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Original Article

Efficacy of hemodialysis and its effect on nutritional status of renal failure patients

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Abstract: Objective: This study aimed to explore the efficacy of hemodialysis and its effect on the nutritional status of patients with renal failure. Methods: A total of 92 patients admitted to our hospital due to rental failure form January 2017 to May 2019 were included as the study subjects and randomized into the study group (n=46) and the control group (n=46) according to a Random Number Table. They were treated by hemodialysis in the control group, hemodialysis and hemodiafiltration in the study group; and compared for indexes for renal function [urea (UA), serum creatinine (Cr), β2-microglobulin (β2-MG), kidney injury molecule 1 (KIM-1)], renal anemia [ferroprotein (SF), hemoglobin (Hb), hepcidin (HePC), and erythropoietin (EPO)], nutritional status [total protein (TP), albumin (Alb), content of calcium and phosphorus)], inflammatory factors [interleukin-6 (IL-6), tumor necrosis factor-α (TNF-α), high-sensitivity C-reactive protein (hs-CRP)] and changes in quality of life before and after treatment, as well as incidences of adverse reactions. Results: After treatment, the observation group reported lower UA, Cr, β2-MG, KIM-1, phosphorus content, IL-6, TNF-α and hs-CRP, and higher SF, Hb, HePC, EPO, TP, Alb, calcium content, and scores of quality of life as compared with the conditions before treatment and with the control group ($P<0.05$). In comparison with the control group, the observation group also reported lower total incidence of adverse reactions ($P<0.05$). Conclusion: Hemodialysis and hemofiltration contributed to improved renal function, renal anemia and nutritional status, alleviated inflammatory reactions, enhanced quality of life and reduced the adverse reactions in patients with renal failure.

Keywords: Renal failure, hemodialysis, hemofiltration, efficacy, nutritional status

Introduction

Renal failure is a common disease that is present in patients seen in the nephrology department. It is a pathological state of partial or total loss of renal function, as various chronic renal diseases progress to the end stage. Clinically, renal failure is divided into acute and chronic; of which, acute failure develops rapidly after the patients suffer from impaired functions or toxic injuries due to insufficient blood supply in the kidneys (mostly because of trauma and burns), and kidney obstruction, while the chronic renal failure is a result of long-term renal lesions which develop as time goes on, resulting in the compromised renal function of the patients [1, 2]. Patients with acute or chronic renal failure have symptoms such as oliguresis, urorrhagia, azotemia and uraemia [3, 4]. Previously, patients with renal failure were clinically treated by hemodialysis, which can effectively remove various toxins from patients, reduce the pathological damage of tissues and organs, and improve the prognosis of patients. However, the traditional hemodialysis therapy mainly removes small molecular substances through the principle of dispersion. With the increase of the relative molecular mass of poisons in the blood, the removal rate of toxins decreases significantly. Medium and large molecular substances often cannot be completely removed, which has become an important factor that induces chronic complications in dialysis patients and may result in unsatisfactory prognosis and nutritional status [5, 6]. Therefore, how to more effectively treat renal failure has become a major subject in the nephrology department in recent years. Continuous hemofiltration is also a common method of hemodialysis, which has good a adsorption and clearance effects on inflammatory molecules and toxic substances with medium molecular weight of

25-40 kd, and can improve the internal environment of patients, increase muscle oxygenation index, stabilize blood pressure, and reduce adverse effects caused by vasoactive drugs. Therefore, the combination of the two dialysis methods may be more effective in patients with renal failure. This study selected 92 patients with renal failure and randomized them into two groups for treatment with hemodialysis or hemodialysis combined with hemofiltration, in order to provide valuable references for the clinical treatment of renal failure. The details are reported as follows.

Materials and methods

General materials

A total of 92 patients who were admitted to our hospital due to renal failure from January 2017 to May 2019 were included and divided into the study group (n=46) and the control group (n=46) according to a Random Number Table. All patients satisfied the diagnosis criteria of renal failure, agreed to and provided informed consent to participate in the study with their family members. Patients with concurrent autoimmune diseases, diseases in brain, infectious diseases, mental disorders, cardiac, hepatic and pulmonary dysfunction were excluded. The study was approved by the Ethics Committee of The First People's Hospital of Wenling.

Treatment method

Both groups, upon hospitalization, were routinely treated by intravenous drip of isotonic saline solution to ensure the balance between water electrolytes and pH value, nutritional support, administration of diuretics and resistance against infection. In the meanwhile, all nephrotoxic drugs were withdrawn. The control group was further treated with hemodialysis according to the procedures of establishing an intravenous pathway, performing the internal arteriovenous fistula operation, and hemodialysis with the Hollow Fiber dialyzer-F14. The membrane surface area was 1.4 m^2. During hemodialysis, the blood flowrate was controlled between 260-300 mL/min and anticoagulant therapy was given with low molecular heparin. For patients with high risk of bleeding, low-dose heparin or absence of heparin was suggested as appropriate. The hemodialysis was conducted twice a week. The study group was treated by hemodialysis and hemofiltration with the FX80 blood filter. The membrane surface area was 1.8 m^2. With the instrument networked, the diluent was produced online and a post-dilution mode was adopted by setting the diluent flowrate between 80-120 mL/min, and blood flowrate between 260-300 mL/min. The hemodialysis was conducted twice a week. Both groups were treated for 4 months.

Observation indexes

The 2 groups were compared for indexes of renal function (UA, Cr, β2-MG, KIM-1), renal anemia (SF, Hb, HePC, and EPO), nutritional status (TP, Alb, content of calcium and phosphorus), inflammatory factors (IL-6, TNF-α, hs-CRP) and changes in quality of life before and after treatment, as well as incidences of adverse reactions. For indexes of renal function, UA and Cr (with serum sample) were measured by an automatic biochemical analyzer, β2-MG (with serum sample) and KIM-1 (with urine sample) by ELISA. For rental anemia indexes, SF (with serum sample) was measured by chemiluminescence method, Hb (with serum sample) by blood cell analyzer, HePC and EPO (with serum sample) by ELISA. For indexes of nutritional status, TP and Alb (with serum sample) were measured by an automatic biochemical analyzer, calcium and phosphorus content (with serum sample) by Arsenazo and phosphomolybdic acid methods. For inflammatory factors, IL-6 and TNF-α (with serum sample) were measured by ELISA method, and hs-CRP (with serum sample) by immunoturbidimetry. The quality of life was assessed according to the SF-36 scale with total points between 0 and 100, which rates positively with the quality of life of the patients. Adverse reactions include infection, cerebrovascular accident and hematosepsis, etc.

Statistical analysis

Statistical analysis was performed with SPSS 22.0. UA, Cr, β2-MG, KIM-1, SF, Hb, HePC, EPO, TP, Alb, content of calcium and phosphorus, IL-6, TNF-α, hs-CRP and quality of life were expressed as Mean ± SD, and comparatively studied through two-way ANOVA. The total incidence of adverse reactions was expressed as %, and validated by chi-squared test. For all statistical comparisons, significance was defined as $P<0.05$.

Table 1. Comparison between the 2 groups for general materials

Group	Gender (male/female)	Age (y)	Height (cm)	Body weight (kg)	Pathological type				Cultural background				
					Primary glomerulonephritis	Diabetic nephropathy	Chronic pyelonephritis	Hypertensive renal arteriosclerosis	Primary school and lower	Junior school	Secondary school	Senior school	College and above
Control Group (n=46)	28/18	51.17±7.88	165.66±4.41	65.62±7.83	16	13	11	6	11	12	9	9	5
Study Group (n=46)	26/20	51.26±7.23	165.73±4.27	65.78±7.51	18	12	12	4	12	13	8	8	5

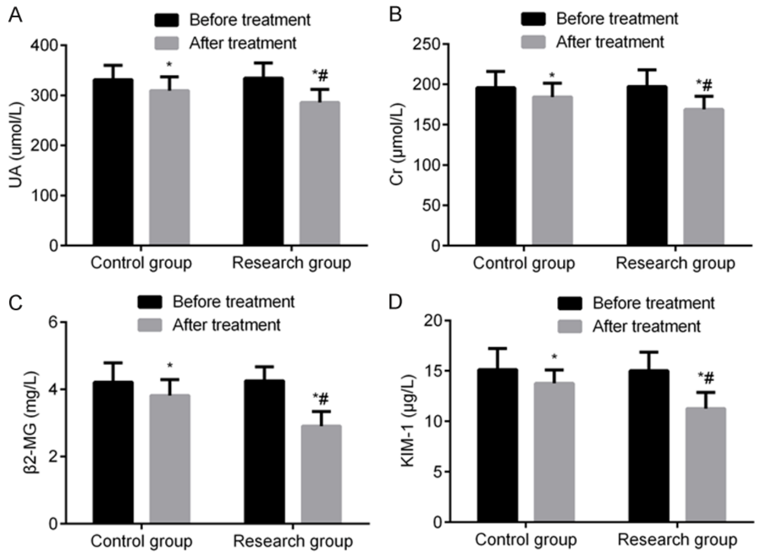

Figure 1. Comparison between the 2 Groups for Changes of Rental Function Indexes before and after Treatment (Mean ± SD). Note: (A) UA; (B) Cr; (C) β2-MG; (D) KIM-1. **P*<0.05 as compared with the conditions before treatment; #*P*<0.05 as compared with the control group.

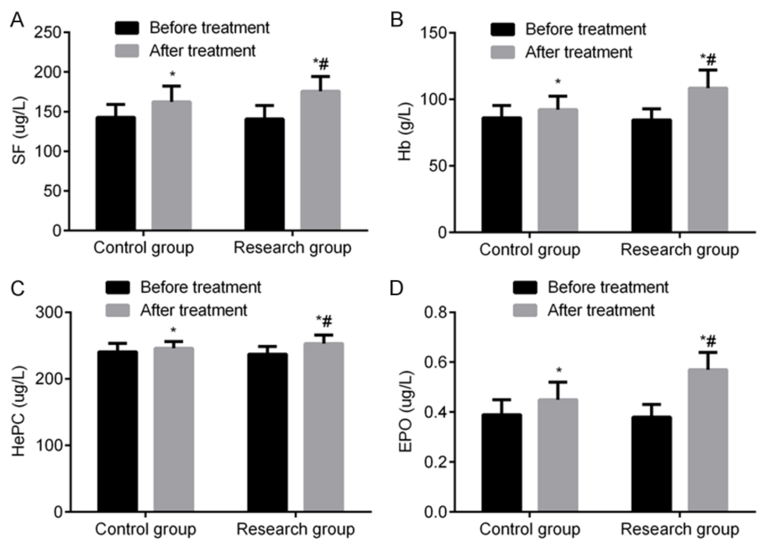

Figure 2. Comparison between the 2 Groups for Changes in Renal Anemia Indexes before and after Treatment (Mean ± SD). Note: (A) SF; (B) Hb; (C) HePC; (D) EPO. **P*<0.05 as compared with the conditions before treatment; #*P*<0.05 as compared with the control group.

Results

Comparison for clinical treatment

The 2 groups had no statistical difference in gender, age, height, weight, pathological type and cultural background (P>0.05, **Table 1**).

Hemodialysis and hemofiltration improving patients' renal functions

Though no statistical difference was demonstrated in the 2 groups in terms of UA, Cr, β2-MG and KIM-1 (P>0.05) before treatment; both groups showed a reduction after treatment, especially the study group in which, the reduction was more significant (P<0.05). These results indicate that the combination of hemodialysis and hemofiltration can significantly improve the renal function of patients better than routine hemodialysis alone (**Figure 1**).

Significant improvement of the patients' renal anemia by hemodialysis and hemofiltration

Before treatment, no statistical difference was observed between the 2 groups for SF, Hb, HePC, and EPO (P>0.05). After treatment, a significant elevation was seen in the study group as compared with the control group (P<0.05). The combination of hemodialysis and hemofiltration can prominently improve renal anemia in patients, making it superior to routine hemodialysis (**Figure 2**).

Hemodialysis and hemofiltration contributing to the significant improvement of patients' nutritional status

Before treatment, the 2 groups had no statistical difference in TP, Alb and calcium content (P>0.05). After treatment, both groups had a rise in nutritional factors, which was significant in the study group. On the contrary, the phosphorus content was reduced in both groups, leading to lower levels in the study group as compared with the control group (P<0.05). This indicated that the

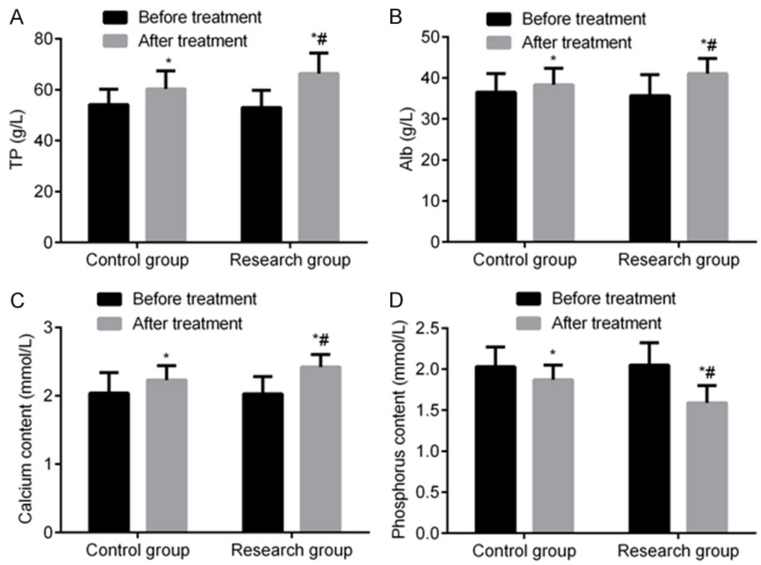

Figure 3. Comparison between the 2 Groups for Changes in Nutritional Status Indexes before and after Treatment (Mean ± SD). Note: (A) TP; (B) Alb; (C) Content of calcium; (D) Content of phosphorus. **P*<0.05 as compared with the conditions before treatment; #*P*<0.05 as compared with the control group.

combination of hemodialysis and hemofiltration can significantly improve patients' nutritional status with better efficacy than the routine hemodialysis (**Figure 3**).

Microinflammation improved by hemodialysis and hemofiltration

Before treatment, the 2 groups were compared for IL-6, TNF-α and hs-CRP without statistical difference (P>0.05). After treatment, the 3 indexes dropped in both groups, and more significantly in the study group as compared with the control group (P<0.05). This revealed a significant contribution of the combination of hemodialysis and hemofiltration to the alleviated microinflammation status and more superior efficacy as compared with routine hemodialysis (**Figure 4**).

Positive contribution of Hemodialysis and hemofiltration to patients' quality of life

Without statistical difference before treatment (P>0.05), both groups attained an increase in the score of quality of life after treatment (P< 0.05). Which was more significant in the study group (P<0.05, **Table 2**), supporting the positive contribution of hemodialysis and hemofiltration to patients' quality of life.

Comparison between the 2 groups for incidence of adverse reactions

The study group reported a total incidence of adverse reactions of 6.52% (3/46); far lower than the control group's 23.91% (11/46) (P<0.05, **Table 3**).

Discussion

Renal failure results from substantial damage to kidneys due to various factors and leads to reduced nephrons, and significantly compromised renal excretion and endocrine functions, resulting in imbalanced electrolytes and pH value, and accumulation of toxic metabolites [7, 8], accompanied with renal malnutrition or anemia, etc. [9, 10]. Previously, patients with rental failure were routinely treated by intravenous drip of isotonic saline solution to ensure the balance between electrolytes and pH value, nutritional support, administration of diuretics and resistance against infection, as well as hemodialysis, which may be effective but fails to purify the blood and cause the toxic metabolites being discharged out of the body. Furthermore, most of the patients with renal failure are not ideal in physical conditions, and they may suffer from various adverse reactions during long-term dialysis, which finally results in poor prognosis. Therefore, how to effectively treat renal failure has become a clinical hot spot in recent years.

Recently, with the progress in medical levels, hemodialysis and hemofiltration have become a routine substitutive therapy of the kidneys for patients with renal failure. Hemodialysis can effectively remove the small molecule toxic metabolites [11, 12], maintain the balance of electrolytes, and pH value, and plays a significant role in improving the clinical symptoms of patients. While, hemofiltration, as compared with routine hemodialysis, is more effective in removing the uremic toxins of middle and large sized molecules from the body of patients [13, 14], and has more advantages in the clearance of toxins and improvement of inflammatory fac-

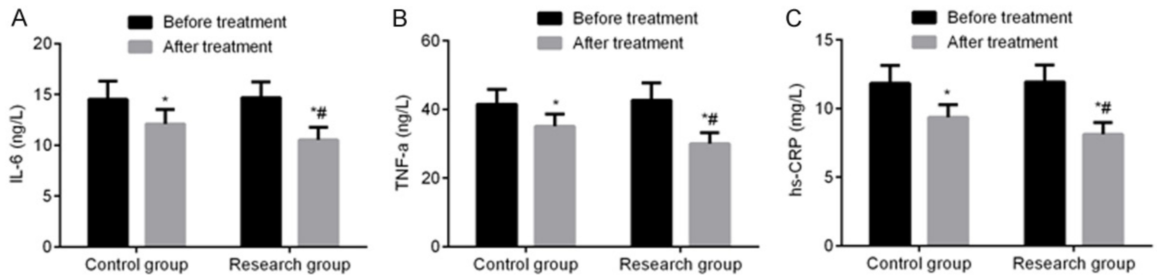

Figure 4. Comparison between the 2 Groups for Changes in Inflammatory Factors before and after Treatment (Mean ± SD). Note: (A) IL-6; (B) TNF-α; (C) hs-CRP. *$P<0.05$ as compared with the conditions before treatment; #$P<0.05$ as compared with the control group.

Table 2. Comparison between the 2 groups for changes in scores of quality of life before and after treatment (Mean ± SD, score)

Group	Before treatment	After treatment	*t*	*P*
Control Group (n=46)	59.32±7.93	65.31±7.27	3.776	0.000
Study Group (n=46)	58.10±8.12	73.10±8.10	8.870	0.000
T	0.729	4.854		
P	0.468	0.000		

tor secretion if combined with routine hemodialysis, showing great significance to the enhanced prognosis of patients. Serum UA, Cr, β2-MG and urine KIM-1 are common clinical indexes reflecting the renal function of patients [15-17]; of which, UA and Cr are metabolites of purine and protein in the blood circulation, which are discharged through kidneys, and common biochemical molecules in blood reflecting the renal function, and β2-MG is a small molecule protein produced by leukomonocytes. It can be decomposed after filtration in glomeruli and re-absorbed in proximal convoluted tubules to effectively reflect the filtration function of glomeruli [18]. According to the study results, the study group achieved a reduction in UA, Cr, β2-MG, and KIM-1 as compared with the conditions before treatment and with the control group, revealing that the combination of hemodialysis and hemofiltration can prominently improve the renal function of patients better than routine hemodialysis. Renal anemia is mainly caused by insufficient synthetic amounts of EPO and ferrum loss, leading to insufficient ferrum on the body [19]. Based on the study results, the study group demonstrated higher SF, Hb, HePC and EPO as compared with the conditions before treatment and with the control group, indicating that the combination of hemodialysis and hemofiltration can prominently alleviate the renal anemia of patients compared to routine hemodialysis. In the process of disease progression, lipids and proteins in the body of patients with renal failure are persistently consumed, which may easily result in malnutrition. For this reason, actively improving the nutritional status of patients plays a significant role [20, 21]. Referring to the study results, after treatment, the study group reported higher TP, Alb and calcium content and lower phosphorus content as compared with the conditions before treatment and with the control group, which was basically consistent with the study results obtained by Pan Xianfeng [5]. Such a result revealed that the combination of hemodialysis and hemofiltration can effectively improve the nutritional status of patients with renal failure in a superior way compared to the routine hemodialysis treatment. Non-microbial infections often result in patients with renal failure with low-strength and non-prominent inflammatory status. According to the study results, after treatment, the study group had lower IL-6, TNF-α and hs-CRP levels as compared with the conditions before treatment and with the control group, making it clear that the combination of hemodialysis and hemofiltration can effectively relieve the patients with renal failure from a microinflammatory status with superior efficacy compared to the routine treatment. In addition, the study results showed that after treatment, the study group achieved higher scores of quality of life than the conditions before treatment and the control group, and reported a lower total incidence of adverse reactions; which supported the fact that the combination of hemodialysis and hemofiltration can effectively improve the quality of life of patients with renal

Table 3. Comparison between the 2 groups for incidence of adverse reactions [n (%)]

Group	Infection	Cerebrovascular accident	Hematosepsis	Total incidence
Control Group (n=46)	5 (10.87)	4 (8.70)	2 (4.35)	11 (23.91)
Study Group (n=46)	2 (4.35)	1 (2.17)	0 (0.00)	3 (6.52)
χ^2	-	-	-	5.392
P	-	-	-	0.000

failure, compared to routine hemodialysis, and with less adverse reactions.

In conclusion, hemodialysis and hemofiltration contributed to the improved renal function, renal anemia and nutritional status, alleviated inflammatory reactions, enhanced quality of life and reduced adverse reactions in patients with renal failure. However, this study also has certain limitations. Due to financial constraints and as a preliminary study, this study did not set up a hemodiafiltration group, and only selected the most commonly used hemodialysis methods used in clinic and compared with the combination of two dialysis methods. It is impossible to observe the effect of hemodiafiltration on the nutritional status of patients with renal failure. Only the conclusion that the combination of the two methods is better than the simple hemodialysis group is achieved. In the next study, a hemodiafiltration group will be established to observe its effects on the nutritional status of patients with renal failure. At the same time, in the selection of indices, the main selections are calcium, phosphorus and other nutritional indices that affect the prognosis of patients with renal failure. No observation was made on triceps skinfold, mid arm muscle circumference, S-transferrin and relative body weight as the nutritional status index for evaluation, and the corresponding indices will be added for further observation in the next study.

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Disclosure of conflict of interest

None.

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References

[1] Borisov VV and Shilov EM. Chronic renal failure. Child Nephrol Urol 2017; 33: 121-184.

[2] Rogan A, McCarthy K, McGregor G, Hamborg T, Evans G, Hewins S, Aldridge N, Fletcher S, Krishnan N and Higgins R. Quality of life measures predict cardiovascular health and physical performance in chronic renal failure patients. PLoS One 2017; 12: e0183926.

[3] Sun R, Ren H and Wei J. Effects of astrogaloside on the inflammation and immunity of renal failure patients receiving maintenance dialysis. Exp Ther Med 2018; 15: 2307-2312.

[4] Rahyussalim AJ, Saleh I, Kurniawati T and Lutfi APWY. Improvement of renal function after human umbilical cord mesenchymal stem cell treatment on chronic renal failure and thoracic spinal cord entrapment: a case report. J Med Case Reports 2017; 11: 334.

[5] Galland R and Traeger J. Short daily hemodialysis and nutritional status in patients with chronic renal failure. Semin Dial 2010; 17: 104-108.

[6] Pérez VO, Hernández EB, Bustillo GG, Penié JB, Porbén SS, Borrás AE, González CM and Martínez AA. Nutritional status in chronic renal failure patients assisted at the hemodialysis program of the "Hermanos Ameijeiras" Hospital. Nutr Hosp 2007; 22: 677-694.

[7] Soleimani A, Foroozanfard F and Tamadon MR. Evaluation of water and electrolytes disorders in severe acute diarrhea patients treated by WHO protocol in eight large hospitals in Tehran; a nephrology viewpoint. J Renal Inj Prev 2017; 6: 109-112.

[8] Arora S, Lahewala S, Virk HUH, Setareh-Shenas S, Patel P, Kumar V, Tripathi B, Shah H, Patel V and Gidwani U. Etiologies, trends and predictors of 30-day readmissions in patients with diastolic heart failure. Am J Cardiol 2017; 119: 760-769.

[9] van den Berge JC, Constantinescu AA, van Domburg RT, Brankovic M, Deckers JW and Akkerhuis KM. Renal function and anemia in relation to short- and long-term prognosis of patients with acute heart failure in the period

1985-2008: a clinical cohort study. PLoS One 2018; 13: e0201714.
[10] Bataille S, Pelletier M, Sallée M, Berland Y, Mckay N, Duval A, Gentile S, Mouelhi Y, Brunet P and Burtey S. Indole 3-acetic acid, indoxyl sulfate and paracresyl-sulfate do not influence anemia parameters in hemodialysis patients. BMC Nephrol 2017; 18: 251.
[11] Tajbakhsh R, Qorbani M, Mehrpour G, Rahimzadeh M, Azimzadeh MM and Mirmiranpour H. Effect of hemodialysis on oxidants and antioxidant factors in chronic renal failure. Saudi J Kidney Dis Transpl 2017; 28: 507.
[12] Hajian-Tilaki K, Heidari B and Hajian-Tilaki A. A comparison of health-related quality of life in patients with renal failure under hemodialysis and healthy participants. Saudi J Kidney Dis Transpl 2017; 28: 133.
[13] Lehner GF, Harler U, Feistritzer C, Haller VM, Hasslacher J, Bellmann R and Joannidis M. Hemofiltration induces generation of leukocyte-derived CD31+/CD41- microvesicles in sepsis. Ann Intensive Care 2017; 7: 89.
[14] Liu C, Li M, Cao S, Wang J, Huang X and Zhong W. Effects of HV-CRRT on PCT, TNF-α, IL-4, IL-6, IL-8 and IL-10 in patients with pancreatitis complicated by acute renal failure. Exp Ther Med 2017; 14: 3093-3097.
[15] Zhang R, Ma J and Liu X. The test of KIM-1, Cys C and β2-MG to assess the early renal damage in OSAHS patients and its clinical significance. Lin Chung Er Bi Yan Hou Tou Jing Wai Ke Za Zhi 2017; 31: 174-179.
[16] Adil M, Kandhare AD, Visnagri A and Bodhankar SL. Naringin ameliorates sodium arsenite-induced renal and hepatic toxicity in rats: decisive role of KIM-1, Caspase-3, TGF-β, and TNF-α. Ren Fail 2015; 37: 1396-1407.
[17] Stasch JP, Schlossmann J and Hocher B. Renal effects of soluble guanylate cyclase stimulators and activators: a review of the preclinical evidence. Curr Opin Pharmacol 2015; 21: 95-104.
[18] Lu B, Tang X and Li X. Effects of hemodialysis and peritoneal dialysis on mean platelet volume and inflammatory factors in patients with chronic renal failure. Zhongguo Zhong Xi Yi Jie He Shen Bing Za Zhi 2019; 20: 139-141.
[19] Shariaty Z, Shan GRM, Farajollahi M, Amerian M and Pour NB. The effects of probiotic supplement on hemoglobin in chronic renal failure patients under hemodialysis: a randomized clinical trial. J Res Med Sci 2017; 22: 74.
[20] Reza HM, Shuvo SD and Ahmad T. Assessing the prevalence of malnutrition in chronic kidney disease patients undergoing hemodialysis in Kushtia District, Bangladesh. Nutr Food Sci 2018; 48: 150-164.
[21] Roach LA, Lambert K, Holt JL and Meyer BJ. Diet quality in patients with end-stage kidney disease undergoing dialysis. J Ren Care 2017; 43: 226-234.