol ratio

Table 5. Pearson correlation analyses.

Correlations

	AGE	ureaentrance	ureaexit	Creaentrance	Creaeaexit	CRP	KTV	URR	UHR
	1	-0.227*	-0.215*	-0.477**	-0.374**	0.016	0.121	0.084	-0.205
AGE		0.038	0.049	0.000	0.000	0.888	0.272	0.449	0.062
	84	84	84	84	84	84	84	84	84
	-0.227*	1	0.790**	0.398**	0.482**	-0.004	-0.103	-0.255*	0.365**
ureaentrance	0.038		0.000	0.000	0.000	0.972	0.351	0.019	0.001
	84	84	84	84	84	84	84	84	84
	-0.215*	0.790**	1	0.460**	0.742**	0.079	-0.274*	-0.726**	0.386**
ureaexit	0.049	0.000		0.000	0.000	0.473	0.012	0.000	0.000
	84	84	84	84	84	84	84	84	84
	-0.477**	0.398**	0.460**	1	0.873**	0.080	-0.104	-0.354**	0.477**
Creaentrance	0.000	0.000	0.000		0.000	0.468	0.346	0.001	0.000
	84	84	84	84	84	84	84	84	84
	-0.374**	0.482**	0.742**	0.873**	1	0.106	-0.183	-0.697**	0.450**
Creaeaexit	0.000	0.000	0.000	0.000		0.335	0.095	0.000	0.000
	84	84	84	84	84	84	84	84	84
	0.016	-0.004	0.079	0.080	0.106	1	-0.092	-0.123	0.067
CRP1	0.888	0.972	0.473	0.468	0.335		0.403	0.266	0.545
	84	84	84	84	84	84	84	84	84
	0.121	-0.103	-0.274*	-0.104	-0.183	-0.092	1	0.265*	-0.098
KTV1	0.272	0.351	0.012	0.346	0.095	0.403		0.015	0.376
	84	84	84	84	84	84	84	84	84
	0.084	-0.255*	-0.726**	-0.354**	-0.697**	-0.123	0.265*	1	-0.288**
URR1	0.449	0.019	0.000	0.001	0.000	0.266	0.015		0.008
	84	84	84	84	84	84	84	84	84
	-0.205	0.365**	0.386**	0.477**	0.450**	0.067	-0.098	-0.288**	1
UHR	0.062	0.001	0.000	0.000	0.000	0.545	0.376	0.008	
	84	84	84	84	84	84	84	84	84

CRP: C-Reactive Protein, UHR: Uric acid to HDL cholesterol ratio, URR: Urea reduction ratio KTV(Kt/V): normalized treatment ratio

DISCUSSION

We showed for the first time in the medical literature that UHR could predict HD sufficiency in CKD patients receiving HD treatment. Significant inverse correlation between UHR and URR and considerable sensitivity and specificity of UHR in selecting subjects with insufficient HD are essential outcomes of the present study.

The role of UHR was foremost proposed by Aktas et al. (10) and Kocak et al. (11) in subjects with type 2 diabetes mellitus and metabolic syndrome. It was considered a metabolic predictor and, thus, an inflammatory marker in chronic conditions characterized by continuous low-grade inflammation. Chronic kidney disease is also related to a chronic inflammatory burden (19;20). Therefore, the relationship between UHR and dialysis sufficiency reported in the present study is not surprising. Indeed, the authors reported an inverse correlation between glomerular filtration rate and UHR (11).

The present study correlated serum creatinine levels before and after dialysis with UHR. Similar studies have been reported in the literature (21;22). Impaired renal functions have been reported in subjects with high normal uric acid levels (13), a component of the UHR. Similar results have been reported by Cai et al. (14). There was a weak but significant inverse correlation between serum uric acid and glomerular filtration rate in a study from Taiwan (15). Per the literature knowledge, we reported a significant correlation between UHR and serum creatinine levels, the most important determinant of glomerular filtration rate.

Various reasons may cause chronic inflammation in the CKD population. Bio-incompatible dialysis membranes, infections of the fistula or graft used as HD access, endotoxin exposure, malnutrition, poor dental hygiene, dialysate, and back filtration are possible components of inflammatory burden in these patients (5; 16-18). Although CRP is nearly a universal marker of inflammation, our study showed that CRP levels of sufficient and insufficient HD groups were not statistically different (23-25). Moreover, there was no significant correlation between UHR and CRP levels. We consider that this was mainly due to the small study population of the present report.

Limitations

Limitations of our study are a retrospective design which may cause difficulties in interpreting the study results and a relatively small study population. The second limitation could be the lack of investigation of the other laboratory parameters, such as TNF alpha and interleukins. However, to our knowledge, this is the first study in the literature that pointed out an association between UHR and HD sufficiency.

CONCLUSION

In conclusion, we suggest that UHR could be an auxiliary tool to URR in determining HS sufficiency in CKD patients receiving HD treatment. However, prospective studies with a larger cohort may be required to suggest the relationship between UHR and inflammation in this population.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Amasya University Non-interventional Clinical Research Ethics Committee (Date: 20.05.2021, Decision No: 16318).

Informed Consent: All participants signed the free and informed consent form.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

REFERENCES

1. Li Z, Lew NL, Lazarus JM, Lowrie EG. Comparing the urea reduction ratio and the urea product as outcome-based measures of hemodialysis dose. Am J Kidney Dis 2000;35(4):598-605.
2. Oberg BP, McMenamin E, Lucas FL, et al. Increased prevalence of oxidant stress and inflammation in patients with moderate to severe chronic kidney disease. Kidney Int 2004;65(3):1009-16.
3. Ruiz S, Pergola PE, Zager RA, Vaziri ND. Targeting the transcription factor Nrf2 to ameliorate oxidative stress and inflammation in chronic kidney disease. Kidney Int 2013;83(6):1029-41.
4. Kir HM, Eraldemir C, Dervisoglu E, Caglayan C, Kalender B. Effects of chronic kidney disease and type of dialysis on serum levels of adiponectin, TNF-alpha and high sensitive C-reactive protein. Clin Lab 2012;58(5-6):495-500.
5. Brito F, Almeida S, Figueredo CM, Bregman R, Suassuna JH, Fischer RG. Extent and severity of chronic periodontitis in chronic kidney disease patients. J Periodontal Res 2012;47(4):426-30.
6. Glantzounis GK, Tsimoyiannis EC, Kappas AM, Galaris DA. Uric acid and oxidative stress. Curr Pharm Des 2005;11(32):4145-51.
7. Obermayr RP, Temml C, Gutjahr G, Knechtelsdorfer M, Oberbauer R, Klauser-Braun R. Elevated uric acid increases the risk for kidney disease. J Am Soc Nephrol 2008;19(12):2407-13.
8. Duman TT, Kocak MZ, Atak BM, Erkus E. Serum uric acid is correlated with HbA1c levels in type 2 diabetes mellitus. Exp Bio Res 2018;1(1):6-9.
9. Atak BM, Duman TT, Kocak MZ, Savli H. Serum uric acid level is associated with type 2 diabetes mellitus and diabetic regulation. Exp Bio Res 2018;1(4):135-9.
10. Kocak MZ, Aktas G, Erkus E, Sincer I, Atak B, Duman T. Serum uric acid to HDL-cholesterol ratio is a strong predictor of metabolic syndrome in type 2 diabetes mellitus. Rev Assoc Med Bras 2019;65(1):9-15.
11. Aktas G, Kocak MZ, Bilgin S, Atak BM, Duman TT, Kurtkulagi O. Uric acid to HDL cholesterol ratio is a strong predictor of diabetic control in men with type 2 diabetes mellitus. Aging Male 2020;23(5):1098-102.
12. Zhang Y-N, Wang Q-Q, Chen Y-S, Shen C, Xu C-F. Association between serum uric acid to hdl-cholesterol ratio and non-alcoholic fatty liver disease in lean chinese adults. Int J Endocrinol 2020;2020:1-6.
13. Rosolowsky ET, Ficociello LH, Maselli NJ, et al. High-normal serum uric acid is associated with impaired glomerular filtration rate in nonproteinuric patients with type 1 diabetes. Clin J Am Soc Nephrol 2008;3(3):706-13.
14. Cai XL, Han XY, Ji LN. High-normal serum uric acid is associated with albuminuria and impaired glomerular filtration rate in Chinese type 2 diabetic patients. Chin Med J (Engl) 2011;124(22):3629-34.
15. See LC, Kuo CF, Chuang FH, et al. Serum uric acid is independently associated with metabolic syndrome in subjects with and without a low estimated glomerular filtration rate. J Rheumatol 2009;36(8):1691-8.

16. Nadeem M, Stephen L, Schubert C, Davids MR. Association between periodontitis and systemic inflammation in patients with end-stage renal disease. SADJ : journal of the South African Dental Association = tydskrif van die Suid-Afrikaanse Tandheelkundige Vereniging 2009; 64: 470-3.
17. Noack B, Genco RJ, Trevisan M, Grossi S, Zambon JJ, De Nardin E. Periodontal infections contribute to elevated systemic C-reactive protein level. J Periodontol 2001;72(9):1221-7.
18. Pejcic A, Kesic LJ, Milasin J. C-reactive protein as a systemic marker of inflammation in periodontitis. European journal of clinical microbiology & infectious diseases : official publication of the European Society of Clin Microbiol 2011; 30: 407-14.
19. Stenvinkel P, Chertow GM, Devarajan P, et al. Chronic Inflammation in Chronic Kidney Disease Progression: Role of Nrf2. Kidney Int Rep 2021;6(7):1775-87.
20. Brennan E, Kantharidis P, Cooper ME, Godson C. Pro-resolving lipid mediators: regulators of inflammation, metabolism and kidney function. Nat Rev Nephrol 2021;17(11):725-39.
21. Agraharkar M, Nair V, Patlovany M. Recovery of renal function in dialysis patients. BMC Nephrol 2003;4:9.
22. Bani-Hani S, Showkat A. Renal function recovery in dialysis dependent patients. Tenn Med 2013;106(8):36-40.
23. Valga F, Monzón T, Vega-Diaz N, Rodriguez-Perez JC, Ruiz-Santana S. Inflammation and hemodialysis adequacy: Are C-reactive protein levels influenced by dialysis dose? Nefrologia (Engl Ed) 2021:S0211-6995(21)00112-0.
24. Hajji M, Khedher R, Mrad M, et al. Effects of Zinc supplementation on serum copper to Zinc and CRP to albumin ratios in hemodialysis patients. J Med Biochem 2021;40(2):193-8.
25. Ridker PM, Rane M. Interleukin-6 Signaling and Anti-Interleukin-6 Therapeutics in Cardiovascular Disease. Circ Res 2021;128(11):1728-46.