Original Article

Abdominal ultrasound in adult sickle cell patients

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Abstract

Background: Sickle cell disease (SCD) causes recurring crises that lead to changes in organs such as the spleen, liver, and kidneys, resulting in high morbidity and mortality.

Materials and Methods: This study was carried out in the Adult Haematology Clinic and the Radiology Department of Lagos State University Teaching Hospital, Ikeja Nigeria. Consenting SCD participants in a steady state and consenting blood donors with HbAA phenotype, representing controls were subjected to an abdominal ultrasound scan. The sizes of their spleen, liver, and kidneys were measured.

Results: There were 82 participants, 41 in each group (SCD and HbAA controls). The mean age for SCD was 25.9 ± 7.49 years and for HbAA was 26.49 ± 4.35 years. In each group, there were 41 participants, comprising 19 males and 22 females. Individuals with HbAA had spleen sizes approximately one and a half times larger than those with SCD (SCD: 6.81 ± 3.83 cm, HbAA: 9.97 ± 1.11 cm, $P = 0.01$). Conversely, participants with SCD exhibited larger liver, right kidney, and left kidney measurements compared to those with HbAA (Liver SCD: 14.91 ± 1.60 cm, HbAA: 13.32 ± 1.56 cm, P = 1.00), (right kidney SCD: 10.52 ± 1.16 cm, HbAA: 9.92 ± 1.04 cm, $P = 0.02$), (left kidney SCD: 10.76 ± 1.45 cm, HbAA: 10.58 ± 1.60 cm, $P = 0.53$).

Conclusion: The study found that SCD affects the sizes of abdominal organs, including the spleen, kidneys, and liver, compared to those without the condition.

Keywords: Abdominal ultrasound scan, HbAA population, sickle cell disease

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INTRODUCTION

Sickle cell disease (SCD) is a group of hemoglobinopathies that include mutations in the gene encoding the beta-subunit of hemoglobin. SCD is characterized by two major components: hemolysis and vaso-occlusive crises (VOC). The defect in the beta-globin gene makes the sickle hemoglobin (HbS) molecule susceptible to converting into rigid, elongated polymers in a deoxygenated state.[1]

SCD is characterized by repeated episodes of severe acute pain and acute chest syndrome and other complications such as stroke, chronic pain, nephropathy, retinopathy, avascular necrosis, priapism, and leg ulcers. In the shift from paediatric to adult-focused healthcare systems there's a continual difference in average life expectancy, with individuals with SCD facing a mortality rate that is 20 years higher than that of the general population.[2]

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In the West African country of Nigeria, more than 150,000 children are born with the disease annually and 4 million people are afflicted. Sickle cell anemia (SCA) is the most common genetic disease and affects approximately 1%–3% of Nigerians.[3-6]

SCD causes a significant challenge to the global population's health. It contributes crucially to the morbidity and mortality of pediatric and adult populations. About 50%–90% of children born with SCD in low- and low-middle-income countries of Sub-Saharan Africa die before their fifth birthday.[7-11]

SCD, particularly in the homozygous states, i.e., SCA, has a significant contribution to the morbidity and mortality of this disorder during crisis. The various types of crises cause changes in different body organs, some of which may have long-term complications for the sickle cell patient. Most of these changes occur in the abdominal organs, that is, the liver, kidneys, spleen, gallbladder, as well as the pancreas. Early detection of these changes enables the caretakers to take preventive measures.[12]

The most common clinical manifestations of SCD is vaso-occlusive crisis. A vaso-occlusive crisis occurs when the microcirculation is obstructed by sickled red blood cells, causing ischemic injury to the organ supplied and resultant pain. Pain crises constitute the most distinguishing clinical feature of SCD. They are the leading cause of emergency department visits and hospitalizations for affected patients.[13] Certain organs involved during the vaso-occlusive crisis in sickle cell patients are the spleen, liver, biliary tract, and kidneys. However, the gastrointestinal tract and adrenals may sometimes be affected; the occurrence is quite low compared to the aforementioned.[14]

Ultrasonography evaluation is becoming a standard screening procedure in all cases of SCD patients for the assessment of pathological changes occurring in the abdominal organs, especially the liver, biliary tract, spleen, kidneys, and pancreas.[12]

Ultrasound is a simple, affordable, and easily accessible imaging modality that plays an important role in the early detection of these changes for further management and follow-up of SCD patients.[15] It is safe, replicable, portable, and can be performed at the bedside, giving precise diagnostic imaging techniques in the examination of the effects of SCA on the size of the liver, kidney, and spleen.

In the abdominal evaluation of organs in SCD, certain sonographic appearances are visualized which are sometimes abnormal due to SCD. Our study aims to compare the sizes of solid organs such as the liver, spleen, and kidney in SCD in their steady state and HbAA individuals.

MATERIALS AND METHODS

This study was carried out in the Adult Haematology Clinic and the Radiology Department of Lagos State University Teaching Hospital, Ikeja. It involved willing participants diagnosed with SCD and healthy blood donors with HbAA phenotype as a control group. All participants underwent abdominal ultrasound scans at the radiology department of a tertiary health-care center after signing an informed consent form. The scans captured measurements of abdominal organs such as the liver, spleen, and kidneys in both SCD group and the HbAA control group. The scans were performed using the "Logiq C5 Premium" machine by GE Medical Systems (China) Co., Ltd. Adults who have been confirmed to be HbSS, HbSC, or other SCD phenotypes were included, and HbAA-confirmed adults served as controls. Exclusion criteria included nonconsenting participants and HbAA controls with hypertension or diabetes. A total of 41 HbSS and 41 HbAA controls were surveyed. Participants were given a questionnaire to gather sociodemographic data, and the study defined steady-state in SCD using the method as stated by Ballas.[16]

The IBM Statistical Package for Social Sciences (SPSS) version 26 software was used to analyze the collected data, with means and standard deviations used to represent normally distributed numerical data. The Student's *t*-test compared continuous variables; $P \leq 0.05$.

Ethical consideration

The approval for conducting the study was obtained from the Research and Ethics Committee of the Lagos State Teaching Hospital. Reference number: LREC/06/10/1760.

RESULTS

This was a comparative cross-sectional study comprising 41 participants of subjects and controls. The mean ages of the two groups were as follows: SCD = 25.9 ± 7.49 years and HbAA = 26.49 ± 4.35 years, which was statistically insignificant.

In each group, there were almost an equal number of males (19 out of 41) and females (22 out of 41), with a ratio of 1:1.15. This information is summarised in Table 1. Other sociodemographic parameters of both the groups are presented in Table 1.

The liver span was also larger in SCD than in control, while the splenic size was larger in control than in SCD.

The splenic size in the control group was almost one and a half (approximately 1.5) times larger than that of subjects within the SCD group [Table 2]. The liver, right and left kidneys, and spleen sizes in cm for both SCD and control are presented in Table 2.

Males with SCD had larger liver and spleen sizes compared to females with SCD, while female had larger spleens than males in the control group

The right kidney was larger and statistically significant in sickle cell subjects than controls in males ($P = 0.01$). The larger size of the right kidney in comparison with controls in females was insignificant.

The measurements for the liver spans, right and left kidneys, and spleen for both male and female subjects can be found in Tables 3 and 4. Compared to controls as found in our study [Figures 1 and 2a,b].

DISCUSSION

This cross-sectional study provided valuable insights into the morphological differences in organs between individuals with SCD and healthy controls. The study aimed to compare the sizes of the liver, kidneys, and spleen in SCD patients and controls, shedding light on the impact of the disease on organ morphology. The results of this study illuminate several critical aspects of SCD and its impact on organ morphology, providing a foundation for a deeper understanding of the disease's complexities.

Notably, an almost equal number of males (19 of 41) and females (22 of 41) participated, resulting in an almost balanced gender ratio (1:1.15). This gender balance within both the SCD and control groups ensures that our findings are representative of diverse perspectives and reinforces the reliability of our results.

Gender-specific differences in organ sizes were highlighted in this study. Male SCD patients had notably larger right kidneys compared to male controls, while no such finding was observed in female SCD patients. Further research is needed to explore the underlying mechanisms contributing to this difference.[17,18]

This gender-specific variation emphasizes the importance of considering sex as a biological variable in SCD research, as males and females might exhibit different disease manifestations and complications.[19]

Table 1: Sociodemographic parameters in sickle cell disease and control study participants

Parameters	SCD	Controls
Age (years), mean±SD	25.59±7.49	26.49±4.34
Sex		
Males	19 of 41 (46.34)	19 of 41 (46.34)
Females	22 of 41 (53.65)	22 of 41 (53.65)
The mean age of diagnosis (years)	6.83±5.35	
History of blood transfusion		
Yes	28 (68.3)	1 (5.3)
No	13 (31.7)	18 (94.7)
Known hypertensive		
Yes	0	1 (5.3)
No	41 (100)	18 (94.7)
Known diabetics		
Yes	0	1 (5.3)
No	41 (100)	18 (94.7)
History of alcohol		
Yes	10 (24.4)	14 (34.1)
No	31 (75.6)	27 (65.9)

SD – Standard deviation, SCD – Sickle cell disease

Table 2: Liver, kidney, and spleen sizes in sickle cell disease and control study participants

Parameters	Mean±SD		*P*
	SCD	Controls	
Age (years)	25.59±7.49	26.49±4.34	0.51
Liver span (cm)	14.91±1.60	13.32±1.56	1.00
Right kidney (cm)	10.52±1.16	9.92±1.04	0.02
Left kidney (cm)	10.76±1.45	10.58±1.60	0.53
Spleen (cm)	6.81±3.83	9.97±1.11	0.01

SD – Standard deviation, SCD – Sickle cell disease

Table 3: Mean values of age and organ sizes in male sickle cell disease and control study participants

Parameters	Mean±SD		*P*
	SCD	Controls	
Age (years)	26.11±6.19	26.00±4.08	0.92
Liver span (cm)	15.18±1.20	13.67±1.82	0.01
Right kidney (cm)	10.73±1.15	9.92±1.23	0.01
Left kidney (cm)	10.91±2.03	10.66±1.56	0.53
Spleen (cm)	8.12±2.74	9.89±1.24	0.01

SCD – Sickle cell disease, SD – Standard deviation

Table 4: Mean values of age and organ sizes in female sickle cell disease and control participants

Parameters	Mean±SD		*P*
	SCD	Controls	
Age (years)	25.14±8.57	27.05±8.57	0.42
Liver span (cm)	14.68±1.87	12.91±1.06	0.01
Right kidney (cm)	10.34±1.16	9.91±0.80	0.10
Left kidney (cm)	10.62±0.63	10.48±1.68	0.61
Spleen (cm)	5.68±4.31	10.07±0.95	0.01

SCD – Sickle cell disease, SD – Standard deviation

The gender-specific differences observed in this study could be influenced by hormonal factors. Estrogen, for instance, has been shown to have a protective effect on the vasculature, potentially mitigating some complications in females with SCD.[19] Understanding these hormonal influences could open avenues for targeted therapies,

tailored to each gender, enhancing the quality of care for SCD patients.

The mean ages of the two groups were comparable (SCD = 25.9 ± 7.49 years; HbAA = 26.49 ± 4.35 years) and insignificant statistically. This finding indicates that age-related variations were unlikely to confound our assessment of organ sizes, enhancing the validity of our comparisons.

The enlargement of organs, particularly the liver and spleen, is a well-documented phenomenon in SCD. The spleen's size reduction in SCD patients could be attributed to recurrent VOC, leading to infarctions and subsequent atrophy.[20] This study revealed significant differences in spleen sizes between SCD patients and controls, with controls exhibiting a spleen size approximately 1.5 times larger than that of SCD patients. This observation aligns with existing literature that discusses splenic sequestration crisis, a common complication in individuals with SCD, leading to spleen size reduction due to repeated episodes of vaso-occlusion.[20]

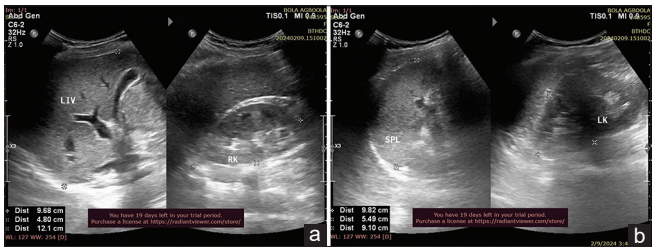

Figure 1: (a) B scan mode of ultrasound shows a normal-sized liver (12.1 cm in length) and right kidney (9.68 cm × 4.80 cm in length and anteroposterior [AP] diameters) in control adults. (b) B scan mode of ultrasound shows normal-sized spleen (9.82 cm in length) and left kidney (spans 9.10 cm × 5.49 cm in length and AP diameters) in control adults

Hepatomegaly in SCD can have multiple underlying causes. Chronic hemolysis, transfusion-related effects, and liver disease risk factors contribute to the development of hepatomegaly [Figure 2c] in these patients.[21-24] The liver disease in SCD can result from intrahepatic sickling of erythrocytes, viral hepatitis, iron overload due to multiple blood transfusions, and gallstone disease from chronic hemolysis. Cholelithiasis is a common complication, while acute hepatic crisis and chronic cholangiopathy are severe complications. Multiple blood transfusions can also lead to liver dysfunction in SCD patients. The manifestations of SCD in the liver include vascular occlusion, acute ischemia, sequestration, and cholestasis. The main hepatic complications of multiple transfusions include hepatitis B and C infections and iron overload. Overall, hepatomegaly in SCD is a complex condition with various contributing factors, and close collaboration between hepatologists and specialists in SCD is crucial for preventing, exploring, and treating these complications.

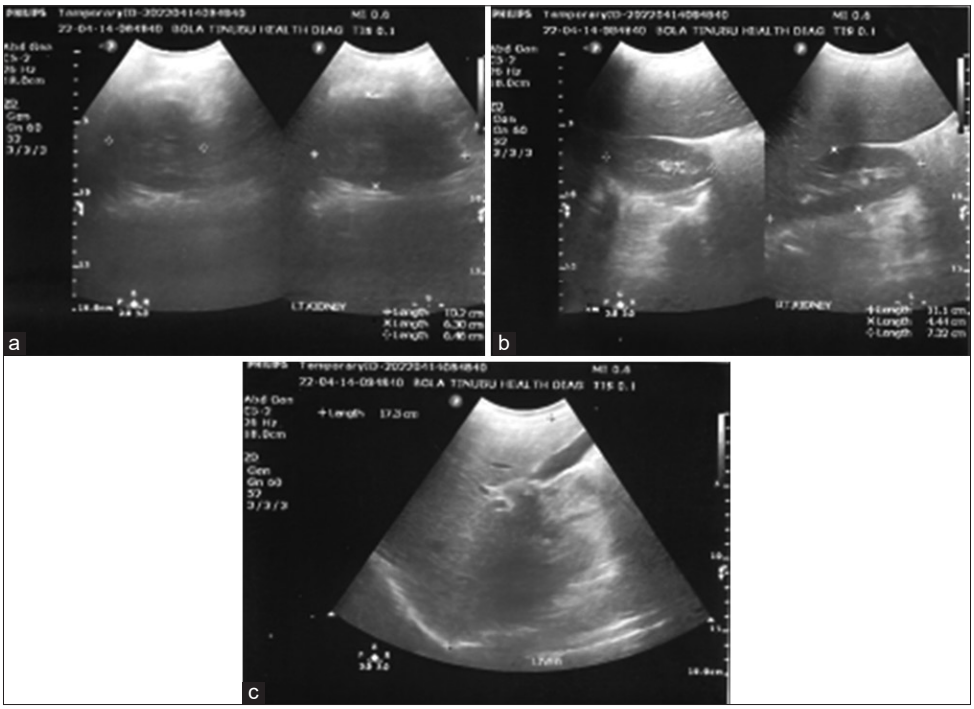

Figure 2: (a) Shows transverse (Left) and longitudinal (Right) views of the left kidney measuring 6.46 x 6.30 x 10.2cm in transverse, AP and longitudinal diameters respectively. (b) Shows transverse (Left) and longitudinal (Right) views of the right kidney measuring 7.32 x 4.44 x 11.1 cm in transverse, AP and longitudinal diameters respectively. (c) shows longitudinal view of the liver showing hepatomegaly (span 17.3 cm)

Our study also revealed gender-specific variations in kidney size. Among male participants, the right kidney's size in the SCD group was significantly larger than in the control group. However, this difference was not statistically significant among female participants. These gender-specific disparities in kidney size within the context of SCD present an intriguing area for further investigation, as they may have implications for the management and care of patients [Table 2].

These observations underscore the multisystemic nature of SCD and highlight the need for comprehensive, multidisciplinary care for affected individuals. Understanding the morphological changes in organs in SCD patients is crucial for clinicians. Enlarged organs, as indicated in this study, might impact the management of sickle cell patients, especially in cases where organomegaly affects the normal physiological functions of these organs. Physicians must be aware of these alterations for accurate diagnosis and treatment planning.

It is important to acknowledge the limitations of the study. The sample size, though comparatively the same as controls, is relatively small due to the small percentage of the steady status of SCD patients with 8 to 12 weeks of crisis-free periods in our environment; most SCD patients are lost to follow-up after resolution of crises. The study does not delve into the potential causes or clinical implications of the observed organ size differences. Future research could focus on longitudinal studies with larger sample sizes to explore the underlying mechanisms and long-term complications behind these disparities and their impact on the clinical course of SCD.

The strength of this study is the contribution to our understanding of how SCD may affect abdominal organ sizes and provide a foundation for ongoing research to enhance the care and outcomes of individuals living with this genetic condition.

CONCLUSION

Our study offers valuable insights into the potential impact of SCD on abdominal organ sizes, particularly the spleen, kidneys, and liver. The findings underscore the importance of regular monitoring and early detection of organ abnormalities in individuals with SCD. Furthermore, the gender-specific variations in kidney size within this context provide an intriguing avenue for future research.

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Conflicts of interest

There are no conflicts of interest.

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