Original Article

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Radiology Section

Sonographic Evaluation of the Renal Volume in Normal Pregnancy at the University of Port Harcourt Teaching Hospital: A Pilot Study

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ABSTRACT

Introduction: The renal system is affected by the changes that occur in pregnancy, with the renal volume being one of the most important changes that occur. The data on the renal volume changes in pregnancy in the west African sub region, including Nigeria, is apparently sparse.

Objective: The purpose of this study was to sonographically establish the range of the renal volume in normal pregnant women in the University of Port Harcourt Teaching Hospital, Nigeria.

Subjects and Methods: A prospective, descriptive, cross sectional study on the sonographic measurements of the renal volume was performed on 150 healthy, normal, pregnant women. The renal volume was calculated by using the ellipsoid method. The body mass index, gestational age and parity were obtained. The correlations between the variables were calculated.

Results: The age distribution of the women ranged from 20-41, with a mean of 29.7 years and the parity ranged from 0-6. The gestational age ranged from 9-40 weeks, while the body mass index ranged from 19.5 to 54. A mean renal volume of 163.44cm^3 $\pm$(SD) 51.3 and 141.85cm^3 $\pm$ 41.07 for the left and right kidneys respectively, was obtained, with a range of 100cm^3-214cm^3 for both the kidneys. The mean renal volume was seen to increase with an increase in the gestational age and the body mass index. It was not so with the parity. The mean renal volume significantly correlated positively with the gestational age ($r=0.29$ and 0.11 ($p<0.001$) for the left and right kidneys respectively) and the body mass index ($r=0.25$ and $r=0.24$, ($p<0.001$) for the right and left kidneys respectively), but not with the parity ($r=0.04$ and 0.07, ($p< 0.17$) for the left and right kidneys respectively). The left mean renal volume was found to be significantly larger in the left kidney than in the right one.

Conclusion: This study was able to establish a range of sonographic measurement of the renal volume in normal pregnancy for the locality.

Key Words: Renal volume, normal pregnancy, Ultrasound scan

INTRODUCTION

The changes in the renal system are important for the favourable outcome of an index pregnancy [1]. These changes in the renal system are anatomical and physiological/functional, which affect the renal blood flow, the kidneys, calyces, ureter, bladder and the urethra. Some of the physiological changes which are seen, are increase in the renal plasma flow and the glomerular filtration rate with corresponding anatomical changes which are seen as changes in the renal volume [2]. These changes occurs in early pregnancy, peaking at various stages of the pregnancy and returning to normal at various times during the pueperium [2,3,4].

Various mechanisms have been described to explain the actual effect of the pregnancy on the kidneys, but these mechanisms remain unclear [5]. These mechanisms are thought to include an increase in the renal volume, changes in the sodium and electrolyte regulation and the hormonal effects of relaxin which is produced in the kidneys during pregnancy.

The renal volume is one of the parameters which is affected by pregnancy and it is an important parameter which assesses the health of the kidneys [5], as it is believed to be an exact measurement of the renal size [6] and a pointer to the functional capacity of the kidney [7], as this relates to the number of nephrons [7].

In pregnancy, sonographic measurements of the renal volume and length are important for the evaluation and follow up of patients with renal pathologies [8-10]. There is however, a paucity of published information on the sonographic assessment of the renal volume in pregnancy, in spite of studies which have been done in other groups such as in chronic renal failure, diabetes and in the non pregnant population [11-14, 15-18].

The ultrasound estimation of the renal volume by using the ellipsoidal method [11] is simple, reliable, non-invasive and reproducible [12]. It has advantages over other radiological imaging modalities such as conventional radiography and computed axial tomography, in that ionizing rays which are harmful to the developing foetus are not used. In ultrasound, sound energy is used and it has been found to have no adverse effect on the developing foetus. Thus, it is safe. It can also be used at any stage of the pregnancy [13-15].

There is a paucity of published information on the normative values for the renal volume in normal pregnancy in our environment, in Nigeria and in the west African sub-region. The above reason has necessitated this study.

SUBJECTS AND METHODS

This was a prospective, descriptive, cross sectional study in which the sonographic evaluation of the renal volume in randomly selected normal pregnant women was done in the Radiology Department of the University of Port Harcourt Teaching Hospital Port Harcourt (UPTH), Rivers state, Nigeria, over a six month period (September 2009-March 2010). UPTH is a 500 bed tertiary hospital which serves as a catchment area for Port Harcourt and the surrounding towns and villages in southern Nigeria. Normal pregnant women with no known renal or cardiovascular diseases, who attended the antenatal clinic of the hospital, who was referred to the Radiology Department for a routine obstetric scan during the period, were recruited for the study after their informed consent was obtained.

The age, parity and blood pressure were obtained. Urinalysis was done by the researchers, by using a dipstick, prior to the ultrasound examination of the women, to exclude proteinuria and glycosuria. The height (in metres) and weight (in kilograms) were obtained. The body mass index (BMI) was calculated by using the formula, weight/(height) [2].

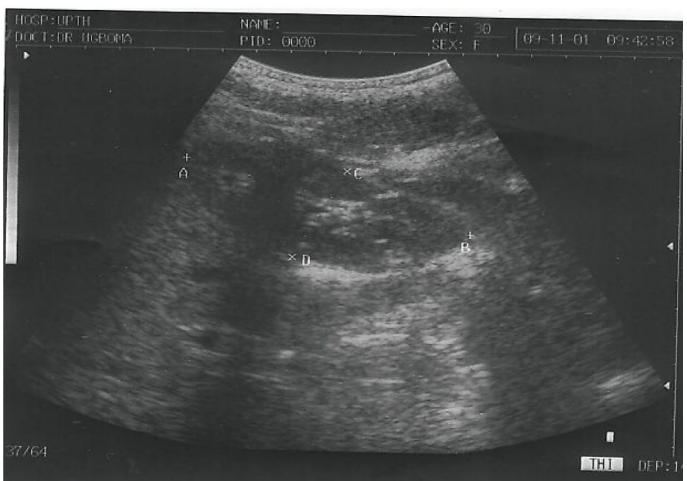
A real time, grey scale, ultrasound examination was done by using an Aloka 3500 machine which was fitted with a 3.5-5MHz curvilinear transducer.

The right kidney was scanned through the left posterior oblique or the left lateral decubitus position by scanning through the anterior axillary line intercostally or subcostally, while the left kidney was scanned through the right posterior oblique or the right lateral decubitus position by scanning through the anterior axillary line intercostally or subcostally [16].

The liver was used as an acoustic window on the right, while the spleen was used on the left for a detailed renal scan.

The kidneys were clearly identified, as were outlined by the brightly echogenic renal capsule with a central (sinus) echogenicity. A longitudinal scan of each kidney was done. The superior and inferior poles were clearly identified and marked. The renal length (L) (in cm) was taken as the longest distance between the poles (A-B) (bipolar length) [Table/Fig-1].

The antero-posterior diameter (AP) (thickness) (in cm) was also measured on the longitudinal scan, (C-D) [Table/Fig-1] with the maximum distance between the anterior and the posterior walls of the kidney at the middle.



[Table/Fig-1]: A Longitudinal ultrasound scan of the right kidney showing the renal length (AB) and renal AP diameter (CD)

The renal width (W) (in cm) was measured on the transverse scan [Table/Fig-2]. The hilum was identified and the transverse diameter was measured at this point (E-F).

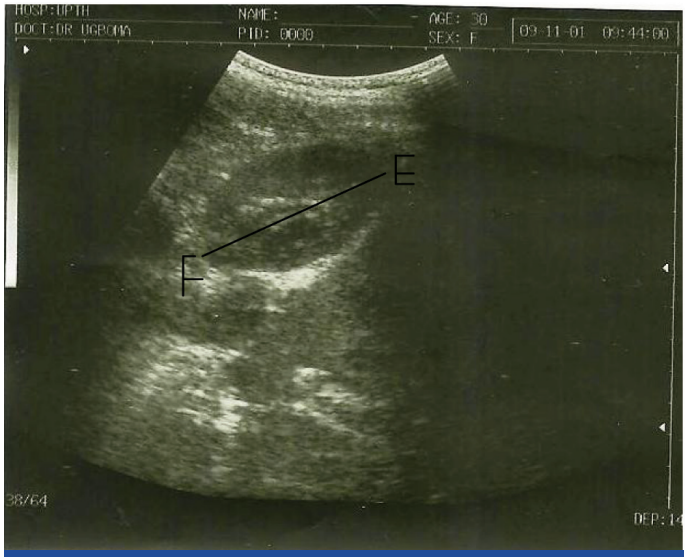
RESULTS

A total of one hundred and fifty women took part in the study, with their ages ranging from 20-41 years, with a mean age of 29 years. The age group of 25-29 years had sixty eight women, which was the highest number of the subjects, while the 40-44 years age group had only three women, which was the lowest incidence.

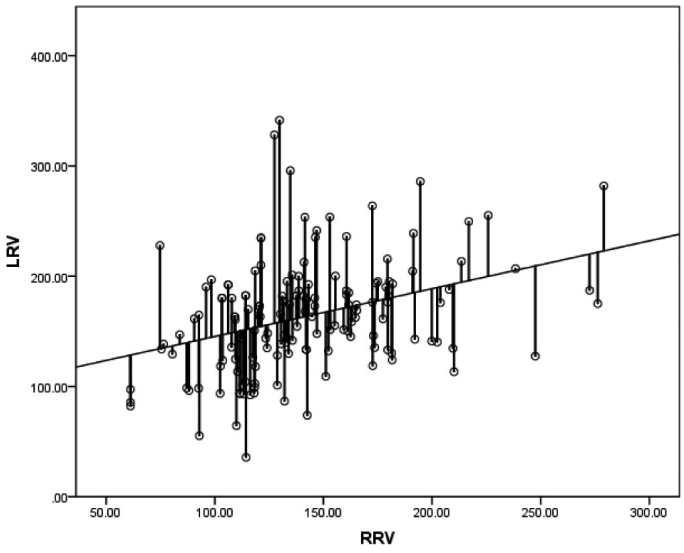
The parity ranged from 0 to 6, with the women of parity 0 having the highest incidence [53, (35.3%)] and those of parity 6 having the lowest incidence [2].

The body mass index (BMI) ranged from 19.5-54, with a mean of 29.45. The obese group had the highest incidence of sixty one (41%), while the underweight had the lowest incidence of eight (5%).

The gestational age ranged from 9-40 weeks, with an average of 28 weeks. Most of the women 93 (61%) were seen in the third trimester, while only 9(6%) were seen in the first trimester.

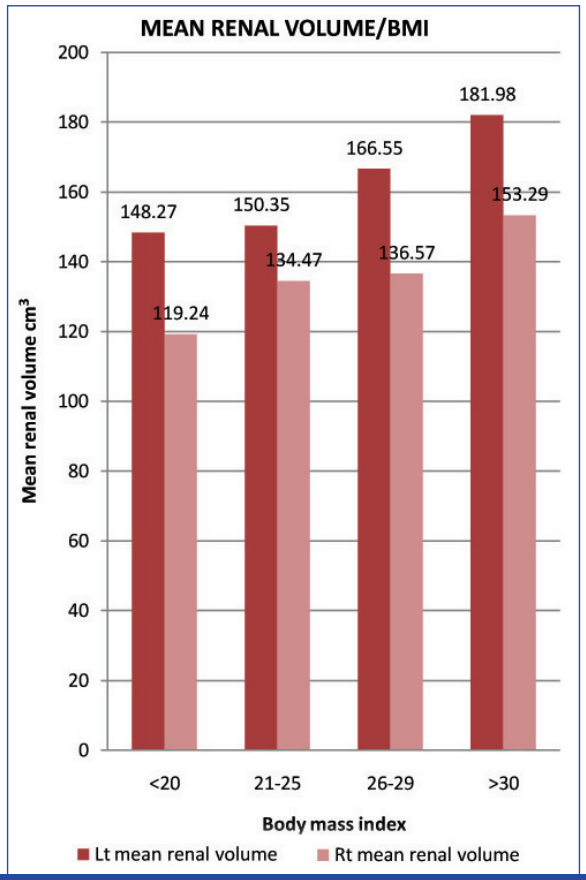


[Table/Fig-2]: A transverse ultrasound scan of the right kidney showing the renal Width (EF)

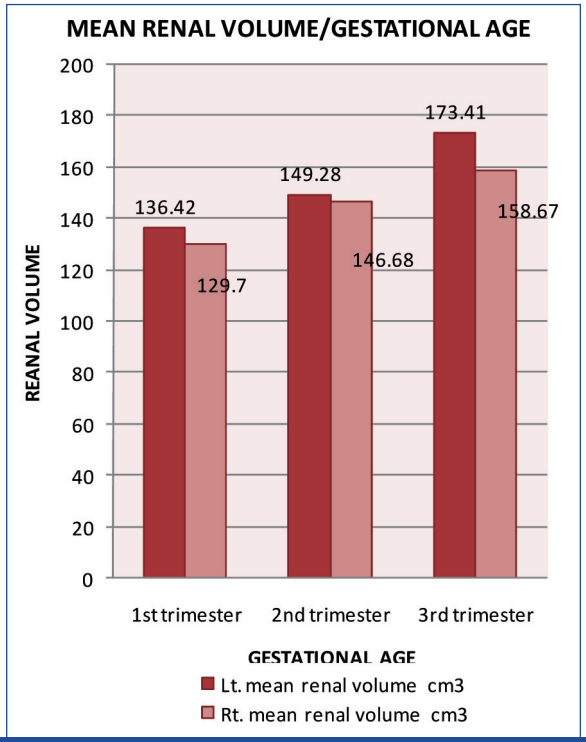


[Table/Fig-3]: Chart showing the correlation between the variables-right renal volume (RRV) and left renal volume (LRV) using Pearson's correlation

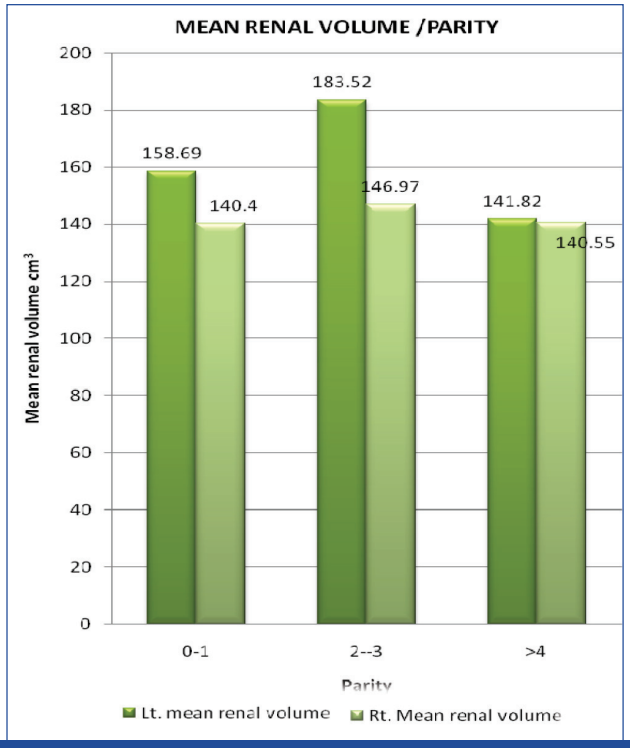
The mean renal volume throughout the pregnancy was found to be 163.44cm^3±51.3 for the left kidney and 141.85cm^3±41.07 for the right kidney, with a range of 100cm^3-214cm^3 for both the kidneys. There was a poor correlation between the left and right mean renal volumes, with the left mean renal volume being significantly greater than the right mean renal volume (p<0001) [Table/Fig-3]



[Table/Fig-4]: Bar chart showing distribution of the mean renal volume and body mass index



[Table/Fig-5]: Bar chart showing distribution of gestational age and mean renal volume



[Table/Fig-6]: Bar charts showing distribution of the mean renal volume and parity of the pregnant women

The lowest mean renal volume of both the kidneys was seen in the under weight group (BMI≤20). The highest values of the renal volumes were seen in the obese group in both the kidneys. On an average, there was a significant steady increase in the mean renal volume with an increase in the BMI in both the kidneys (p<0.01) [Table/Fig-4]. In addition, a significant positive linear correlation was seen between BMI and the renal volume, r=0.25 and r=0.24, (p<0.001) for the right and left kidneys respectively.

There was a significant steady increase in the mean renal volume with an increase in the gestational age, with the highest value in the first trimester (p<0.01) [Table/Fig-5]. There was also a significant linear positive correlation between the gestational age and the renal volume r=0.29 and 0.11 ;(p<0.001) for the left and right kidneys respectively.

Women of parity 2-3 had the highest values of the mean renal volume. On an average, there was no significant increase in the renal volume with an increase in the parity in both the kidneys (p <0.01) [Table/Fig-6]. There was no significant correlation between the parity and renal volume, r=0.04 and 0.07, (p< 0.17) for the left and right kidneys respectively.

The relationship between RRV and LRV shows large variations between their values making them poorly correlated.

DISCUSSION

This study showed that the mean renal volume in pregnancy was found to be 163.44cm^3±51.33 for the left kidney and 141.85cm^3 ±41.08 for the right kidney, with a range of 100-214cm^3 for both the kidneys.

The renal volume was seen to increase significantly throughout the pregnancy, with the mean renal volume being the largest in the third trimester (p<0.01). This was in agreement with Reynard et al [17], findings, who postulated that the renal volume increased during pregnancy, with the renal plasma flow rate increasing by 75% in the third trimester. This could be explained by the fact that in

late pregnancy, there was the highest increase in the renal plasma flow, the glomerular filtration rate and hyperfiltration, leading to this increase in the renal volume.

Weight gain is normal in pregnancy and with this, there is an increase in the body mass index. In the absence of weight gain, a poor pregnancy outcome is seen [18]. This weight gain is due to the weight of the foetus, placenta, membranes and the liquor amni. Cohen et al, [19] and other researchers [14, 15], showed that the total renal volume correlated positively with the body mass index in the non-pregnant state. This has now also been proved to occur in the pregnant state, as the present study showed a significant positive linear correlation between the renal volume and the body mass index. In pregnancy, the additional factors which are responsible for this, could be explained by the fact that the increase in the renal volume may be linked to other factors which are connected with the physiological state of the pregnancy, such as an increase in the renal plasma flow with hyperfiltration and increased accumulation of the intrarenal fluid, leading to an increase in the renal volume.

There was no real significant difference in the renal volumes across the various parities. Also, there was no significant correlation of the renal volume with an increase or decrease in the parity. ($r=.04, p<0.01$). This was found to agree with the findings of the study which was done by Obembe et al [20], where the parity was found to have little or no effect on the renal function. This could be explained by the fact that after pregnancy, the renal volume returns to its pre-pregnancy state and thus in subsequent pregnancies, there is no added additional enlargement. However, more long term studies are needed to be done where the pre-pregnancy and post partum renal sizes are assessed in women of various parities, to see if there are any significant changes and these women should be followed up through their subsequent pregnancies.

This study also revealed that the renal volume on the left was consistently larger than that on the right, as was seen in some studies which were done on women who were in the non pregnant state. Emamian et al [6], in Denmark, evaluated the kidney dimensions sonographically in 665 adult volunteers and showed that the renal volume of the left kidney was larger than that of the right kidney. This was contradictory to the findings of Okoye et al's [21] study in Enugu, Nigeria, who by using the mean renal length and mean renal volume as a determinant parameter of the renal size, demonstrated no significant difference between the sizes of the left and right kidneys. This was however contradicted in the study which was done by Ibe-Lambert [22], in Lagos, among normal Nigerian adults, where the left kidney was found to be longer than the right kidney. The reason for the larger left kidney could be that the spleen which has a superior correlation of the kidney, is smaller than the liver, thus giving the left kidney more room to grow. Also, because the left renal artery is shorter and straighter than the right one, the increased blood supply to the left kidney via the left renal artery may result in the relatively increased volume [22] of that kidney.

CONCLUSION

This study established a value for the renal volume in pregnancy in this environment, which can be used as a reference value for pregnant women.

The study also showed that the body mass index and gestational age had a significant positive linear correlation with the renal volume, but not with the parity.

The limitations of this study were the small population size and the inability to compare the pre and post pregnancy renal volumes, as well as the pre and post BMI to the various factors. Further investigations are needed to compare these factors, as well as a larger study population is required,which may improve the precision of the values which are obtained.

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