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Characterization of Kidney's Morphology in Patients With Sickle Cell Diseases Using Ultrasonography

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ABSTRACT

The aim of this study was to evaluate the impact of sickle cell diseases (SCD) on renal morphology by using ultrasonography. The method adapted was an experimental study among a sample consists of 115 SCD patients and 100 as control group. Grayscale ultrasonography of right and left kidneys performed among all patients and controls. All the patients were scanned instable state condition. The results analysis carried out by EXCELL software for the collected variables which revealed that: The disease (SCD) was higher in male than female (54.6% vs. 45.4% respectively). The renal volume decreased in patients with (SCD) while echogenicity of kidneys increased in 36.5% for right kidneys and 37.4% for left kidneys in (SCD) patients. The volumes of kidneys were decreased in patients with (SCD) relative to control group. The left kidney was slightly increased in echogenicity and enlarged than the right kidney.

Early sonographic assessment of kidneys in patients with (SCD) can be used as early sonographic predictors of morphologic changes in kidneys. Thereby, these findings can guide the clinicians initiating adequate treatment at an early stage to avoid more complications.

Keywords: Sickle Cell Disease, ultrasonography, echogenicity

1. Introduction

Sickle cell disease (SCD) is among the most common of inherited hemoglobinopathies. The disease has been known since James Herrick, a Chicago cardiologist, first reported it as "peculiar elongated and sickle-shaped red corpuscles in a case of severe anemia" [1]. SCD is a multisystem disorder affecting almost every tissue of the body, however it could induces renal dysfunction and further leading to sickle nephropathy in the later stages.

Ultrasound is an accurate imaging method and provides thorough assessment of kidney size and echogenicity. SCD is associated with several functional and structural complications of the kidney [2] which may develop to chronic renal failure (CRF) and end-stage renal disease [3]. In

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previous studies renal failure had been reported in SCD and the prevalence ranged from 5 to 18% of the total population [4]. Kidneys are vulnerable of SCD and infarction, especially in renal medullae which causes capillary obliteration that results in papillary and medullary necrosis. Several studies reported sonographic changes in renal parenchyma and cortex; they demonstrated diffuse increased echogenicity of renal medullae in patients with SCD [5]. On the other hand, SCD has significant impact on kidney size which was significantly increased in patients with SCD [6], so sonographic evaluation of kidneys is very necessary since complications of SCD may progress to renal failure. On grayscale sonography evaluation of renal morphologic features in SCD, almost half of the patients with SCD have large kidneys, believed to be a result of increased renal blood volume from the anemia [5]. Also, the kidneys may display normal echogenicity (89% of patients); may be diffusely, mildly echogenic (5%); or may exhibit increased medullary echogenicity with normal cortical echogenicity (3%). Over time, the kidneys may shrink if renal failure ensues [2]. However, most of the gray-scale sonography morphologic features are observed in the late course of the disease [7]. The trend of this study is to assess the kidneys in patients with SCD using ultrasonography.

2. Methodology:

This study was an experimental clinical study conducted in west of Sudan where the high incidence of SCD among the community during the period from July 2016 to April 2017. The sample consisted of 115 patients with SCD referred to the ultrasound department for routinely abdominal scan with age range of 3–21 years. Other 100 patients considered as control group consisting of randomly selected patients who were routinely attending to abdominal ultrasonography.

The groups have been scanned with two U/S machines (*Accuvixxg – AVXGL30-samsung –Korea and Mindary DC-N6 –China*). The probe used was curve linear multi-hertzs probe with utilization of U/S gel to avoid reflection of ultrasound and to maintain a good transmission of U/S beam inside the body. The examination began in supine position. The para-aortic region was examined to exclude the presence of horse show kidneys. Length, width, depth and cortical thickness of the kidneys were measured. The longitudinal dimensions of the kidneys were upper pole to lower pole to represent the longest longitudinal section. Coronal or Sagittal view were also taken. The width and depth were measured in a section perpendicular to the long axis of the kidney as assessed from the longitudinal image. The transverse section was taken to pass through the hilum of the kidney. Width and depth were then measured in two orthogonal directions; renal volume was estimated from the three orthogonal measurements on the base of ellipsoid formula.
The echogenicity of the cortex for each kidney was compared with the liver in the right side and spleen in the left side to evaluate echogenicity changes.

3. Results

The following section will highlight the right and left kidney's volume and echogenicity for SCD patients and control group.

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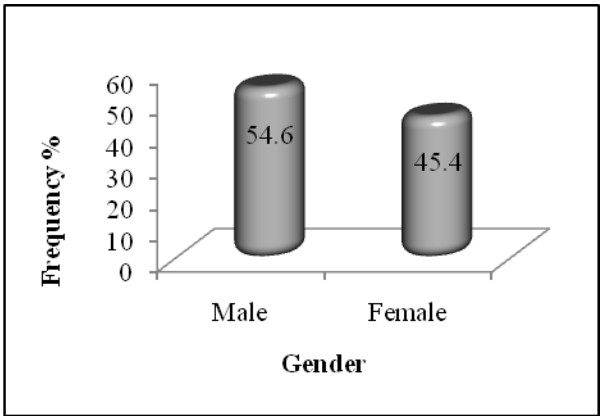

Figure 1: *Gender frequency of SCD patients.*

Table 1.*Mean and Std. deviation of age, and BMI for SCD patients and control group.*

Parameters	*Mean*	*Std. deviation*
Age/ Patients	10.5	4
BMI/ Patients	16.8	3
Age/ Control Group	17	4.9
BMI/ Control Group	23.2	5.5

Table 2. *Mean and Standard deviation of Kidneys volume, and length for SCD patients & control group.*

Parameters	***Mean***		***Std. Deviation***	
	Patient	Control group	Patient	Control group
Right Kidney Volume(Cm^3)	59.41	97.85	2.21	29.53
Right Kidney Length.(Cm)	8.78	9.14	5.22	1.04
Left Kidney Volume (Cm^3)	98.38	100.2	21.38	22.73
Left Kidney Length(Cm)	8.93	9.5	5.22	1.04

Table 3*. Frequency of echogenicity of kidneys in patients with SCD.*

Characteristics	***Frequency***	***Percent***
Echogenicity of the right kidney		
hyperechoic	42	36.5%
Normal echogenicity	73	63.5%
Echogenicity of the left kidney		
Hyperechoic	43	37.4%
Normal echogenicity	72	62.6%

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3. Discussion &analysis:

This study was conducted to detect early morphological renal changes in patients with sickle cell disease in Sudan using ultrasonography.

About 115 SCD patients and 100 normal subjects as control group, the study included 63 male (54.6%) and 52 female (45.4%) which explain the high incidence of SCD among male (**Figure 1**).

The mean age in (years) of SCD patients included in this study was 10.5±4 while 17±4.9 for control group, with their mean BMI (kg/m2) 16.8±3 & 23.2±5.5 for SCD patients and control group respectively (**Table 1**).

The average measurement of the right kidney length (cm) and volume (cm3) for SCD patients was 8.78±1.04 & 59.41±2.21 respectively, while the left kidney measures 8.93±5.22/cm (length) & 98.38±21.38/ cm3 (volume), the control group shows 9.14±1.04/cm and 97.85±29.53/ cm3 for right kidney length and volume respectively, as well as the left kidney length = 9.5±1.04/cm, while the volume =100.2±22.73/ cm3 (**Table 2**).

The effect of SCD on renal echogenicity had been reported in previous studies. The increased echogenicity involves medullae and cortex and may be diffused or focal. In the current study, the incidence of increased echogenicity was 36.5% (42 patients) & 37.4% (43 patients) for right and left kidney respectively (**Table 3**). This result is agreed with Daneil et al. (1993) who reported increased echogenicity in various types of sickle hemoglobinopathies. Our finding was also consistent with Ali et al. (2008) who reported increased focal and diffused echogenicity in 7.1% and 9.5% of the cases. Marina et al. (2003) reported that increased echogenicity was found in17.6% of patients with sickle-cell syndromes. The etiology of increased echogenicity was unknown; however, glomerulofibrosis, renal papillary necrosis, renal sclerosis, increased concentrations of iron deposits within tubular epithelial cells, focal scarring and interstitial fibrosis in vasa recta system have been suggested as contributing factors [8].

However, to our knowledge, most of the studies assessed the sonography of the whole abdominal organs, but few studies demonstrated the sonographic changes in one organ such as kidneys. Early sonographic evaluation of kidneys helps to prevent severe complications that may end to renal failure.

In the present study, the SCD has an impact on size of the kidneys. In previous studies the size of kidneys had been evaluated in general without determining which left or right one. But in this study we have assessed the size of each kidney separately. It was observed that the left kidney is more enlarged than the right kidney. In a study conducted by Ali et al. [8] reported that the renal enlargement was 30.1% in SCD. This finding was agreed with our result, thus we found 32.47 % (summation of incidence of right and left renal enlargements). Accordingly, it was observed the measurement of length of the left kidney was higher than that of the right kidney (**Figure 2 & Figure 3**). The etiology of renal enlargement in SCD is unknown. It was suggestive to glomerular hypertrophy and increased renal blood volume as likely contributors [11, 12].

The effect of SCD on renal echogenicity had been reported in previous studies. The increased echogenicity involves medullae and cortex and may be diffused or focal (**Figure 4 & Figure 5)**.

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In the current study, the incidence of increased echogenicity (hyperechoic) was 36.66%. This result is agreed with Daneil et al. [13] who reported increased echogenicity in various types of sickle hemoglobinopathies. Our finding was also consistent with Ali et al who reported increased focal and diffused echogenicity in 7.1% and 9.5% of the cases [8]. Marina et al reported that increased echogenicity was found in17.6% of patients with sickle-cell syndromes [14].

The etiology of increased echogenicity was unknown; however, glomerulo-fibrosis, renal papillary necrosis, renal sclerosis, increased concentrations of iron deposits within tubular epithelial cells, focal scarring and interstitial fibrosis in vasa recta system have been suggested as contributing factors [8].

SCD is a disorder that worsens over time and so several complications had been reported. The current study showed a significant positive correlation between duration of SCD and renal length and volume (p-value = 0.00). It was observed that renal volume and length increased significantly over time due to SCD. This correlation is weak since the enlargement of kidneys occurs in early stage, but over time the complications accelerate Kidney disease progression to end-stage renal failure which was characterized by shrunken kidney [15].

4. Conclusion:

Since the sickle cell disease has an impact in renal morphology, the worth outcome of this study proved that: Early sonographic assessment of kidneys in patients with (SCD) can be used as early sonographic predictors of morphologic changes in kidneys. Thereby, these findings can guide the clinicians initiating adequate treatment at an early stage to avoid more complications.

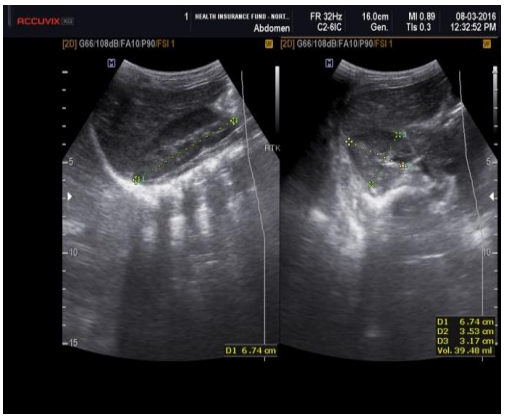

Figure 2: *Small right kidney in 11 years old male patient with sickle cell disease*

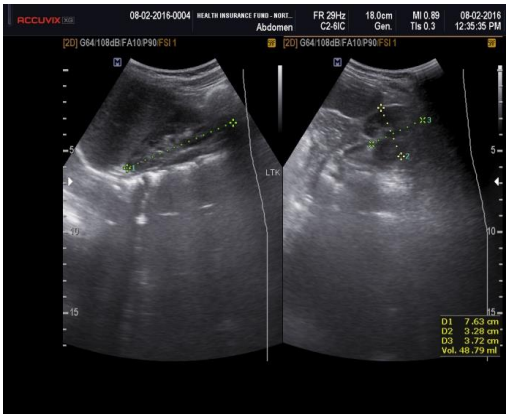

Figure 3: *Small left kidney in 11 years old male patient with sickle cell disease*

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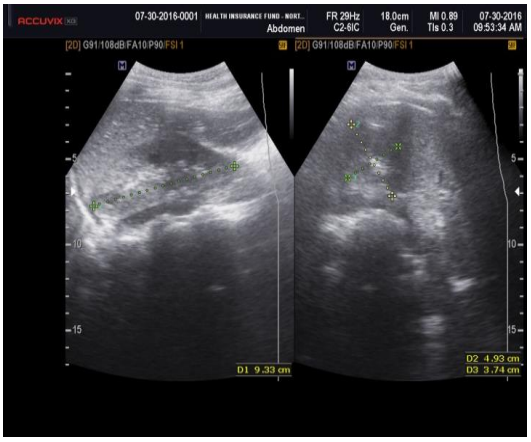

Figure 4: *The left kidney with increased echogenicity in 17 years old male patient with sickle cell disease*

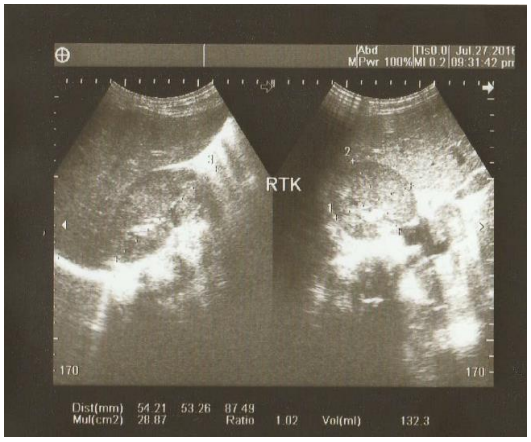

Figure 5: *The right kidney with increased echogenicity in 13 years old male patient with sickle cell disease*

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