Original Research Article

SONOGRAPHIC EVALUATION OF RENAL DIMENSIONS AND VOLUME IN NORMAL PREGNANCY IN BAYELSA STATE, SOUTH-SOUTH, NIGERIA

ABSTRACT

Background: Physiological changes in the renal system lead to important modifications in electrolyte, acid-base balance and renal function. Some of these changes occur in the renal dimensions and volume, and to adequately interpret these changes, physiological changes in pregnancy should be well understood.

Objective: To sonographically evaluate the renal dimensions and volume, and correlate them with age, parity and trimesters in normal pregnancy in Bayelsa State, Nigeria.

Materials and Methods: This prospective, descriptive, cross-sectional study was conducted at the Departments of Obstetrics and Gynaecology, and Radiology of the two tertiary hospitals in Bayelsa State, Nigeria, from July to December, 2021. Sonographic assessments of the renal dimensions and volume in 400 consecutive normal pregnant women in both tertiary institutions were done, after obtaining written informed consent from them. Data were entered into a pre-designed proforma, and analysed using SPSS version 25.0. Results were presented in frequencies and percentages for categorical variables and mean and standard deviation for continuous variables.

Results: A total of 400 pregnant women were scanned. The mean renal bipolar length, mean antero-posterior diameter and mean renal width were 10.9 ± 1.0 cm, 4.7 ± 0.6 cm and 6.4 ± 0.7 cm respectively. Mean renal volume was 174.2 ± 44.8 cm. Renal volume was highest in the left kidney of women > 35 years (186.8 ± 47.3 cm3), and was lowest (162.8 ± 33.6 cm3) in the right kidney of women < 20 years. The mean values of the renal dimensions and volume increased with parity of the women and trimester of pregnancy.

Conclusion: This study produced a mean renal volume in pregnancy for our locality. It was revealed that the renal volume and dimensions were lowest in younger women and highest in older women. The renal volume increased as pregnancy advanced; and with increasing parity.

Keywords: Physiological changes, Renal dimensions, Renal Volume, Kidney, Age, Parity, Trimesters.

1. INTRODUCTION

Pregnancy is associated with many physiological changes, and the renal system is not left out. These physiological changes in the renal system lead to important modifications in electrolyte, acid-base balance and renal function.[1] The changes in the renal system occur in the kidneys, renal calyces,

ureter, urinary bladder and the urethra. To adequately interpret patients' investigation results, these physiological changes in pregnancy should be well understood.

The size of the kidneys increases by 1 – 1.5 cm.[1] This is due to the smooth muscle-relaxing effect of progesterone and relaxin.[1,2] This change may be present till 12 weeks postpartum, and should not be misdiagnosed as hydronephrosis on ultrasound scan.

From early pregnancy, the glomerular filtration rate starts increasing, and increases to about 50% in the second trimester and then reduces to about 20% before term.[1] Renal plasma flow increases to as high as 85% in the second trimester as a result of increase in cardiac output and increased renal vasodilation.[1] These changes should not be misdiagnosed as renal disease in pregnancy. The renal volume increases by about 30% due to increase in renal vascular and interstitial volume, and not as a result of increase in the number of nephrons.[1,2] The various physiological changes in pregnancy return to normal at different times in the puerperium.

During pregnancy, ultrasound measurement of renal dimensions and volume is crucial for routine evaluation, and for follow-up of those with renal disease in pregnancy. This investigative modality is non-invasive, cheap, reliable, easy and safe in pregnancy. Ultrasonography uses sound energy, and has an advantage of not using ionizing radiation, like computed tomographic scan. Therefore, the objective of this study is to sonographically evaluate the renal dimensions and volume, and correlate them with age, parity and trimester in normal pregnancy in Bayelsa State, Nigeria.

2. MATERIALS AND METHODS

This was a prospective, descriptive, cross-sectional study. This study was conducted at the Departments of Obstetrics and Gynaecology, and Radiology of the two tertiary hospitals in Bayelsa State, Nigeria, over a six-month period, from July to December, 2021. The hospitals are the Federal Medical Centre, Yenagoa and Niger Delta University Teaching Hospital, Okolobiri. The core mandate of these tertiary health institutions revolves around service, training and research, and serve as referral centres for hospitals in Bayelsa State and neighbouring Delta and Rivers States.

The sample size for this study was calculated using the formula:

$n = z^2pq/d^2$ [3]

Where

n = minimum sample size

z = normal standard deviation set at 95% confidence limit = 1.96

p = prevalence.

q = 1 – p (complementary probability).

d = margin of error = 5% = 0.05

Sonographic assessments of the renal dimensions and volume in 400 consecutive normal pregnant women in both tertiary institutions were done. Pregnant women without any known renal or

cardiovascular diseases were included in the study. Women with known medical condition(s) in pregnancy were excluded from the study. Participants were recruited from the antenatal clinic. After a written informed consent, pregnant women that met the inclusion criteria were referred to the Radiology Department for routine obstetric ultrasound scan. The age of the women, parity, gestational age, and blood pressure were obtained and documented. To rule out proteinuria and glycosuria prior to ultrasound scan evaluation, urinalysis was done with the use of dipstick.

A real time, grey scale, ultrasound examination was carried out with the use of the 2012 Philips HD11 machine fitted with a 3.5 MHz curvilinear transducer, with electronic calipers to measure the length, width and thickness of each of the kidneys. Sonography was performed in the semi prone position in other not to put pressure on the pregnant uterus. All patients were required to empty their urinary bladder prior to scanning.

All scans were performed posteriorly through the back. The real time grey scale images were frozen following clear identification of the inferior and superior renal poles in the longitudinal plain. The renal length (L) was taken as the longest distance between the poles using an electronic caliper while the antero-posterior (AP) diameter (thickness) was measured from anterior wall to the posterior wall of the kidney at its mid portion. The renal width (W) was measured on transverse scan and the maximum transverse diameter was taken at the level of the hilum as the renal width. The unit of measurement was centimeter (cm). Using the formula, volume = length x width x breadth x 0.523, the renal volume was calculated.

Data were entered into a pre-designed proforma, and were analysed using Statistical Package for Social Sciences version 25.0. Results were presented in frequencies and percentages for categorical variables and mean and standard deviation for continuous variables.

3. RESULTS

Demographic and obstetric characteristics

A total of 400 pregnant women were scanned, their mean age was 28.7 years with a standard deviation of 6.1 years. The modal (30%) age group was 25 – 29 years (Table 1). Table 1 further reveals that most (39%) of the women were nulliparous women. Parity ranged between 0 and 6 with a median of 1. Above half (56%) of the women were in the second trimester of pregnancy.

Table 1: Demographic and obstetric features of the participants

Characteristics	Frequency N = 400	Percent (%)
Age		
> 20 years	28	7.0
20 - 24 years	76	19.0
25 - 29 years	120	30.0
30 - 34 years	100	25.0
> 35 years	76	19.0
Mean Age ± SD in years	28.7 ± 6.1	

Parity		
Nulliparous	156	39.0
Primiparous	92	23.0
Multiparous	132	33.0
Grand multiparous	20	5.0
Median Parity	1 (0 – 6)	
Trimester of Pregnancy		
First trimester	28	7.0
Second trimester	224	56.0
Third trimester	148	37.0

Renal dimensions and volume in Pregnancy

The mean renal bipolar length, mean antero-posterior diameter and mean renal width were 10.9 ± 1.0 cm, 4.7 ± 0.6 cm and 6.4 ± 0.7 cm respectively (Figure 1, Table 2). Mean renal volume was 174.2 ± 44.8 cm**.**

The right and left kidneys were averagely of the same dimension with very minimal difference in variations. The student's t-test that explored the differences between the dimensions of the right and left kidneys showed no significant difference ($p > 0.05$).

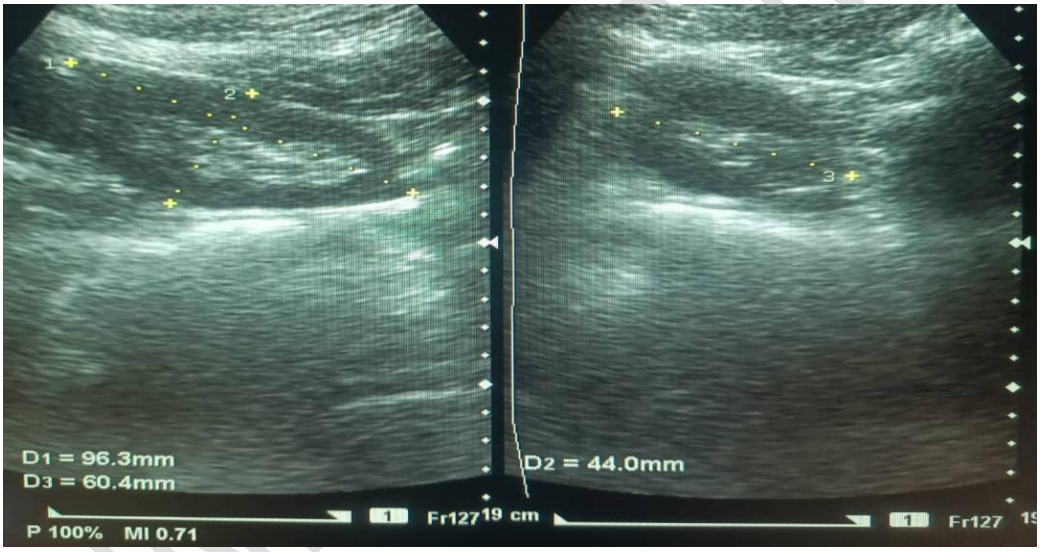

Figure 1: Sonogram showing renal dimensions.

Table 2: Comparing dimensions and volume of the right and left kidneys in the pregnant women

Renal parameter	Renal Dimensions – Mean ± SD (cm)			T -test	p-Value
	Both Kidneys	Right Kidney	Left Kidney		
Renal Bipolar length	10.9 ± 1.0	10.9 ± 1.0	10.9 ± 1.1	0.14	0.887
AP Diameter	4.7 ± 0.6	4.7 ± 0.6	4.7 ± 0.5	1.08	0.282
Renal Width	6.4 ± 0.7	6.5 ± 0.7	6.3 ± 0.7	1.17	0.243
Renal Volume	174.2 ± 44.8	174 .4 ± 46.9	174 .0 ± 42.9	0.05	0.956

SD – Standard deviation; AP – Anterio-posterior.

Relationship between age of respondents, and renal dimensions and volume

The mean renal bipolar length in the right kidney was lowest (10.7 ± 0.9 cm) among participants who were aged 20 – 24 years and highest (11.1 ± 1.1 cm) among pregnant women aged > 35 years. For the left kidney, a similar trend was noticed, participants aged 20 – 24 years also had the lowest dimensions (10.8 ± 0.7 cm) while those aged > 35 years had mean renal bipolar length of 11.1 ± 1.1 cm (Table 3).

Mean renal antero-posterior diameter for the right and left kidneys was 4.5 cm for women aged > 35 and < 20 years respectively (Table 3). Women aged 20 – 24 years had the highest renal antero-posterior diameter in the right kidney (4.7 ± 0.5 cm) and left kidney (4.9 ± 0.5 cm).

Renal volume was highest in the left kidney of women > 35 years (186.8 ± 47.3 cm^3), and was lowest (162.8 ± 33.6 cm^3) in the right kidney of women < 20 years. All the renal dimensions measured were not significantly different ($p > 0.05$) in relation to the age of the participants (Table 3).

Table 3: Relationship between renal dimensions and volume, and the age of pregnant women

Renal Parameter	Frequency N = 400 (%)	Right Kidney		Left Kidney	
		Mean ± SD (cm)	F-Statistic (p-Value)	Mean ± SD (cm)	F-Statistic (p-Value)
Renal bipolar length					
> 20 years	28 (7.0)	10.9 ± 1.0	0.32	11.0 ± 0.8	0.53
20 - 24 years	76 (19.0)	10.7 ± 0.9	(0.865)	10.8 ± 0.7	(0.713)
25 - 29 years	120 (30.0)	11.0 ± 0.9		10.8 ± 1.0	
30 - 34 years	100 (25.0)	10.9 ± 1.1		11.1 ± 1.2	
> 35 years	76 (19.0)	11.1 ± 1.2		11.1 ± 1.1	
Renal antero-posterior diameter					
< 20 years	28 (7.0)	4.6 ± 0.4	0.33	4.5 ± 0.4	1.32
20 - 24 years	76 (19.0)	4.7 ± 0.5	(0.855)	4.9 ± 0.5	(0.267)
25 - 29 years	120 (30.0)	4.7 ± 0.6		4.6 ± 0.5	
30 - 34 years	100 (25.0)	4.6 ± 0.7		4.8 ± 0.8	
> 35 years	76 (19.0)	4.5 ± 0.7		4.8 ± 0.6	
Renal width					
< 20 years	28 (7.0)	6.3 ± 0.7	0.60	6.4 ± 0.8	1.04
20 - 24 years	76 (19.0)	6.6 ± 0.6	(0.664)	6.4 ± 0.6	(0.389)
25 - 29 years	120 (30.0)	6.5 ± 0.7		6.2 ± 0.7	
30 - 34 years	100 (25.0)	6.5 ± 0.8		6.3 ± 0.6	
> 35 years	76 (19.0)	6.3 ± 0.8		6.3 ± 0.7	
Renal volume					
< 20 years	28 (7.0)	162.8 ± 33.6	0.22	164.8 ± 36.5	1.01
20 - 24 years	76 (19.0)	174.6 ± 37.7	(0.929)	177.8 ± 27.7	(0.406)
25 - 29 years	120 (30.0)	177.4 ± 37.1		163.5 ± 36.6	
30 - 34 years	100 (25.0)	177.7 ± 59.7		176.6 ± 55.3	

> 35 years	76 (19.0)	174.4 ± 46.9	186.8 ± 47.3

Relationship between obstetric features and renal dimensions and volume

Parity of respondents and renal dimensions and volume

The mean renal bipolar length, antero-posterior diameter and width increased gradually from the primiparous to grand multiparous women in both the right and left kidneys (Table 4). This gradual change in renal dimensions as parity changes was however not statistically significant ($p > 0.05$). The mean values for all the renal dimensions were highest in grand multiparous women in both the left and right kidneys. The mean bipolar length was 11.3±1.3 cm and 11.7±1.2 cm; mean antero-posterior diameter was 4.7± 0.3 cm and 5.0±0.4 cm; mean renal width was 6.8 ± 0.8 and 6.9 ± 0.8, and mean renal volume was 188.7 ± 42.0 cm^3 and 208.5 ± 35.2 cm^3 for right and left kidney respectively (Table 4).

Table 4: Relationship between renal dimensions and volume, and the parity of pregnant women

Renal parameter	Frequency N = 400 (%)	Right Kidney		Left Kidney	
		Mean ± SD (cm)	F-Statistic (p-Value)	Mean ± SD (cm)	F-Statistic (p-Value)
Renal bipolar length					
Nulliparous	156 (39.0)	10.9 ± 0.9	0.44 (0.728)	10.9 ± 0.9	1.31 (0.275)
Primiparous	92 (23.0)	10.8 ± 1.0		10.8 ± 1.2	
Multiparous	132 (33.0)	11.0 ± 1.1		11.0 ± 1.0	
Grand multiparous	20 (5.0)	11.3 ± 1.3		11.7 ± 1.2	
Renal antero-posterior diameter					
Nulliparous	156 (39.0)	4.5 ± 0.5	0.40 (0.752)	4.6 ± 0.5	0.59 (0.619)
Primiparous	92 (23.0)	4.6 ± 0.7		4.7 ± 0.7	
Multiparous	132 (33.0)	4.7 ± 0.7		4.8 ± 0.6	
Grand multiparous	20 (5.0)	4.7 ± 0.3		5.0 ± 0.4	
Renal width					
Nulliparous	156 (39.0)	6.3 ± 0.6	1.09 (0.356)	6.3 ± 0.8	1.99 (0.120)
Primiparous	92 (23.0)	6.4 ± 0.8		6.1 ± 0.8	
Multiparous	132 (33.0)	6.6 ± 0.7		6.5 ± 0.5	
Grand multiparous	20 (5.0)	6.8 ± 0.8		6.9 ± 0.8	
Renal volume					
Nulliparous	156 (39.0)	166.6 ± 39.4	0.89 (0.467)	168.5 ± 40.9	1.63 (0.187)
Primiparous	92 (23.0)	172.7 ± 49.9		168.1 ± 52.8	
Multiparous	132 (33.0)	182.6 ± 53.5		179.3 ± 36.7	
Grand multiparous	20 (5.0)	188.7 ± 42.0		208.5 ± 35.2	

Trimester of pregnancy and renal dimensions and volume

The mean values of the renal dimensions and volume measured in relation to the trimesters of pregnancy followed the same trend as parity of the women. The renal dimensions increased from the first trimester to the third trimester of pregnancy, with the mean values highest in the third trimester of pregnancy in both the right and left kidneys.

The mean renal bipolar length in the first trimester of pregnancy for the right and left kidneys was 10.2 ± 0.6 cm and 10.3 ± 0.8 cm respectively, while in the third trimester of pregnancy the mean bipolar length was 11.3 cm ± 1.1 cm and 11.1 ± 0.2 cm respectively (Table 5). Mean renal volume of the right kidney was 136.9 ± 24.7 cm^3, 168.5 ± 41.1 cm^3 and 190.3 ± 52.8 cm^3 in the first, second and third trimesters respectively and the renal volume of the left kidney was 146.8 ± 25.0 cm, 172.6 ± 40.3 cm and 181.2 ± 47.7 cm respectively (Table 5).

The mean difference in the values of the dimensions of the left kidney had no statistically significant difference ($p > 0.05$), but the differences observed in the dimensions were significant statistically in the renal bipolar length (f-test=4.29;p-0.016), renal antero-posterior diameter (f-test=3.33;0.040) and renal volume (f-test=5.19;p-0.007). A Post-hoc test done revealed that third trimester values of renal bipolar length and renal volume in the right kidney were significantly different from the values of these measurements in pregnant women in the first and second trimesters, whereas in the left kidney, significant difference exists between the first and the third trimester for only the renal antero-posterior diameter (Table 5).

Table 5: Relationship between renal dimensions and volume, and the trimester of pregnancy

Renal Parameter	Frequency N = 400 (%)	Right Kidney		Left Kidney	
		Mean ± SD	F-Statistic (p-Value)	Mean ± SD	F-Statistic (p-Value)
Renal bipolar length[a]					
First Trimester	28 (7.0)	10.2 ± 0.6	4.29 (0.016)	10.3 ± 0.8	1.73 (0.182)
Second Trimester	224 (56.0)	10.8 ± 0.9		10.9 ± 1.0	
Third Trimester	148 (37.0)	11.3 ± 1.1		11.1 ± 0.2	
Renal antero-posterior diameter[b]					
First Trimester	28 (7.0)	4.2 ± 0.5	3.33 (0.040)	4.5 ± 0.3	1.19 (0.310)
Second Trimester	224 (56.0)	4.6 ± 0.6		4.7 ± 0.5	
Third Trimester	148 (37.0)	4.8 ± 0.6		4.8 ± 0.6	
Renal width					
First Trimester	28 (7.0)	6.2 ± 0.4	2.36 (0.099)	6.1 ± 0.4	0.79 (0.453)
Second Trimester	224 (56.0)	6.4 ± 0.6		6.3 ± 0.7	
Third Trimester	148 (37.0)	6.7 ± 0.8		6.4 ± 0.8	
Renal volume[a]					
First Trimester	28 (7.0)	136.9 ± 24.7	5.19 (0.007)	146.8 ± 25.0	2.01 (0.140)
Second Trimester	224 (56.0)	168.5 ± 41.1		172.6 ± 40.3	
Third Trimester	148 (37.0)	190.3 ± 52.8		181.2 ± 47.7	

[a]Post-hoc test revealed a significant difference in between the first, second and third trimester values. [b]Post-
hoc test revealed a significant difference only between the first and third trimester values.

4. DISCUSSION

Our study revealed a mean renal volume in pregnancy of 174.4 ± 46.9 for the right kidney and 174.0 ± 42.9 for the left kidney, with an average of 174.2 ± 44.8 for both kidneys. These were not statistically significant. Our values are higher than the 141.85 ± 41.08 (right kidney); 163.44 ± 51.33 (left kidney) reported by Ugboma et al [2] in South-South, Nigeria, the 147.75 ± 1.87 (right kidney); 172.53 ± 2.13 (left kidney) reported by Ugochinyere et al [4] in Enugu, South-East Nigeria, and the 105.77 ± 27.29 (right kidney); 104.23 ± 28.18 (left kidney) reported by Kamble et al [5] in Central India.

Our study revealed that the renal volume and dimensions were lowest in younger women and highest in older women. However, this difference was not statistically significant. In non-pregnant women, the renal volume and dimensions decrease with age. [6–8] This is due to parenchymal reduction as one advances in age.

In this study, the renal volume and dimensions increased as parity increased. Various studies are in tandem with this finding. [2,5,9,10] This increase in our study was however, not statistically significant ($p > 0.05$). This agrees with the findings from previous studies, where there was no statistical correlation between renal dimensions and increase in parity. [2,5,9,10] The reason for this is that the renal volume and dimensions return to normal after every pregnancy, and there is therefore, no additional increase in the size of the kidneys in subsequent pregnancies.

Renal volume gradually increased from the first trimester to the third trimester. This finding is in line with the reports of previous studies, [2,4,5] and it results from the steady increase in glomerular filtration rate, renal plasma flow and hyperfiltration in pregnancy, which is maximal in the third trimester. Our study revealed no significant difference between the renal volume of the right and left kidneys. This finding is in consonance with the report of Okoye et al [11] in non-pregnant patients in Enugu, South-East Nigeria, but different from the reports of Ogunmoroti et al [12] in Ile-Ife, South-West Nigeria, Kolade-Yunusa et al [13] in Abuja, North-Central Nigeria and Emamian et al[7] in Denmark, where the volume of the left kidney was more than that of the right kidney.

In our study, the antero-posterior diameter, renal length and width increased as pregnancy advanced. These dimensions also increased as the parity of the women increased. This is expected, because as the renal volume increases, the renal dimensions are also expected to increased. Our finding is in agreement with the report by Edevbie et al [14] in Benin, South-South Nigeria. The length of the left kidney is about 1.5 cm longer than that of the right. [1] This may be related to the fact that the left renal artery is shorter

and straighter than the right renal artery. Therefore, there is increased blood supply to the left kidney which increases its volume, and consequently, its size. Another plausible reason for the slightly bigger left kidney is that the spleen that lies superior to the left kidney is smaller than the liver that lies superior to the right kidney. This relationship of the spleen to the left kidney gives it relatively more space to grow. Our study however, did not show any significant difference in the dimensions of the right and left kidneys. This corresponds to the report of Okoye et al. [11]

The strength of this study lies in the fact that it is a prospective study where women with normal pregnancies were recruited. This removed confounding variables, like medical conditions in pregnancy, which would have affected the measurements of renal volume and dimensions.
This study is limited by the fact that it is a hospital-based study. Therefore, it may not reflect what is obtainable in the general population of pregnant women.

CONCLUSION

This study produced a mean renal volume in pregnancy for our locality. It was revealed that the renal volume and dimensions were lowest in younger women and highest in older women. The renal volume increased as pregnancy advanced; and with increasing parity.

ETHICAL APPROVAL

The research work was examined and approved by the hospitals' research and ethics committee.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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