Hemodialysis is autoimmune disease result from inflammation, oxidative stress, and fibrosis. It is characterized by renal glomeruli damage, podocyte injury, tubule interstitial, and proteinuria. Electrolyte balance is the main function of the renal and any form of electrolyte disorders may lead to excess blood volume, hypertension, and difficulty in maintaining natural blood sodium. Renal erythropoietin has an important role in the balance of vascular active substances, such as prostaglandins and thromboxanes; therefore, patients undergoing hemodialysis observe decreased production of erythropoietin with iron loss through hemodialysis machine as well as weakened iron absorption and mobilization from the intestine to the bloodstream. Ferritin, total iron-binding capacity (TIBC), unsaturated iron-binding protein capacity (UIBC), iron free, and transferrin are used to confirm iron status. According the clinical characterization of the results, no normality was observed in patients undergoing hemodialysis. There was hypertension, anemia, lean symptoms and equal distribution of age parallel with developed disease, there was significant increased in renal function except albumin, it was decreased in the patients compared with control groups. In addition, there was a decreased level of iron status in all parameters such as packed cell volume (%), TIBC, UIBC, iron free, and transferrin except ferritin; there was an increased level of iron status in all parameters in patients compared with control groups.

**Keywords:** Ferritin, hemodialysis, total iron-binding capacity, transferrin, unsaturated iron-binding protein capacity

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the production of red blood cells (RBCs), without it cannot express in sufficient amount. In hypoxia, the kidneys produce more levels of erythropoietin to induce RBC production and enhance their survival and protection from cell death programs. Many studies suggest that erythropoietin improves memory by affecting hematocrit. Erythropoietin therapy is used to treat anemia and vasoconstriction by stimulating vascular formation, proliferation of smooth muscle fibers, and increasing iron absorption by inhibiting hepcidin levels. It has been used to promote vascular active of thromboxane, prostaglandins, and produce more calcium levels and impaired vasodilatation with nitric oxide. Uncontrolled hypertension caused increased levels of calcitriol and renin hormone that produced from kidneys. Patients undergoing hemodialysis observe low levels of transferrin that is a vital protein used to transport iron from endothelial reticulum to the bone marrow. Tubular interstitial observe, which replacement parts of nephrons by scar tissue and increased levels of renin by angiotensin system. Interstitial edema often reaches 30% of body weight by increasing sodium and fluid retention in capillary walls, in addition to changes in the permeable of tubular and glomerular membrane defect in lipoprotein lipase activity and blood clotting. During hemodialysis, it was observed an enhanced level of free radicals compared to the levels of antioxidants materials and uremic poisoning that develops hypoxia in the kidneys. Creatinine is not absorbed by tubes; therefore, it was commonly used to measure glomerular filtration rate. So, the creatinine filter is returned to the bloodstream leading to high blood levels. Increased blood urea concentration, nitrogen wastes and accumulation of waste products in the blood stream albumin test is important to evaluate chronic renal failure it is changes in blood vessels that supply peripheral nerves to permeable of albumin metabolic acidosis appear in patients which increase hydrogen levels and reduce levels of bicarbonate. Metabolic acidosis promotes acid excretion in the urine; the kidneys tend to lower the pH of tissues and increase ammonia production. The treatment of hemodialysis is transplantation of kidney, although it includes many complications especially immunosuppressant.

**Aim of the study**

Our aim was to review the relationship between hemodialysis and iron status by transferrin, TIBC, UIBC, and ferritin proving that changes in glomerular barrier may increase sodium retention, hypervolemia, and hypoproteinemia that activates rennin–angiotensin–aldosterone system, which leads to vasoconstriction.

**Materials and Methods**

A blood sample of 20 people was collected as patient groups at Baghdad Teaching Hospital and 30 people as control groups. Blood was separated by centrifugation and then frozen at −20°C. The questionnaires were designed in the form of different questions covering the duration of hemodialysis, vascular disease, hypertension, history, drugs, weight, height, and smoking of all patients and control groups.

**Statistical analysis**

Sensitive and specific database calculations were performed by using Microsoft Office 2010 and data were analyzed by using Statistical Package for the Social Sciences software program, version 18.0. Categorical variables were expressed as absolute values and ratios. The central trend measures were used for quantitative variety and quality iterations. A significant difference was expressed as a value of \( P \) equal to or less than 0.05.

**Results and Discussion**

According to the clinical characterization of the results, no mortality was observed in patients undergoing hemodialysis. There were hypertension, anemia symptoms, lean patients, and equal distribution of age parallel with developed disease [Table 1]. There was significant increase in renal function except albumin. There was decreased level in patients compared with control groups [Table 2].

The results showed decreased levels in the iron status in all parameters including packed cell volume (%), TIBC, UIBC, iron free, and transferrin except ferritin. There was an increased level of iron status of these parameters in patients compared with control groups [Table 3].

A positive correlation was observed between UIBC and TIBC in patients undergoing hemodialysis, whereas a negative correlation was observed between UIBC and iron, and UIBC and transferrin in patients undergoing hemodialysis as shown in Table 4, Figures 1–3.

Anemia is the most common problem in patients undergoing hemodialysis. Levels of saturated and unsaturated iron binding capacity (UIBC, TIBC) as alternative markers of transferrin saturation and hypopigmentation, there was evaluate iron overload along with Hb and any elevated due to increased inflammation which inhibits hepcidin. Also ferritin and the UIBC indicate iron status. Ferritin is a better sign of iron overload as compared to the UIBC that diagnoses iron depletion, because it is a protein inside every place that releases iron in a controlled manner and found in

**Aim of the study**

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the many cells as a cytosolic function, whereas a little quantity is excreted in the blood. Plasma ferritin is also an indirect sign of the total iron storage in the blood; therefore, ferritin is used as a diagnosis of anemia but transferrin is the most important of dynamic carriers; iron is occupied approximately one-third of the binding iron sites of transferrin. Hence, the serum has a large reserve iron-binding capacity. Iron in the form of Fe^{3+} is associated with transferrin levels. Variety of iron levels are affected by iron ingestion and infections. Transferrin is the main transporter of iron in blood; TIBC can be replaced by transferrin test. It refers to availability of iron binding sites on transferrin that inverses relation with iron levels; however, transferrin is usually a direct relation with iron levels, but it does not reflect the amount of iron. Transferrin deficiency is due to three categories: iron requirements, defect in iron storage, and absorbance. In the first category, RBCs are raised by erythropoiesis drugs. Secondly, a turbulent secretes iron from ferritin in the mononuclear phagocyte system and from liver cells is occur in patients with inflammatory anemia, where ferritin rises independently of the bone marrow. Significantly defect of TIBC and ferritin in chronic renal failure associates with chronic inflammatory condition or tumors and proteinuria. Inverse relationship between ferritin levels and transferrin indicates that elevated ferritin production can compensate for the decreased levels of iron-bound transferrin, which reduces the quantities of iron status. Routine monitoring of ferritin levels in hemodialysis patients is a vital role to prevent iron deficiency and to avoid continuing increase value of ferritin. Defect iron supplies may lead to iron deficiency.

### Table 1: Clinical characteristics in patients undergoing hemodialysis

| Items                | No. | %  |
|----------------------|-----|----|
| Hypertension         | 17  | 85 |
| Smoking              | 4   | 20 |
| Anemia               | 19  | 95 |
| Hemodialysis         | 20  | 100|
| Weight               |     |    |
| Lean                 | 7   | 35 |
| Healthy              | 6   | 30 |
| Overweight           | 4   | 20 |
| Obese                | 3   | 15 |
| Age                  |     |    |
| 15–30                | 6   | 30 |
| 30–50                | 8   | 40 |
| 50–70                | 6   | 30 |

### Table 2: Renal injury biomarkers in patients and control groups

| Parameters   | Groups     | Mean ± standard deviation | Minimum | Maximum | P value |
|--------------|------------|---------------------------|---------|---------|---------|
| Urea mg/dL   | Control    | 21.28 ± 1.547             | 19      | 24      | 0.00**  |
|              | Patients   | 126.81 ± 32.675           | 57      | 177     |         |
| Creatinine mg/dL | Control    | 0.964 ± 0.115             | 0.8     | 1.2     | 0.00**  |
|              | Patients   | 7.954 ± 2.215             | 4.4     | 12.7    |         |
| Total protein g/dL | Control    | 6.86 ± 0.293              | 6.3     | 7.1     | 0.11    |
|              | Patients   | 5.758 ± 0.717             | 4.6     | 7       |         |
| Albumin g/dL  | Control    | 4.42 ± 0.365              | 4       | 5.1     | 0.002** |
|              | Patients   | 3.177 ± 0.587             | 2.5     | 4.6     |         |

Significant using Statistical Package for the Social Sciences for two independent means at significance *P ≤ 0.05 and **P ≤ 0.01

### Table 3: Iron status in patients and control groups

| Parameters       | Groups     | Mean ± standard deviation | Minimum | Maximum | P value |
|------------------|------------|---------------------------|---------|---------|---------|
| PCV (%)          | Control    | 41.663 ± 1.911            | 37.3    | 44.5    | 0.00**  |
|                  | Patients   | 25.831 ± 4.537            | 16.6    | 36.1    |         |
| Ferritin ng/mL   | Control    | 65.142 ± 12.253           | 40      | 75      | 0.00**  |
|                  | Patients   | 809.271 ± 281.44         | 410     | 1138    |         |
| TIBC µmol/L      | Control    | 57.428 ± 6.1875           | 50      | 65      | 0.001** |
|                  | Patients   | 38.452 ± 7.844            | 28.48   | 47.6    |         |
| UIBC µmol/L      | Control    | 30.582 ± 12.144           | 10.5    | 51.17   | 0.697   |
|                  | Patients   | 26.845 ± 12.802           | 3.83    | 40.5    |         |
| Iron free µmol/L | Control    | 21.285 ± 2.984            | 18      | 25      | 0.021** |
|                  | Patients   | 11.607 ± 7.941            | 4.56    | 24.65   |         |
| Transferrin µmol/L | Control    | 37.607 ± 7.718          | 29.032  | 49.019  | 0.663   |
|                  | Patients   | 32.714 ± 27.333           | 11.281  | 86.552  |         |

PCV = packed cell volume; TIBC = total iron-binding capacity, UIBC = unsaturated iron-binding protein capacity

Significant using Statistical Package for the Social Sciences for two independent means at significance *P ≤ 0.05 and **P ≤ 0.01
whereas a long-term hemodialysis caused erythropoietin deficiencies. Iron drugs have adverse effects when the transferrin binding capacities are overcome and when the concentration of non-transferrin reactive iron increases in the plasma. Sodium retention is due to sodium reabsorption along the collection channels. Induction de novo synthesis from Na/K-ATPase (sodium–potassium adenosine triphosphatase) is the main factor to stimulate sodium reabsorption along the distant nephron. There is a significant change in the glomerular filtration barrier that is responsible for proteinuria and hypoalbuminemia, in addition to induce distant nephrons K⁺ ATPase that regulating hydration and electrolyte status that the main physiological roles

| TIBC µmol/L | Iron free µmol/L | Transferrin µmol/L |
|-------------|------------------|--------------------|
| UIBC µmol/L | Correlation      | Sig. (two-tailed)  |
|             | 0.808            | 0.028*             |
|             | −0.814           | 0.026*             |
|             | −0.917           | 0.004**            |
| Sig. (two-tailed) |          |                   |
| 0.028*      | 0.026*           | 0.004**            |
| N           | 20               | 20                 | 20                 |

TIBC = total iron-binding capacity, UIBC = unsaturated iron-binding protein capacity

Table 4: Difference correlation coefficient between unsaturated iron-binding protein capacity and total iron-binding capacity, iron free, and transferrin

Significant using Statistical Package for the Social Sciences for two independent means at significance *P ≤ 0.05 and **P ≤ 0.01

**Figure 1**: Positive correlation between unsaturated iron-binding protein capacity (UIBC) and total iron-binding capacity (TIBC) in patients undergoing hemodialysis

**Figure 2**: Negative correlation between unsaturated iron-binding protein capacity (UIBC) and iron free in patients undergoing hemodialysis

**Figure 3**: Negative correlation between unsaturated iron-binding protein capacity (UIBC) and transferrin in patients undergoing hemodialysis
of kidney deterioration and hypertension. Excessive dehydration leads to hypervolemia and edema, and weak itching in the patients undergoing dialysis. Hypervolemia and defect in cardiac system are almost certainly widespread because of impaired tissue perfusion without general clinical signs. Creatinine in the blood is used as an indicator to estimate renal function; it is influenced by many factors including glomerular filtration, such as malabsorption, and some drugs that may interfere with tubular creatinine secretion. Recently, it was found an increased risk of heart failure during dialysis. Chronic infections are usually observed in patients undergoing hemodialysis; therefore, the inflammatory responses caused protein deleterious such as C-reactive protein.

**CONCLUSION**

The following conclusions can be drawn from the study:

1. Changing of the glomerular filtration barrier may increase sodium retention and edema formation that activate the renin–angiotensin–aldosterone system; a small portion of sodium is excreted to the collection tube through Na+ and Na+-K+ ATPase channels.

2. Erythropoietin has a range of actions including vasoconstriction-dependent hypertension, stimulating the formation of blood vessels and inducing proliferation of smooth muscle. It can increase iron absorbance by suppressing the hepcidin hormone.

3. UIBC is an alternative parameter of iron status. Ferritin is a better sign of iron overload as compared to UIBC that diagnoses iron depletion.

4. Inverse relationship between ferritin levels and transferrin indicates that elevated ferritin production can compensate of decreased levels of iron-bound transferrin, which reduce the quantities of iron levels.

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**Conflicts of interest**

There are no conflicts of interest.

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