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ASSESSMENTS OF RENAL FUNCTION PARAMETERS (CREATININE, UREA, AND EGFR) AMONG PEDIATRIC PATIENTS WITH SEVERE SICKLE CELL ANEMIA AT EL-DAMAZIN TEACHING HOSPITAL, BLUE NILE REGION, SUDAN (MARCH – OCTOBER, 2025)

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ABSTRACT

Background: Sickle cell anemia (SCA) is a hereditary hemoglobinopathy characterized by chronic hemolysis, recurrent vaso-occlusive crises, and multi-organ dysfunction. It is particularly prevalent in sub-Saharan Africa, including Sudan, where the burden of sickle cell disease remains high due to consanguineous marriages and limited access to comprehensive healthcare. Among the various complications of SCA, renal dysfunction is a significant yet understudied concern, especially in pediatric populations. Despite the high burden of SCA in Sudan, particularly in Blue Nile Region, limited studies have assessed the renal function of pediatric SCA patients in this area. **Objective:** This study aimed to assess renal function among pediatric patients with severe SCA at Al-Damazin Teaching Hospital. Specifically, the study examines the prevalence of renal dysfunction, and their association with clinical and demographic factors in this population. **Methods:** A case-control, analytic, descriptive hospital based study, was conducted at El-Damazin teaching hospital, during March to August 2025. Pediatric patients aged 1-16 years diagnosed with sickle cell anemia was included. Renal function was assessed using, serum creatinine, serum urea, and estimation of glomerular filtration rate (eGFR). Data on demographics, sickle cell-related complication, and clinical parameter were collected and analyzed used statistical methods. **Results:** A total of **116 participants** were enrolled in the study, comprising **66 children with severe sickle cell anemia** (cases) and **50 healthy children** (controls), all aged between 1 and 16 years. Regarding gender distribution, the SCA group comprised 37 males (56%) and 29 females (44%), while the control group included 26 males (54%) and 24 females (46%). A strong **negative correlation** was observed between **GFR** and both **age ($r = -0.788$, $p < 0.01$)** and **weight ($r = -0.727$, $p < 0.01$)**, indicating that as children grow older and gain weight, their GFR tends to decrease. Additionally, a **significant negative correlation** was found between GFR and disease **duration ($r = -0.267$, $p < 0.05$)**. In contrast, **GFR was positively correlated with hemoglobin levels** ($r = 0.484$, $p < 0.01$), suggesting that better hemoglobin status is associated with improved kidney function. Regarding **serum urea**, **positive correlations** were found with **age ($r = 0.716$)**, **weight ($r = 0.684$)**, and **duration of illness ($r = 0.299$)**, all statistically significant, indicating that urea levels increase with these variables. Conversely, **urea showed a significant negative correlation with hemoglobin levels** ($r = -0.361$, $p < 0.01$), implying that lower hemoglobin is associated with higher urea levels. **Serum creatinine** also showed very **strong positive correlations** with **age ($r = 0.917$)** and **weight ($r = 0.974$)**, both at **$p < 0.01$**, suggesting that creatinine levels increase significantly with age and body mass. Moreover, creatinine was positively correlated with **disease duration ($r = 0.348$, $p < 0.01$)** and negatively correlated with **hemoglobin ($r = -0.403$, $p < 0.01$)**. **Conclusion** Sickle cell anemia is prevalent among pediatric in Sudan particularly n the Blue Nile Region. Earl detection and monitoring of the renal function are crucial for preventing long-term kidney damage and improving the overall prognosis for these patients. The study highlights the need for regular screening and targeted interventions, as well as greater awareness of renal complications in SCA.

KEYWORDS: Sickle cell anemia, Hemoglobin, Creatinine.

INTRODUCTION

Sickle cell anemia (SCA) is a hereditary hemoglobinopathy characterized by chronic hemolysis, recurrent vaso-occlusive crises, and multi-organ dysfunction (Rees, Williams & Gladwin, 2010). It is particularly prevalent in sub-Saharan Africa, including Sudan, where the burden of sickle cell disease remains high due to consanguineous marriages and limited access to comprehensive healthcare (El-Hazmi et al., 1996). The kidneys are highly susceptible to damage in SCA due to chronic hypoxia, hyperfiltration, and micro-infarctions, leading to conditions such as glomerulopathy, tubular dysfunction, and eventually chronic kidney disease (CKD) (Nath & Hebbel, 2015). Pediatric patients are particularly vulnerable because renal impairment often progresses silently, becoming clinically apparent only in advanced stages. Early assessment of renal function in children with SCA is therefore essential for timely management and improved outcomes.

In Sudan, where healthcare resources are limited and the prevalence of SCA is high, there is a paucity of data on renal complications among pediatric patients. Most studies on SCA-related nephropathy have been conducted in high-income countries, leaving a gap in understanding the disease's impact in resource-limited settings (Alzain et al., 2019). This study aims to evaluate renal function among children with SCA at El-Damazin Teaching Hospital, providing insights into disease progression and potential risk factors. Renal dysfunction in SCA is typically identified through biomarkers such as proteinuria, elevated serum creatinine, and reduced estimated glomerular filtration rate (eGFR) (McClellan et al., 2012).

OBJECTIVE

To assess renal functions Parameters (Creatinine, Urea, and eGFR) among pediatric patients with severe sickle cell anemia (SCA) at El-Damazin Teaching Hospital, Blue Nile Region, Sudan, (March to August 2025).

MATERIAL AND METHODS

Study Design

This is was a hospital-based, case-control, descriptive and analytic study conducted at El-Damazin Teaching Hospital, El-Damazin City, Blue Nile Region, Sudan, during March to August 2025.

Study Area

The study was carried out at El-Damazin Teaching hospital. Al-Damazin is the capital of Blue Nile Region; it is the location Rosaries Dam & power generation plant. The towns connect to Khartoum, the capital of Sudan via decent road and plan. El-Damazin pediatrics hospital, Blue Nile Region, It's a teaching hospital with daily outpatient visits about 200 pts and 24 hrs admission ranging between 30 to 50 patients.

The hospital receiving patients from different parts of the Blue Nail Region. The hospital consists of: Emergency department, 2 short stay wards. There's also pediatric High-Density Unit (HDU), Neonatal Intensive Care Unit (NICU).

Nutritional and immunization department, laboratory department, Blood bank, x ray room and echocardiography and U/S section.

Study Population

Cases: The study consisted of pediatric patients with sickle cell anemia, both sexes, with different age group (1 to 16 years) admitted to the hospital or attended the pediatric department of El-Damazin Teaching Hospital during the study period.

Control: Age- and sex-matched apparently healthy children without sickle cell disease, selected from hospital outpatient clinics and the local community.

Study Period

The study was conducted over five-months, from March to August 2025.

Inclusion Criteria

- Pediatric patients diagnosed with sickle cell anemia based on hemoglobin electrophoresis or a positive sickling test
- Both parents (and legal guardians) must provide written informed consent for the child's participation in the study.

Exclusion Criteria

- Pediatric patients with pre-existing renal diseases not related to sickle cell anemia.

Sample Size

The sample size was calculated using the standard formula for case-control studies.

Pediatric SCA patients fulfilling the inclusion criteria were selected consecutively until the required sample was reached. Age- and sex-matched healthy children attending the outpatient clinic for minor illnesses served as control.

The sample size was calculated by using the formula (per group).

$$n = \frac{(Z^{\alpha}\backslash 2 + Z^{\beta})^2 \,|p1(1—p1) + p2(1—p2)|}{(p1—p2)}$$

Where

- $Z^{\alpha}\backslash 2$ = (1.96 for 95%) Cl.
- Z^{β} = 0.84 for 80% power.
- p1 = expected proportion (outcome/ exposure) in cases
- p2 = expected proportion in healthy controls

A total of 116 participants were enrolled in this study, comprising 66 children with severe sickle cell anemia (cases) and 50 healthy children (controls).

Materials and Equipments

- Colorimeter
- Microscope
- Centrifuge and Automatic pipette.
- Syringes, gloves, alcohol (70% ethanol) , lithium heparin and EDTA containers
- Automatic pipette
- Test tubes
- Markers
- Glass slides and cover slips
- Dropper or pipette

Sampling Techniques

Sample Collection

Blood samples were collected from each subject having obtained their informed consent to participate in the study. Using a 5 ml syringe and by vein-puncture 5 ml of blood were collected from the middle capital vein in the antecubital fosse into tubes containing lithium heparin and in EDTA sample containers. The samples collected into EDTA tubes were used for Sickling test, while the sample in the lithium heparin tubes were centrifuged at 4000 rpm for 10min at room temperature within two hours of sample collection, the plasma were collected in plane containers and store frozen at -80°C until urea and creatinine value were quantified.

Sickling Test

The sickling test is a diagnostic laboratory test used to detect the presence of sickle-shaped red blood cells (RBCs), which are characteristic of sickle cell disease (SCD) or sickle cell trait.

Slide Sickling Test

Rapid screening test to detect present of sickling hemoglobin (HbS) by observing sickled red cells under low-oxygen conditions.

Principle

Sickling of the red cells, on a blood film, can be induced by the addition of sodium meta-bisulfate.

Sickle solubility test, a mixture of HbS in reducing solution (sodium and dithionate) gives a turbid appearance, whereas normal Hb gives a clear solution.

Materials and Equipments

- Fresh whole blood (capillary or venous) in EDTA (preferred) or heparin tube.
- Clean glass slides and cover slips.
- 2% sodium metabisulfite solution (fresh prepared) ---- reducing reagent.
- Pasteur pipettes or disposable micropipettes (1—10 µL).
- Marker (to label slide).
- Light microscope (with the 10x and 40x objectives).
- Timer
- Gloves, Lab coat, Eye protection.
- Waste bin for biohazard us material and sharps container.

Controls

Positive control: sample with known HbS (SS or AS).

Negative control: Sample without HbS (normal HbAA).

Run controls with each batch of the patient slides.

Procedures

- Label the slide with patient ID and control labels
- Place a small drop (~1—2 µL) of 2% sodium metabisulfite on the slide (near one end).
- Add a small drop(~1—2 µL) of well-mixed fresh whole blood to the reagent drop.
- Mix gently
- Immediately place a clean cover slip over the mixed drops (avoid large air bubbles).
- Seal the edges of the cover slip with a thin line of Vaseline or fast-drying sealant to limit oxygen diffusion.
- Start timer, incubate at room temperature, observe at intervals 5—10 min, 10—30 min.
- Examine the slide under the microscope (first use the 10x objective to locate fields, then 40x objective for morphology, look for characteristic sickling-shaped RBCs and any rouleaux or changes.
- Record findings and compare with positive and negative controls.

Measurement of hemoglobin (Hb)

Value of test: Hemoglobin is measured to detect anemia and its severity and to monitor an anemic patient's response to treatment.

Colorimetric Method for hemoglobin measurement

Photometric Methods (Cyan-hemoglobin).

Most accurate method for estimation of hemoglobin recommended by international committee standardization in Hematology because: all forms of Hb are converted to Cyan-methemoglobin (except sulfa-hemoglobin) stable and reliable STD is available.

Principle

- blood is mixed with drabkin's solution
- erythrocyte are lyses producing an evenly distributed Hb
- Potassium ferricyanide converts Hb to methemoglobin
- Metheglobin combines with potassium to form Cyanmethemoglobin
- all Hb present in blood converted to this form
- absorbance is measured in spectrophotometer at 540 nm
- To obtain amount of unknown Hb sample, its absorbance is compared with the STD Cyanmethemoglobin solution.

Procedure

- Take 5 ml of drabkin's solution then add 20 ul of blood
- mix several times
- All to stand for 5 min.

- Transfer the sample to cuvette
- Read the absorbance in the spectrophotometer at 540 nm
- also take the absorbance of STD solution

Calculation Formula

HB in g/dl = Abs of test sample X Conc. Of STD / Abs of Standard

Normal Range

At birth: 20 - 23 g/dl
Adult Males: 14 – 18 g/dl
Adult Females: 12 – 15 g/dl

Measurement of Urea

Enzymatic methods (indirect method)

Principle of the Method

Urea in the sample originates, by means of the coupled reaction described below, a colored complex that can be measured by spectrophotometer.

Urea + H2O ⟹ urase $2NH_4 + CO_2$

NH4 + salicalyate + NaCIO ⟹ nitroprusside Indophenol

Reagent Composition

A1 Reagent : Sodium salicylate 62 mmol/L, sodium nitroprusside 3.4 mmol/L, phosphate buffer 20 mmol/L, pH 6.9.
A2 Reagent: Ureas> 500 U/Ml.
B Reagent: sodium hypochlorite 7 mmol/L, sodium hydroxide 150 mmol/L.
S Urea standard 50 mg/dl.

Reagent preparation

Reagent (B) and standard (S) are provided ready to use.
Reagent (A) transfer the contents of one reagent A2 vial into reagent A1 bottle. Mix thoroughly.

Specimen

Serum or plasma collected by standard procedure, heparin is recommended as the anticoagulant.

Procedure

1. Bring the reagent to room temperature.
2. Pipette into labeled test tubes.

	Blank	Standard	Sample
Urea standard	-	10 µL	-
Patient's serum/plasma	-	-	10 µL
Reagent (A)	1.0 mL	1.0 ML	1.0 mL

3. Mix thoroughly and incubate the tubes for 10 minutes at room temperature.
4. Pipette

Reagent (B)	1.0 mL	1.0 mL	1.0 mL

5. Mix thoroughly and incubate the tubes for 10 minutes at room temperature.
6. Read the absorbance (A) of the standard and the sample at 600 nm against the blank.

Calculation

The urea concentration in the sample is calculated using the following general formula:

Urea Con (mg/dL) = A Sample X Con of standard (50 mg/dL) / A standard

Reference Range

For children (Serum/plasma)…….. 3-25 mg/dl

Chemical method: Jaffe reaction

Principle of the Method

Creatinine in the sample reacts with picrate in alkaline medium forming colored complex. The complex formation rate is measured in short period to avoid interference.

Test Method

Reagent

A reagent Sodium hydroxide 0.4 mol/L
B reagent Picric acid 25 mmol/L
S Creatinine standard 2 mg/dL
Mix equal volumes of the sodium hydroxide reagent, and picric acid
Reagent, mix will to form working reagent.

Specimen

Serum or plasma collected by standard procedures. Heparin, EDTA, Oxalate and Fluoride may be used as anticoagulant.

Procedure

1. Take three test tubes and label each set as follows:
B ..... – Reagent blank
S ..... – Standard
P ..... – Patient's serum

2. Add to each tube as follows

	Blank tube(B)	Standard tube(S)	Sample tube(p)
Working Reagent	**1.0 Ml**	**1.0 mL**	**1.0 Ml**
Standard	-	100µL	-
patient's serum	-	-	100µL

3. Mix and insert cuvette into the photometer, start stopwatch.
4. Record the absorbance at 500 nm after 30 seconds (A1) and after 90 seconds (A2).

Calculations

The creatinine concentration in the sample is calculated using the following general formula:

Sample Con (mg/dL) = **(A2 – A1) sample X Co of standard (2 mg/dL) / (A2 – A1) standard**

Reference Range

Child: 0-0.6 mg/dl
Men: 0.9 – 1.3 mg/dl
Women: 0.6 – 1.1 mg/dl

Estimated GFR (eGFR)
National Kidney Foundation recommends an EGFR be calculated each time a serum creatinine is reported.

$$\text{eGFR (ml/min)} = \frac{(140 - \text{age}) \times \text{Weight in kg}}{72 \times \text{Serum creatinine in mg/dl}} \times (0.85 \text{ if female})$$

Data Analysis
Data was analyzed and tabulated using statistical package for social sciences (IBM SPSS) program version 20, T test, a crosstabs and correlation were performed.

Ethical Approval issue
The study approval taken from Blue Nile Region Research Ethical Committee, Al-Bahrain college review board and medical director of El-Damazin Teaching hospital. The objectives of this study were explained to all individual participating in this study an informed consent was obtained from all participants. (see appendix).

Data Analysis
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RESULTS
This study aimed to assess renal function parameters among pediatric patients diagnosed with severe sickle cell anemia (SCA) compared to healthy controls. It was conducted over a five-months period (March to August 2025) at El-Damazin Teaching Hospital, located in El-Damazin City, Blue Nile Region, Sudan.

A total of **116 participants** were enrolled in the study, comprising **66 children with severe sickle cell anemia** (cases) and **50 healthy children** (controls), all aged between 1 and 16 years. The demographic characteristics of the study population are presented in Table 4.1.

Regarding gender distribution, the SCA group comprised 37 males (56%) and 29 females (44%), while the control group included 26 males (54%) and 24 females (46%). These figures indicate a nearly equal representation of males and females in both the case and control groups. This balanced distribution helps minimize gender-related bias and ensures a more reliable comparison of renal function indicators between the groups.

Participants were also categorized into two age groups: children aged 6 years or younger, and those older than 6 years. Among the sickle cell patients, 56% (n=37) were aged ≤6 years, whereas 44% (n=29) were older than 6 years. In comparison, the control group had 42% (n=21) in the ≤6 years age category and 58% (n=29) in the >6 years group. Although there is a slight variation in age distribution between the two groups, both groups include a reasonable representation of younger and older pediatric patients, which supports a fair comparison of renal function across developmental stages.

The age statistics further illustrate the age differences between the two groups. The mean age of the SCA patients was 6.2 ± 4.05 years, while the mean age of the controls was 7.9 ± 3.04 years. The median age in the SCA group was 5.0 years, compared to 8.0 years in the control group. The age range among sickle cell patients was from 1 to 16 years, whereas the control group ranged from 2 to 14 years. These data show a slightly younger patient population in the SCA group compared to the controls.

Table (1): Demographic Characteristics of Pediatric Patients with Severe Sickle Cell Anemia and Healthy Controls.

		Cases N= 66		Control N= 50	
		Frequency	**Percent**	**Frequency**	**Percent**
Gender	Male	37	56	26	54
	Female	29	44	24	46
	Total	66	100	50	100
Age Groups / Years	≤ 6 Years	37	56	21	42
	> 6 Years	29	45	29	58
	Total	66	100	50	100
Age/Years	Mean± SD	6.2 ± 4.05		7.9 ± 3.04	
	Median	5.0		8.0	
	Minimum	1		2	
	Maximum	16		14	

Figure (1) illustrates the distribution of residence among the 66 pediatric patients with severe sickle cell anemia included in the study. The majority of patients, **59% (n=39)**, were from **rural areas**, while **41% (n=27)** resided in **urban areas**. This indicates that a larger proportion of the affected pediatric population comes

from rural settings, which may reflect disparities in healthcare access, awareness, or environmental factors contributing to the burden of sickle cell disease in these communities.

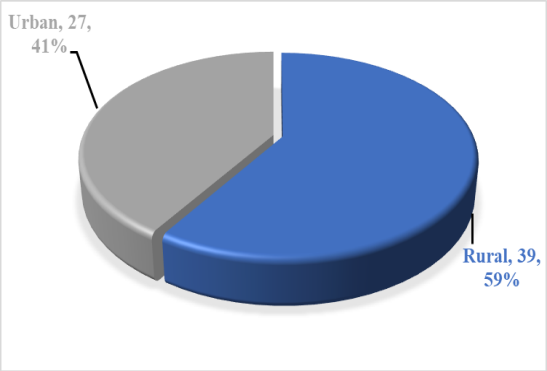

Figure (1): Distribution of Residence among Pediatric Patients with Severe Sickle Cell Anemia.

Figure (2) presents the distribution of disease duration among the 66 pediatric patients diagnosed with severe sickle cell anemia. Out of the total, **51.5% (n=34)** had been living with the condition for **five years or less**, while **48.5% (n=32)** had a disease duration of **more than five years**.

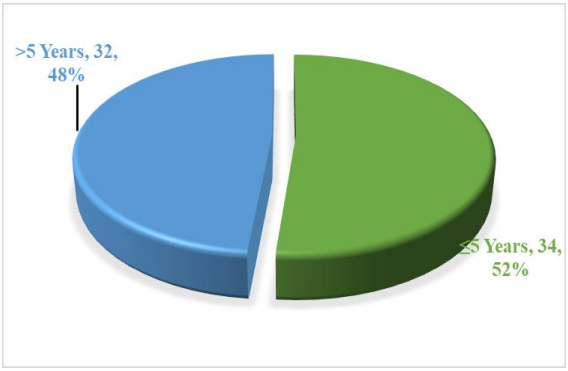

Figure (2): Duration of Sickle Cell Anemia among Pediatric Patients.

Figure 4.3 shows the classification of sickle cell anemia severity among the 66 pediatric patients based on their hemoglobin levels. The majority of the patients, **67% (n=44)**, were classified as having **severe sickle cell disease (SCD)**. Another **29% (n=19)** were categorized as having **moderately severe SCD**, while only **4% (n=3)** fell into the **mild to moderate SCD** category.

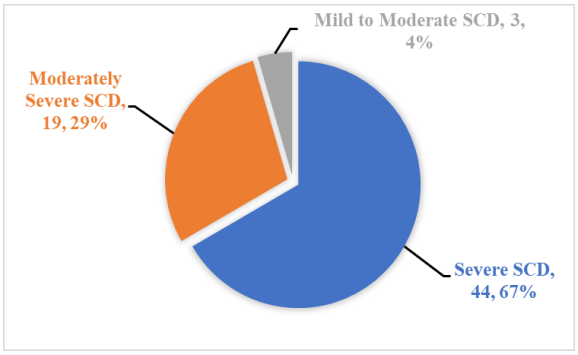

Figure (3): Classification of Severity of Sickle Cell Anemia Among Pediatric Patients According to Hemoglobin Levels.

Table 4.3 presents the comparison of renal function markers—glomerular filtration rate (GFR), serum urea, and serum creatinine (Cr)—between **male** and **female** pediatric patients with severe sickle cell anemia (SCA).

The mean **GFR** among males was **91.96 ± 13.34 mL/min/1.73 m²**, slightly lower than that of females (**95.63 ± 14.71 mL/min/1.73 m²**). However, the difference was **not statistically significant** (p = 0.293), indicating that GFR values were comparable between genders.

For **serum urea**, male patients had a higher mean level (**26.24 ± 9.40 mg/dL**) compared to females (**22.99 ± 9.30 mg/dL**), but again, this difference was **not statistically significant** (p = 0.167).

In contrast, a **significant gender difference** was observed in **serum creatinine levels**, with males showing a significantly higher mean (**0.570 ± 0.35 mg/dL**) compared to females (**0.348 ± 0.26 mg/dL**), with **p-values of 0.005 and 0.004** respectively.

Table (2): Comparison of Renal Function Parameters Between Male and Female Pediatric Sickle Cell Anemia Patients.

Parameter	Gender	N	Mean	Std. Deviation	Sig. (2-tailed)
GFR (mL/min/1.73 m²)	Male	37	91.962	13.3431	.293
	Female	29	95.634	14.7115	.299
Urea (mg/dL)	Male	37	26.238	9.3990	.167
	Female	29	22.997	9.2968	.167
Creatinine (mg/dL)	Male	37	.570	.3455	.005
	Female	29	.348	.2586	.004

Table (3) presents the **Pearson correlation coefficients** between renal function parameters (GFR, urea, and creatinine) and selected clinical variables including age, weight, duration of sickle cell disease, and hemoglobin (Hb) levels among 66 pediatric patients with severe sickle cell anemia.

A strong **negative correlation** was observed between **GFR** and both **age (r = -0.788, p < 0.01)** and **weight (r = -0.727, p < 0.01)**, indicating that as children grow older and gain weight, their GFR tends to decrease. Additionally, a **significant negative correlation** was found between GFR and disease **duration (r = -0.267, p < 0.05)**. In contrast, **GFR was positively correlated with hemoglobin levels** (r = 0.484, p < 0.01), suggesting that better hemoglobin status is associated with improved kidney function.

Regarding **serum urea**, **positive correlations** were found with **age (r = 0.716)**, **weight (r = 0.684)**, and **duration of illness (r = 0.299)**, all statistically significant, indicating that urea levels increase with these variables. Conversely, **urea showed a significant negative correlation with hemoglobin levels** (r = -0.361, p < 0.01), implying that lower hemoglobin is associated with higher urea levels.

Serum creatinine also showed very **strong positive correlations** with **age (r = 0.917)** and **weight (r = 0.974)**, both at **p < 0.01**, suggesting that creatinine levels increase significantly with age and body mass. Moreover, creatinine was positively correlated with **disease duration (r = 0.348, p < 0.01)** and negatively correlated with **hemoglobin (r = -0.403, p < 0.01)**.

Table (3): Correlation between Renal Function Parameters and Clinical Variables among Pediatric Sickle Cell Anemia Patients (N = 66)

Renal Function Parameter	Clinical Variable	Pearson Correlation (r)	Sig. (2-tailed)	Significance Level
GFR (mL/min/1.73 m²)	Age (Years)	-0.788	0.000	**p < 0.01**
	Weight (Kg)	-0.727	0.000	**p < 0.01**
	Duration (Years)	-0.267	0.030	*p < 0.05*
	Hemoglobin (g/dL)	0.484	0.000	**p < 0.01**
Urea (mg/dL)	Age (Years)	0.716	0.000	**p < 0.01**
	Weight (Kg)	0.684	0.000	**p < 0.01**
	Duration (Years)	0.299	0.015	*p < 0.05*
	Hemoglobin (g/dL)	-0.361	0.003	**p < 0.01**
Creatinine (mg/dL)	Age (Years)	0.917	0.000	**p < 0.01**
	Weight (Kg)	0.974	0.000	**p < 0.01**
	Duration (Years)	0.348	0.004	**p < 0.01**
	Hemoglobin (g/dL)	-0.403	0.001	**p < 0.01**

Note

- **Significance at the 0.01 level** (2-tailed) is indicated by **.
- **Significance at the 0.05 level** (2-tailed) is indicated by *.

DISCUSSION

This study assessed renal function among pediatric patients with severe sickle cell anemia (SCA) compared to healthy controls in Al-Damazin Teaching Hospital, Sudan. The findings provide valuable insights into the renal complications associated with SCA in a resource-limited, high-prevalence region.

1. Demographic and Clinical Characteristics

The age and gender distribution between SCA patients and controls was relatively balanced, minimizing bias. However, the SCA group had a slightly younger mean age (6.2 years) compared to the control group (7.9 years). The higher prevalence of rural residency (59%) among SCA patients may reflect limited healthcare access, increased consanguinity, and delayed diagnosis in these areas, consistent with patterns observed in similar low-resource settings.

2. Renal Function Markers

A significant reduction in estimated glomerular filtration rate (eGFR) was observed in SCA patients compared to controls (93.6 vs. 99.3 mL/min/1.73 m², p = 0.044), indicating early signs of renal impairment. Although these values remain within acceptable clinical ranges, the statistical difference suggests that kidney function begins to decline even in pediatric stages of SCA, corroborating previous literature emphasizing early onset nephropathy (Guasch et al., 2006).

Interestingly, serum creatinine levels were lower in SCA patients (0.473 mg/dL) compared to controls (0.657 mg/dL), which appears paradoxical but aligns with findings in previous studies. This is likely due to reduced muscle mass and increased tubular secretion of creatinine in SCA patients, which can mask true kidney dysfunction unless corrected eGFR calculations or novel biomarkers are used (Ataga et al., 2014).

Conversely, serum urea levels were significantly higher in SCA patients (24.8 mg/dL vs. 12.8 mg/dL; p < 0.000), suggesting impaired urea clearance or increased protein catabolism due to chronic hemolysis and inflammation. Elevated urea is a sensitive indicator of early renal stress and warrants clinical attention.

3. Gender Differences

While no significant gender differences were observed in GFR and urea levels, males had significantly higher serum creatinine than females (0.570 vs. 0.348 mg/dL, p = 0.005), likely reflecting differences in muscle mass

rather than kidney function per se. These findings suggest that gender-specific reference ranges should be considered when interpreting renal markers in pediatric SCA patients.

4. Correlations with Clinical Variables
Renal dysfunction showed strong associations with age, weight, and duration of disease.

GFR negatively correlated with age (r = -0.788), weight (r = -0.727), and duration of illness (r = -0.267), and positively with hemoglobin levels (r = 0.484). This pattern confirms that older, heavier children with longer disease duration and lower Hb levels are at higher risk of declining kidney function.

5.Urea and creatinine positively correlated with age, weight, and disease duration, while both had negative correlations with hemoglobin levels. This highlights the role of chronic anemia and disease burden in worsening renal parameters.

These correlations suggest that renal damage in SCA patients progresses with age and disease duration, emphasizing the need for early screening and interventions.

CONCLUSION

Sickle cell anemia is prevalent among pediatric patients in Sudan particularly the Blue Nile Region. Early detection and monitoring of the renal function are crucial for preventing long-term kidney damage and improving the overall prognosis for these patients. The study highlights the need for regular screening and targeted interventions, as well as greater awareness of renal complications in SCA.

This study demonstrated that children with severe sickle cell anemia exhibit significant alteration in renal function compared to healthy control. Elevated serum urea and creatinine levels, along with reduced estimated glomerular filtration rate (eGFR), highlight the early onset of renal impairment in this high-risk group. These findings emphasize the importance of routine monitoring of renal function parameters in pediatric sickle cell patients to enable early detection, timely intervention, and prevention of progressive kidney damage.

RECOMMENDATIONS

The study recommended to.

- Pediatric patients with SCA should be under regular screening for renal dysfunction.
- Raise awareness about the potential renal complication in sickle cell anemia, especially in rural and underserved areas.
- Conduct further research to assess the long-term progression of renal dysfunction in SCA patients in Sudan, particularly in under-researched regions like Blue Nile Region.

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