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Determination of hemoglobin level, mean cell volume and red cell distribution width among patients with renal failure in Khartoum state

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Abstract

As a body fluid, blood supplies nutrients and oxygen to cells and carries away metabolic waste products. A cross-sectional study was conducted between February and April 2021 in Khartoum state to examine the effect of renal failure on hemoglobin level, mean cell volume (MCV), and red cell distribution width (RDW) in Sudanese patients. One hundred and thirty-five samples were collected from patients with renal failure, 100 of them were chronic, 35 were acute, and thirty 30 samples were from normal individuals as control, the age of patients between eighteen 18 and eighty 80 years, all the selected participants were not suffering from heart diseases or liver diseases.3 ml of venous blood samples were collected in ethylene diamine tetra acetic acid (EDTA) containers. The haemoglobin, MCV, and RDW were investigated using a haematological analyzer (Sysmex KX-21N).

The hemoglobin level was significantly low among patients with renal failure compared to normal individuals (P value=0.011). While no significant differences in mean cell volume (MCV) and red cell distribution width (RDW) between patients and normal individuals, with P-values (0.842) and (0.254) respectively. The study results reveal that the haemoglobin levels are lower in patients with kidney failure than in healthy individuals. Additionally, the haemoglobin levels decrease as the patient progresses into chronic renal failure in contrast to acute renal failure.

Keywords: Hemoglobin; Mean Cell Volume; Red Cell Distribution; Renal Failure

1. Introduction

The kidneys function as filters of the blood, removing waste products and controlling the balance of fluids and electrolytes. One of the lesser known functions of the kidneys is the production of erythropoietin, a signaling molecule that stimulates red blood cell production, in response to decreased oxygen levels in the blood [1].

Renal failure is a condition in which the kidneys are unable to adequately filter toxins and waste products from the blood, classified into two forms of acute renal failure (ARF) and chronic renal failure (CRF). Acute renal failure describes as a syndrome by rapid decline in the ability of the kidney to eliminate waste products, regulate acid–base balance, and manage water homeostasis. When this impairment is prolonged and entered chronic phase, erythropoietin secretion by this organ is decreasing and toxic metabolic accumulates and causes hematological changes include decrease of Hb level, MCV, RBC and HCT[2].

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The major outcomes of CKD include progression to kidney failure as well as the complications of decreased kidney function, such as cardiovascular disease, anemia and bone disease. With the rising prevalence of diabetes and hypertension, the incidences of both earlier stages of CKD as well as its associated outcomes, including progression to kidney failure, are expected to rise [3].

Renal diseases are associated with a variety of haemopoietic changes. Anemia parallels the degree of renal impairment, and its most important cause is failure of renal erythropoietin secretion. Other factors include depressed red cell production and reduced red cell survival [4].

Blood is a body fluid in humans and other animals that delivers necessary substances such as nutrients and oxygen to the cells and transports metabolic waste products away from those same cells. In vertebrates, it is composed of blood cells suspended in blood plasma. Plasma, which constitutes 55% of blood fluid, is mostly water 92% by volume and contains proteins, glucose, mineral ions, hormones, carbon dioxide (plasma being the main medium for excretory product transportation), and blood cells themselves [5].The blood cells are mainly red blood cells (also called RBCs or erythrocytes), white blood cells (also called WBCs or leukocytes) and platelets (also called thrombocytes) [6].

Hemoglobin is the protein molecule in red blood cells that carries oxygen from the lungs to the body's tissues and returns carbon dioxide from the tissues back to the lungs. Hemoglobin is made up of four protein molecules (globulin chains) that are connected together. The normal adult hemoglobin (abbreviated Hgb or Hb) molecule contains two alpha-globulin chains and two beta-globulin chains. In fetuses and infants, beta chains are not common, and the hemoglobin molecule is made up of two alpha chains and two gamma chains. As the infant grows, the gamma chains are gradually replaced by beta chains, forming the adult hemoglobin structure. Each globulin chain contains an important iron-containing porphyrin compound termed heme. Embedded within the heme compound is an iron atom that is vital in transporting oxygen and carbon dioxide in our blood. The iron contained in hemoglobin is also responsible for the red color of blood. Hemoglobin also plays an important role in maintaining the shape of the red blood cells. In their natural shape, red blood cells are round with narrow centers resembling a donut without a hole in the middle. Abnormal hemoglobin structure can, therefore, disrupt the shape of red blood cells and impede their function and flow through blood vessels [6].

High hemoglobin levels could be indicative of the rare blood disease, polycythemia. It causes the body to make too many red blood cells, causing the blood to be thicker than usual. This can lead to clots, heart attacks, and strokes. It is a serious lifelong condition that can be fatal if it is not treated.

High hemoglobin can also be caused by dehydration, smoking, or living at high altitudes, or it can be linked to other conditions, such as lung or heart disease.

Low hemoglobin levels usually indicate that a person has anemia. There are several kinds of anemia:

- Iron-deficiency anemia is the most common type. This form of anemia occurs when a person does not have enough iron in their body, and it cannot make the hemoglobin it needs. Anemia is usually caused by blood loss but can also be due to poor absorption of iron. This can happen, for example, when someone has had gastric bypass surgery.
- Pregnancy-related anemia is a kind of iron-deficiency anemia, which occurs because pregnancy and childbirth require a significant amount of iron.
- Vitamin-deficiency anemia happens when there are low levels of nutrients, such as vitamin B12 or folic acid (also called folate), in the diet. These anemias change the shape of the red blood cells, which makes them less effective.
- Aplastic anemia is a disorder where blood-forming stem cells in the bone marrow are attacked by the immune system, resulting in fewer red blood cells.
- Hemolytic anemia can be the result of another condition, or it can be inherited. It occurs when the red blood cells are broken up in the bloodstream or the spleen.
- Sickle cell anemia is an inherited condition where the hemoglobin protein is abnormal. It means the red blood cells are sickle-shaped and rigid which stops them flowing through small blood vessels.

Anemia can also be caused by other conditions, such as kidney disease and chemotherapy for cancer, which can also affect the body’s ability to make red blood cells. Newborns have a temporary anemia when they are 6-8 weeks old. This occurs when they run out of the red blood cells, they are born with, but their bodies have not made new red blood cells. This condition will not affect the baby adversely unless they are sick for some other reason.

Babies can also have anemia from breaking down cells too quickly, which results in yellowing skin, a condition known as jaundice. This often occurs if the mother and baby have incompatible blood types [7].

Mean cell volume (MCV) mean corpuscular volume (MCV) is a laboratory value that measures the average size and volume of a red blood cell. It has utility in helping determine the etiology of anemia — calculation of the value is by multiplying the percent hematocrit by ten divided by the erythrocyte count. Along with the hemoglobin and hematocrit, MCV can determine the classification of anemia as microcytic anemia with MCV below the normal range, normocytic anemia with MCV within the normal range, macrocytic anemia with MCV above the normal range. Furthermore, it is useful for calculating the red blood cell distribution width (RDW).(8) A low MCH value typically indicates the presence of iron deficiency anemia. Iron is important to produce hemoglobin. Your body absorbs a small amount of iron that you eat in order to produce hemoglobin. Some of the general causes of iron deficiency include eating a diet that is low in iron, major surgery or trauma, or blood loss. In more rare cases, low MCH can be caused by a genetic condition called thalassemia. In this condition, production of hemoglobin is limited. This means there aren't as many red blood cells circulating in your bloodstream.(9) High MCH value can often be caused by anemia due to a deficiency of B vitamins, particularly B-12 and folate. Both vitamins are required by your body in order to make red blood cells. These types of anemia can develop if your diet is low in B vitamins or if your body does not absorb B-12 or folate properly. It's important to be aware of the symptoms of a B-12 deficiency (10).

Red cell distribution width: Abbreviation of red cell distribution width, is a measure of the range of variation of red blood cell volume that is reported as part of a standard complete blood count. RDW blood test is often part of a complete blood count (CBC), a test that measures many different components of your blood, including red cells. The RDW test is commonly used to diagnose anemia, a condition in which your red blood cells can't carry enough oxygen to the rest of your body. The RDW test may also be used to diagnose:

Other blood disorders such as thalassemia, an inherited disease that can cause severe anemia

- Medical conditions such as heart disease, diabetes, liver disease, and cancer, especially colorectal cancer (11).

A low RDW means your red blood cells are all about the same size. A high RDW means you have both very small and very large red blood cells. You may also have a "normal" RDW. A normal RDW range is 12.2%–16.1% for women and 11.8%–14.5% for men. But that doesn't always mean you're in perfect health. Even though your red blood cells are all about the same size, they could all be smaller or larger than they should be. If your doctor reviews your RDW because of a health concern and the results are normal, the doctor will likely look at the results of other parts of your CBC for more information.

A high or normal RDW can be a sign of:

- Different types of anemia
- Heart disease
- Liver disease
- Diabetes
- Cancer
- Kidney disease
- Low nutrients, such as folate or B12

A high RDW can tip doctors off about a vitamin or nutrient deficiency earlier than other parts of the CBC test can. RDW is also a key test for telling the difference between types of anemia, which helps your doctor find the right treatment (12).

Kidney failure is a medical condition in which the kidneys are functioning at less than 15% of normal levels, Kidney failure is classified as either acute kidney failure, which develops rapidly and may resolve; and chronic kidney failure, which develops slowly and can often be irreversible. Symptoms may include leg swelling, feeling tired, vomiting, loss of appetite, and confusion. Complications of acute and chronic failure include uremia, high blood potassium, and volume overload. Complications of chronic failure also include heart disease, high blood pressure, and anemia (13).

The National Kidney Foundation (NKF) divided kidney disease into five stages. This helps doctors provide the best care, as each stage calls for different tests and treatments. Doctors determine the stage of kidney disease using the glomerular filtration rate (GFR), a math formula using a person's age, gender, and their serum creatinine level (identified through

a blood test). Creatinine, a waste product that comes from muscle activity, is a key indicator of kidney function. When kidneys are working well they remove creatinine from the blood; but as kidney function slows, blood levels of creatinine rise (14).

Stages of chronic kidney disease:

- Stage 1 with normal or high GFR (GFR > 90 mL/min)
- Stage 2 Mild CKD (GFR = 60-89 mL/min)
- Stage 3A Moderate CKD (GFR = 45-59 mL/min)
- Stage 3B Moderate CKD (GFR = 30-44 mL/min)
- Stage 4 Severe CKD (GFR = 15-29 mL/min)
- Stage 5 End Stage CKD (GFR <15 mL/min)

Objectives

General objective

- To determinate Hemoglobin level, mean cell volume and Red cell Distribution Width among patients with renal failure disease in Khartoum state.

Specific objectives

- To measure HB, MCV and RDW in patients with acute and chronic renal failure disease.
- To measure HB, MCV and RDW in control group.
- To compare the parameters between cases and control group.
- To compare the parameters between the subgroups of cases, acute and chronic.

To compare parameters between genders, male and female.

2. Material and methods

2.1. Study design

This was cross sectional study.

2.2. Study area and duration

The study was conducted in Khartoum, Sudan, during the period from February 2021 to April 2021.

2.3. Study population

The study carried on Sudanese patients with acute and chronic renal failure in Khartoum state.

2.4. Ethical consideration

Informed consent was taken from dr. Najeeb specialized hospital renal section, and approval from Alzaeim Alazhari University was obtained.

2.5. Inclusion criteria

Case group were patients with acute or chronic renal failure.

2.6. Exclusion criteria

Previous history of thrombosis, cardiovascular diseases hypertension and Liver diseases.

2.7. Sample collection

Three millimeters of venous blood was drowned from each participant into EDTA containers. Hemoglobin level, MCV and RDW was done using CBC Automatic analyzer sysmex (KX-21).

2.8. Hematological profile

Laboratory analysis was done within 2 hours from the time of collection. On each blood sample, PLT count and MPV were obtained by automated cell counter (KX-21), Neutrophils to Lymphocytes ratio was calculated by dividing the neutrophils by lymphocytes. A blood cell counter sysmex kx21 was used is an automatic multi –parameter cell counter for vitro diagnostic use in clinical laboratories.

The kx-21 processes approximately 60 samples per hour. It gives data of 18parameters, as the analysis of results. This is done in fast, accurate and precise way.

2.9. Data analysis

Data was analyzed by using SPSS Version 20 and Excel worksheet. Independent T test was used to compare between cases and controls as well as cases with acute and chronic kidney disease. Results were presented as tables and figures.

3. Results

One hundred and sixty five Sudanese individuals were participating in this study, Divided into two groups 135 case with mean ±STD and 30 control with mean ±STD,.all participant was in age ranged of 18-80 years old, group the age to see the effect of it and compared with parameters, the most frequent group fall in age range 38-48 year (55%), according to gender (52%) was male and (48%) female.

The hemoglobin level in cases was lower than controls, significant decrease in HB level (P. value =0.011), while MCV (P. value =0.842) and RDW (P. value =0.256) showed no significant difference between cases and controls.

The group of cases divided to two subgroups, Acute and chronic and there is significant difference between them in HB level, chronic cases was significantly decreased than acute cases (P. value =0.031), MCV (P. value =0.158) and RDW (P. value =0.296). According to gender there was no significant difference between male and female in HB level (P. value = 0.087) and no significant difference in MCV (P. value= 0.223) and RDW (P. value= 0.835).

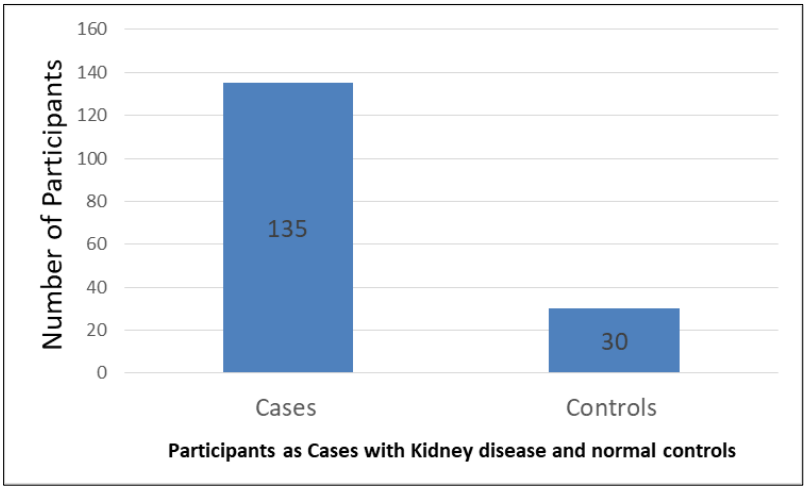

Figure 1 Distribution of Participants as Cases with Kidney disease and normal controls

Table 1 Comparison between cases and controls in Hb g/dl, MCV f/L, RDW-CV%

Variable	Participants	Mean	Std. Deviation	P-value
Hb g/dl	Cases	11.604	2.8311	0.011
	Controls	16.480	21.3403	
MCV f/L	Cases	83.330	7.9689	0.842
	Controls	83.630	4.5130	
RDW-CV%	Cases	16.113	13.8593	0.254

	Controls	13.207	0.9759	

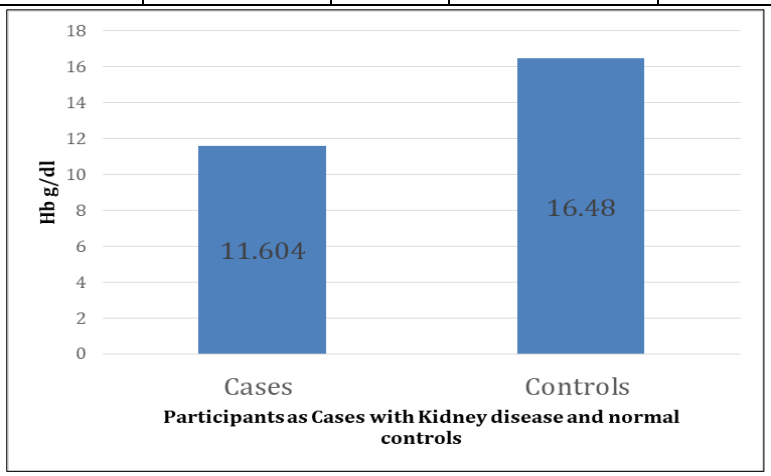

Figure 2 Comparison between cases and controls in their Hb g/dl

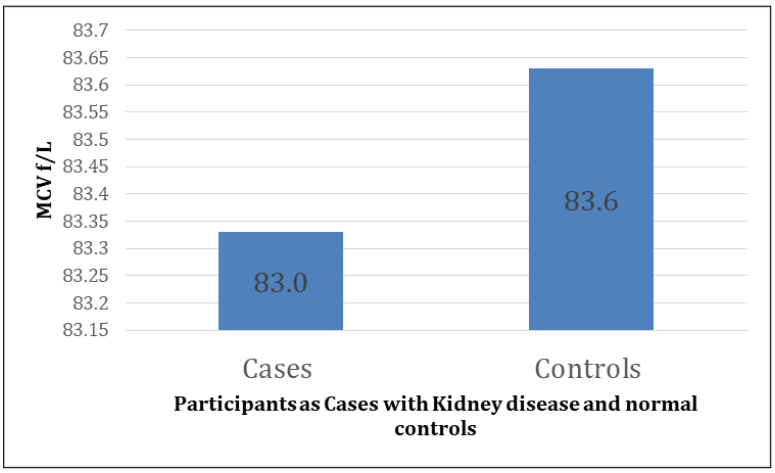

Figure 3 Comparison between cases and controls in their MCV f/L

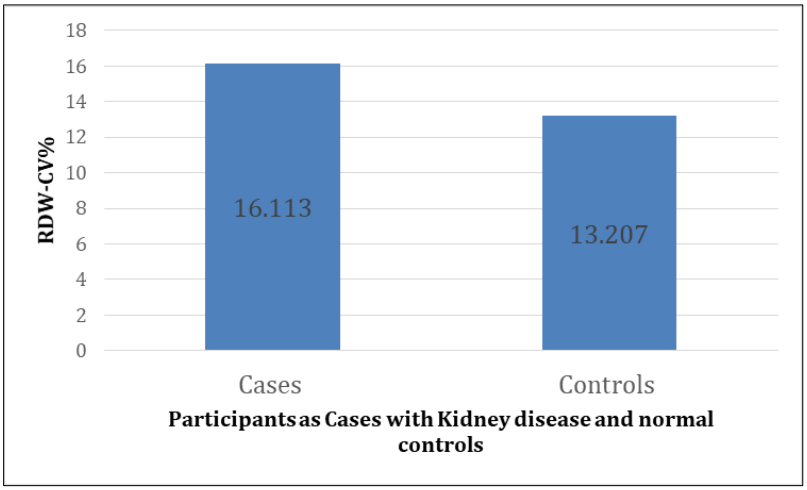

Figure 4 Comparison between cases and controls in their RDW-CV%

Table 2 Comparison between cases in their Hb g/dl, MCV f/L, RDW-CV% according to their gender

Variable	Gender	Mean	Std. Deviation	P-value
Hb g/dl	Male	12.024	2.8752	0.087
	Female	11.190	2.7452	
MCV f/L	Male	84.175	4.3422	0.223
	Female	82.497	10.3449	
RDW-CV%	Male	15.861	13.7755	0.835
	Female	16.362	14.0393	

Table 3 Comparison between patients with chronic and acute kidney diseases in Hb g/dl, MCV f/L, RDW-CV%

Variable	Participants	Mean	Std. Deviation	P-value
Hb g/dl	Chronic Kidney disease	11.293	2.8538	0.031
	Acute Kidney disease	12.491	2.6040	
MCV f/L	Chronic Kidney disease	82.756	8.9189	0.158
	Acute Kidney disease	84.969	3.8632	
RDW-CV%	Chronic Kidney disease	16.854	16.0193	0.296
	Acute Kidney disease	13.997	1.8956	

4. Discussion

This study was conducted in group of renal failure Sudanese patients, to assess the effect of kidney disease on hemoglobin, mean cell volume (MCV) and red cell distribution width (RDW).

This study showed that there was significance decrease in hemoglobin level (P value =0.011) when compare between cases and controls. This findings in agreement with study obtained by (Naeem,*et al*) [15].

It has been observed in our study that concentrations of hemoglobin are decreased in chronic renal failure patients when compared to acute renal failure patients group (p value =0.031). This findings also in agreement with study obtained by ot (Kaul A, *et al*) [16].

On other hand our study showed no significant change in MCV FL and RDW% between cases and controls (P value=0.842, =0.254) respectively, and between acute and chronic renal failure groups (p value =0.158, =0.296) respectively, and that was incompatible in RDW with other study (Dorgalaleh A,*et al*) [2].

5. Conclusion

The study concluded that there are decreased in HB level in patients with kidney failure compared to healthy individuals. Also observed decreased HB level in chronic kidney failure patients compared to acute kidney failure patients.

Compliance with ethical standards

Acknowledgments

Grateful thank to the patients and healthy who agreed to participate in this study.

Disclosure of conflict of interest

There was no conflict of interest in this study. Statement of informed consent Informed consent was obtained from all individual participants included in the study.

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