INTRODUCTION

The kidneys function as filters of the blood, removing waste products and controlling the balance of fluid and electrolytes. Filtration occurs via bundles of capillaries called glomeruli. A reduction in the glomerular filtration rate (GFR) to $>$60 mL/minute/1.73 m\(^2\) indicates chronic kidney disease (CKD), as do structural or functional renal abnormalities, which may be present in people with normal GFR [1]. Cross-sectional estimates of the prevalence of CKD in the United States range from 1.5\% to 15.6\% [2].

Chronic kidney disease is a worldwide public health problem. Major outcomes of CKD include progression of CKD to end-stage renal disease, development of different complication due to impaired kidney function, and increased risk for development of cardiovascular disease (CVD) [3]. One of the common complications of CKD is the anemia which is associated with increased risk for CVD, increased morbidity and mortality, especially in high-risk group [4]. The National Kidney Foundation (NKF) defines anemia in CKD as a hemoglobin (Hb) level $>$13.5 g/dl in men and 12.0 g/dl in women [5]. Anemia is common in diabetic patients with CKD [6]. It is estimated that one in five patients with diabetes and stage 3 CKD have anemia, and its severity worsens with more advanced stages of CKD and in those with proteinuria [7-9].

The prevalence and severity of anemia are related to the kidney disease stage and the relative deficiency or reduction in erythropoietin (EPO) production is the main cause. EPO deficiency; blood loss; hemolysis, hyperparathyroidism and inflammation, and these should be investigated before the introduction of EPO replacement therapy [10,11].
patients with anemia than in those without [24], and quality of life issues (e.g., fatigue, reduced productivity) are common [22,23]. Anemia causes fatigue, reduced exercise capacity, reduced libido, and cognitive function, which ultimately have a negative impact on their quality of life [25,26] in addition to being related to heart failure, CVDs are the leading causes of mortality in CKD [27]. Thus, RBC indices, serum iron, transferrin, and ferritin saturation, among others, are tests that may be part of the clinical investigation and monitoring of patients with CKD [11]. Whereas anemia is one of the main consequences of CKD and when found, requires proper treatment and monitoring, checking the tests results can characterize the hematologic changes, iron behavior dynamics, as well as urea and creatinine concentrations and their possible relations with anemia in CKD patients on hemodialysis. Thus, this study aimed at checking the correlation between anemia and chronic kidney diseases in patients who underwent hemodialysis in Sabratha Hospital in the West of Libya.

**METHODS**

This study was conducted on 60 patients (36 males and 24 females) with chronic renal failure from October 2015 to April 2016 and a group of 40 (20 males and 20 females) individuals as control. Ethical approve and patients consent statement were taken from everyone, and the study was performed in Sabratha Hospital in the West of Libya. At first, all patients with proven chronic renal failure were included in the study. Patients with especial established disorders such as endocrinopathies, and hepatosplenomegaly and also patients with use of certain drugs such as heparin were excluded from the study. During the study, no patient had blood or blood components such as fresh frozen plasma and platelet transfusion. To eliminate effects of sex and age on a comparison between cases and control groups, age and sex were chosen in each pair of groups as similar as possible. Demographic and anthropometric data including age, sex, weight, height, body mass index, and blood pressure were measured for the participants. All of patients and normal participants were Libyans, above 18 years of age, and free from chronic degenerative diseases such as cancer or peritonitis.

A volume of 5 ml of blood was drawn by venipuncture. Collected blood sample was divided into two vials, that is, ethylenediamine tetraacetic acid vial for hematological tests and plain vial for biochemical test. After clotting of blood in the plain vial, serum was separated, within an hour; by centrifugation at 3000-5000 g for 5 minutes. Serum was used for measurements of urea, creatinine, uric acid, and iron levels. Laboratory standard operation procedures were maintained for all laboratory analysis. Internal quality control sera, both normal and pathological, were also run for each lot of the test, for the validation of laboratory analysis. Internal quality control sera, both normal and pathological, were also run for each lot of the test, for the validation of laboratory analysis. Serum creatinine, and uric acid in serum, and GFR was estimated for each patient had blood Group AB, and there were only 2.8% of males who have this blood group. 11.1% for males and 4.1% for females, but there were no any female has blood Group AB, and there were only 2.8% of males who have this blood group (Fig. 2).

Anemia was defined as Hb level <13.0 g/dL for men and <12.0 g/dL for women as per the World Health Organization guidelines. CKD was defined as reduced excretory function with an estimated GFR (eGFR)<60 ml/minutes/1.73 m² as a marker of kidney dysfunction. Furthermore, CKD was defined and classified into five stages of CKD as per NKF guidelines. The formula of Cockcroft and Gault equation was used to calculate eGFR [28].

\[
eGFR\text{ [in male]}=\frac{[140-\text{age [in years]}]\times \text{weight [in kg]}}{[72/\text{serum creatinine [mg/dL]}} \]

A companion equation for women, based on their 15% lower muscle mass (on average):

\[
eGFR\text{ [in female]}=\frac{[140-\text{age [in years]}]\times \text{weight [in kg]}}{0.85/[72/\text{serum creatinine [mg/dL]}} \]

### Statistical analysis

The data were analyzed using Excel 2010, and GraphPad Prism software version 5. Association between anemia and chronic kidney disease was tested by Pearson’s correlation test. Comparison of mean value of continuous data was tested by t-test and ANOVA test. p-value of <0.05 (two-tailed) was used to establish statistical significance.

### RESULTS

In this study, sixty patients (36 males, and 24 females) were classified according to their eGFR using of Cockcroft R and Gault equation into three categories for each gender, stage III, stage IV, and stage V. In stage III, GFR from 30 to 59 ml/minutes, in stage IV, from 15 to 29 ml/minutes, and in stage V, the GFR is <15 ml/minutes. In our study, most of the patients within stage V limits, as illustrated in Fig. 1, 64% of males and 50% of females. Stage IV patients are 25% of males and 33% of females, and the patients who within stage II limits are only 11% for males, and 17% for females.

The patients also were classified according to their blood groups, we found that most of the patients were have blood Group O, 58% for males and 83.2% for females, and blood Group A were 27.7% for males and 12.5% for females, the percentages of patients with blood Group B were 11.1% for males and 4.1% for females, but there were no any female has blood Group AB, and there were only 2.8% of males who have this blood group (Fig. 2).

The kidney function tests which carried for these patients are, urea, creatinine, and uric acid in serum, and GFR was estimated for each patient using the formula of Cockcroft and Gault equation, by using the collected data of age, weight, and sex for each patient. These measured parameters, as illustrated in Table 1, showed that highly significant increase in serum creatinine in all stages of chronic renal...
failure in male patients by 27%, 61%, and 94% in stages III, IV, and V patients, respectively. The increase of serum creatinine levels in female patients was 506%, 728%, and 1142% in stages III, IV, and V patients, respectively, as compared to control group. Serum urea levels were also increased significantly in all stages of chronic renal failure in male patients by 103%, 1015%, and 913% in stage III, IV, and V patients, respectively, and the female patients showed highly significant elevations in serum urea by 658%, 966%, and 910% in stage III, IV, and V patients, respectively, as compared to healthy persons. The eGFR in all patient groups was decreased with highly significant degrees, as illustrated in Table 1. It decreased in male patients by -67%, -84%, and -90% in stage III, IV, and V patients, respectively. This parameter was reduced in female patients by -75%, -85%, and -90% in stage III, IV, and V patients, respectively, as compared to control persons. Serum uric acid was increased also by significant in male patient groups by 71%, 44%, and 27% in stage III, IV, and V patients, respectively, whereas, its changes in female patients were 40%, 50%, and 31% in stage III, IV, and V patients as compared to healthy control group (Table 1).

Measurements for peripheral blood were carried out for RBCs, white blood cells (WBCs), and platelets count, Hb concentration, hematocrit, and serum iron were also measured, mean corpuscular hemoglobin (MCH), MCH concentration (MCHC) and mean corpuscular volume (MCV) were calculated. The hematological data were tabulated in Table 2 which showed significant changes compared to healthy control group, these changes were appeared as decrease in Hb concentrations in male patients by -17%, -18%, and -30% in stage III, IV, and V patients, whereas the changes in this parameter in female patients are -11%, -20%, and -26% in stage III, IV, and V patients as compared to control. RBCs count was also decreased in all patient groups with statistically significant degrees, as illustrated in Table 2. The changes in RBCs count in male patients are -34%, -38% and -38% in stage III, IV, and V patients, respectively, whereas, these changes in females are -21%, -28%, and -28% for stage III, IV, and V patients, respectively as compared to healthy women. Hematocrit percentage were also reduced in all patient groups by -37%, -46%, and -38% in male patient groups of stages III, IV, and V, respectively, whereas, in female patients the percentages of reduction in this parameter are -30%, -36%, and -32% in stage III, IV, and V patients.

Serum iron levels were also reduced by -34% and -42% in stage IV and V patients respectively, but there is a significant change in stage II male patients. In female, the degrees of reduction in serum iron are -29% and -41% in stage IV and V patients. Platelets count was also decreased in patient groups by -38% and -26% in stage V male and female patients, respectively.

The data in Table 3 show the correlation between the changes in kidney function tests and hematological parameters. This correlation was appeared between serum creatinine and Hb, RBCs count, hematocrit, MCH, MCHC, and serum iron, on the other hand, no correlation between creatinine and WBCs or platelets count. In this table also, the correlation between serum urea concentration and blood data were illustrated. These data showed a correlation between serum urea and Hb and RBCs count but no correlation between urea and other hematological data. eGFR also showed correlation with Hb, RBCs count, MCHC, and serum iron.

**DISCUSSION**

Chronic kidney disease is a major public health problem and a major cause of morbidity and mortality worldwide. CKD is diagnosed on the basis of the presence of markers of kidney damage and kidney function. This study was carried out to assess the hematological profile in CKD including the Hb, RBCs count, WBCs count, hematocrit, MCH, MCHC, MCV, and serum iron and their correlation with renal function tests.

Anemia in CKD is typically normocytic, normochromic, and hypoproliferative. The demonstration of a circulating factor responsible for stimulating erythropoiesis in the kidneys and the main source of EPO in the 1950s [29,30] engendered the hypothesis that EPO deficiency is a predominant cause of anemia in CKD.

Numerous studies suggest that circulating uremic-induced inhibitors of erythropoiesis contribute to the anemia, shortened RBC survival also contributes, as demonstrated by radioisotope labeling studies. Although the etiology is not entirely clear, metabolic, and mechanical factors have been proposed [31,32]. In this study, reduction in Hb, RBCs count, and hematocrit is in accordance with the study of Pouel et al [33], Bueno and Frizzo, [34] and de Francisco et al. [35].

Iron deficiency in the general population is a common cause of anemia and is prevalent in patients with diabetes and CKD. In these same patients, dietary deficiency, low intestinal absorption, and gastrointestinal bleeding may result in absolute iron-deficiency anemia. Numerous studies suggest that circulating uremic-induced inhibitors of erythropoiesis, leading to the iron sequestration, hypoferremia, and anemia that are presumably as a mechanism to sequester iron from invading pathogens, and inflammatory cytokines directly induce hepcidin transcription, leading to the iron sequestration, hypoferremia, and anemia that are hallmarks of many chronic diseases including CKD. Numerous studies show that hepcidin is elevated in CKD patients. Mechanisms suggested...
Table 2: Hematological parameters in healthy persons and chronic kidney disease patients

<table>
<thead>
<tr>
<th>Patient groups</th>
<th>Gender</th>
<th>mean±SD</th>
<th>RBCs (mill/µl)</th>
<th>Hb (g/dl)</th>
<th>MCV (fl)</th>
<th>Hematocrit (%)</th>
<th>MCH (pg)</th>
<th>MCHC (g/dl)</th>
<th>WBCs (×10³/µl)</th>
<th>Platelets (×10³/µl)</th>
<th>Iron (µg/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>Male</td>
<td>4.5±0.52</td>
<td>13±0.82</td>
<td>92±5.55</td>
<td>45.5±5.23</td>
<td>30.56±3.33</td>
<td>35.2±4.25</td>
<td>7.27±1.55</td>
<td>25±0.52</td>
<td>120±25.55</td>
<td>109±22.12</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>3.9±0.48</td>
<td>12.5±0.62</td>
<td>93±6.26</td>
<td>39.3±6.33</td>
<td>29.5±2.51</td>
<td>34.5±3.23</td>
<td>7.42±1.23</td>
<td>250±55.62</td>
<td>116±39.84</td>
<td>116±39.84</td>
</tr>
<tr>
<td>Stage III</td>
<td>Male</td>
<td>2.97±0.25</td>
<td>10.75±0.91</td>
<td>95.40±1.12</td>
<td>28.65±2.33</td>
<td>36.46±6.223</td>
<td>37.75±6.293</td>
<td>6.200±1.697</td>
<td>214.5±12.02</td>
<td>155.4±13.44</td>
<td>102±15.59</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>3.06±0.38</td>
<td>11.1±0.42</td>
<td>96.95±3.32</td>
<td>27.50±0.701</td>
<td>36.65±5.961</td>
<td>40.40±2.546</td>
<td>16.52±1.768</td>
<td>213.5±13.44</td>
<td>193.6±68.46</td>
<td>77.89±24.09</td>
</tr>
<tr>
<td>Stage IV</td>
<td>Male</td>
<td>2.79±0.46</td>
<td>10.66±1.14</td>
<td>91.53±5.66</td>
<td>24.50±4.753</td>
<td>38.83±15.15</td>
<td>46.08±15.46</td>
<td>6.890±2.148</td>
<td>213.5±13.44</td>
<td>193.6±68.46</td>
<td>77.89±24.09</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>2.93±0.30</td>
<td>9.93±1.64</td>
<td>95.06±8.123</td>
<td>25.00±2.426</td>
<td>35.83±7.228</td>
<td>40.09±4.111</td>
<td>6.675±1.871</td>
<td>193.6±68.46</td>
<td>193.6±68.46</td>
<td>77.89±24.09</td>
</tr>
<tr>
<td>Stage V</td>
<td>Male</td>
<td>2.80±0.72</td>
<td>9.15±1.95</td>
<td>88.35±11.30</td>
<td>27.85±5.915</td>
<td>33.70±6.608</td>
<td>33.41±6.608</td>
<td>6.81±2.221</td>
<td>210.2±62.35</td>
<td>182.8±49.08</td>
<td>64.36±24.66</td>
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<tr>
<td></td>
<td>Female</td>
<td>2.81±0.56</td>
<td>9.3±1.95</td>
<td>95.30±5.93</td>
<td>26.73±3.810</td>
<td>33.56±6.675</td>
<td>34.82±5.792</td>
<td>7.008±2.122</td>
<td>182.8±49.08</td>
<td>182.8±49.08</td>
<td>64.36±24.66</td>
</tr>
</tbody>
</table>

*Significant difference compared to control group (p<0.05). **Highly significant difference compared to control group (p<0.01).

RBC: Red blood cell, MCV: Mean corpuscular volume, MCH: Mean corpuscular hemoglobin, MCHC: Mean corpuscular hemoglobin concentration, WBC: White blood cell, SD: Standard deviation

Table 3: Correlation between kidney function tests and hematological data in chronic kidney disease patients

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Hb</th>
<th>RBCs</th>
<th>Hematocrit</th>
<th>WBCs</th>
<th>MCV</th>
<th>MCHC</th>
<th>MCH</th>
<th>Platelets</th>
<th>Iron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation of creatinine with hematological data</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Pearson r</td>
<td>−0.424</td>
<td>−0.367</td>
<td>−0.4217</td>
<td>−0.105</td>
<td>−0.121</td>
<td>−0.272</td>
<td>−0.337</td>
<td>−0.0705</td>
<td>−0.2991</td>
</tr>
<tr>
<td>p value (two-tailed)</td>
<td>0.0009</td>
<td>0.0046</td>
<td>0.0010</td>
<td>0.4326</td>
<td>0.3825</td>
<td>0.0386</td>
<td>0.0096</td>
<td>0.5989</td>
<td>0.0349</td>
</tr>
<tr>
<td>p value summary</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>ns</td>
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<tr>
<td>Correlation of urea with hematological data</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Pearson r</td>
<td>−0.348</td>
<td>−0.293</td>
<td>0.019</td>
<td>−0.0613</td>
<td>−0.01</td>
<td>−0.14</td>
<td>−0.124</td>
<td>−0.0085</td>
<td>0.1877</td>
</tr>
<tr>
<td>p value (two-tailed)</td>
<td>0.0074</td>
<td>0.0256</td>
<td>0.8874</td>
<td>0.6473</td>
<td>0.9427</td>
<td>0.2947</td>
<td>0.3523</td>
<td>0.9492</td>
<td>0.1918</td>
</tr>
<tr>
<td>p value summary</td>
<td>**</td>
<td>*</td>
<td>ns</td>
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<tr>
<td>Correlation of eGFR with hematological data</td>
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</tr>
<tr>
<td>Pearson r</td>
<td>0.3832</td>
<td>0.2954</td>
<td>0.01421</td>
<td>0.05451</td>
<td>0.09044</td>
<td>0.2831</td>
<td>0.2513</td>
<td>0.05444</td>
<td>0.2807</td>
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<tr>
<td>p value (two-tailed)</td>
<td>0.0030</td>
<td>0.0244</td>
<td>0.9157</td>
<td>0.6845</td>
<td>0.5154</td>
<td>0.0313</td>
<td>0.0571</td>
<td>0.6848</td>
<td>0.0398</td>
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</tbody>
</table>

*Significant difference compared to control group (p<0.05). **Highly significant difference compared to control group (p<0.01). RBC: Red blood cell, MCV: Mean corpuscular volume, MCH: Mean corpuscular hemoglobin, MCHC: Mean corpuscular hemoglobin concentration, WBC: White blood cell, eGFR: Estimated glomerular filtration rate, NS: Not significant
to account for this are increased expression by inflammatory cytokines and reduced renal clearance [38].

Based on its ability to donate and accept electrons, iron is essential for many important biologic reactions, including oxygen transport, cellular respiration, and DNA synthesis. However, this same property makes excess iron toxic by generating free radicals that can damage or destroy cells. Systemic and cellular iron levels must, therefore, be tightly regulated. The majority of iron (20-25 mg) is provided by recycling from senescent RBCs, which are phagocytosed by reticuloendothelial macrophages to store iron until it is needed, with lesser amounts provided by dietary absorption in the duodenum (1-2 mg) and release from liver stores. Plasma iron, which circulates bound to transferrin, is relatively limited at 3 mg, and therefore must be turned over several times to meet the daily requirements for erythropoiesis. With no regulated mechanism for iron removal, typical iron losses are 1-2 mg daily, mainly from intestinal and skin cell shedding and menstruation in reproductive-age women. Systemic iron balance is, therefore, maintained by regulating dietary iron absorption and iron release from storage sites in the liver and reticuloendothelial macrophages [39]. In the current study, serum iron level was reduced significantly in stage V patients of CKD, and this in accordance with the previous studies of Mezzano et al. [37] and Babitt and Lin [39].

Both deficiency and hyporesponsiveness to EPO contribute to anemia in diabetic patients with CKD. The cause of EPO deficiency in these patients is thought to be reduced renal mass with consequent depletion of the hormone. Hyporesponsiveness is defined clinically as a requirement for high doses of EPO to raise blood Hb level in the absence of iron deficiency. It is believed to represent impaired antiprotein action of EPO on proerythroblasts. Possible causes of this EPO hyporesponsiveness include systemic inflammation and microvascular damage in the bone marrow [9]. However, some studies suggest that other factors (i.e., autonomic failure) may play a role in impaired EPO production or secretion by failing kidneys.

Hasoon et al. [40] found that the percentage of the renal failure patients that carried O blood group was the highest (55%) followed by the B blood (25%), A blood group (12.5%) and AB blood group (9.4%) [40]. In another study, the occurrences of renal failure in Group O were 69.5%, and Group B was 42%, whereas AB was zero and 69% was for A blood group [41]. In our study, about 65% of CDK patients with blood Group O, which in accordance with the previous studies. Dorgalahe et al. [42] reported that platelet count was statistically significant decreased and mild thrombocytopenia in chronic renal failure patients. Although the mean platelet count did not show that our patients have not in a potential bleeding risk thrombocytopenia was an important risk factor for the occurrence of bleeding among a minority of our study patients. Furthermore, authors were found a mild thrombocytopenia among chronic renal failure patients.

CONCLUSION

This study concluded that there is a correlation between progression of chronic kidney diseases and reduction in Hb, RBCs count, hematocrit, and serum iron.

REFERENCES

Azab and Elsayed


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AQ1: Kindly provide significant value