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Original Research Article

Relationship between estimated foetal weight and maternal renal volume in normal pregnant women in Bayelsa state, South-South Nigeria

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ABSTRACT

Background: The weight of the foetus is an important factor to consider when determining the outcome of pregnancy. The birth weight is reliable in predicting perinatal outcome. Excessive and low weights of the baby are associated with increased risk of newborn complications during labour, delivery and postpartum. The objective of the study was to determine the relationship between estimated foetal weight and maternal renal dimensions and volume in normal pregnant women in Bayelsa State, Nigeria.
Methods: This prospective, descriptive, cross-sectional study was conducted at the Obstetrics and Gynaecology, and Radiology Departments of the two tertiary hospitals in Bayelsa State, Nigeria, from July to December, 2021. Sonographic assessments of estimated foetal weight and the maternal 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 Statistical Product and Service Solutions for windows® version 25, (SPSS Inc.; Chicago, USA). 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. There was a valid relationship between right renal antero-posterior diameter ($\Gamma = 0.32$; p – 0.010), right renal width ($\Gamma = 0.32$; p – 0.007), right renal volume ($\Gamma = 0.32$; p – 0.007) and estimated foetal weight. The left renal width and renal volume showed the same trend as the right parameters with slight differences in values.
Conclusions: This study revealed that estimated foetal weight increased with increase in maternal renal volume and dimensions.

Keywords: Foetal weight, Renal dimensions, Renal volume, Complications

INTRODUCTION

Foetal weight is a crucial indicator of the outcome of pregnancy, and birth weight is a reliable predictor of perinatal outcome.[1,2] Life actually depends on the weight of the baby at birth.3 In spite of the recent advances employed in neonatal care, the survival of a preterm baby is closely associated with birth weight than any other factor

in pregnancy.[3] In fact, excessive and low weights of the baby are associated with increased risk of newborn complications during labour, delivery and postpartum.[4,5]

In obstetric practice, the decision on the route of delivery of a baby is markedly influenced by the estimated foetal weight in some clinical conditions like intra-partum management of a breech presenting foetus, vaginal birth after Caesarean section and diabetic pregnancy. This emphasises the significance of estimation of foetal weight to the obstetrician.

Many studies have documented the relationship between estimated foetal weight and the foetal renal volume. Foetal weight reduces with reduction in foetal renal volume, and increases with increase in foetal renal volume.[6–8] However, there is paucity of published data on the relationship between estimated foetal weight and the maternal renal volume. Increase in maternal renal volume is a physiological change in pregnancy, which increases with trimester of pregnancy, parity and maternal age.[9–14] 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.[9]

The above reason of paucity of published data on the subject matter necessitated this research. Therefore, the objective of this study is to determine the relationship between estimated foetal weight and the maternal renal volume in normal pregnant women in Bayelsa State, South-South Nigeria, as this study will also be a stepping stone for other studies of this kind.

METHODS

This was a prospective, descriptive, cross-sectional study. It was conducted at the Obstetrics and Gynaecology, and Radiology Departments of the two tertiary health institutions in Bayelsa State, Nigeria, over a six-month period, from July to December, 2021. The health institutions 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 following formula.[15]

$$n = Z^2pq \div d^2$$

Where,

n = minimum sample size

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

p = proportion of women in the target population which was 50% (0.5) from a previous study.[8]

q = 1 – p (complementary probability).

d = margin of error = 5% = 0.05

Calculation

$n = (1.96)^2 \times 0.5 \times 0.5/(0.05)^2$

$n = 3.8416 \times 0.5 \times 0.5/0.0025$

$n = 0.9604 / 0.0025$

$n = 384.16$

After considering attrition of 5%, ‘n’ was adjusted to 400.

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 HD machine fitted with a 3.5 MHz curvilinear transducer, with electronic calipers to measure the length, width and thickness of each of the kidneys.[11] In supine position, the ultrasound foetal weight was calculated automatically by the ultrasound machine, using Hadlock’s reference table, which uses the biparietal diameter, abdominal circumference and femur length.[16] The rest of the sonography was then performed in the semi prone position in other not to put pressure on the pregnant uterus. All patients were subsequently required to empty their urinary bladder.

The 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 Product and Service Solutions for windows® version 25, (SPSS Inc.; Chicago, USA). Results were presented in frequencies and percentages for categorical variables and mean and standard deviation for continuous variables. P-value less than 0.05 was taken as being statistically significant.

RESULTS

Demographic and obstetric features

There were 400 pregnant women in the study with an average age of 28.7 years and a standard deviation of 6.1 years. The modal (30%) age-group was 25-29 years. There were 28 (7%) teenage pregnancies (Table 1).

Table 1: Demographic and obstetrics features.

Characteristics	Frequency N = 400 (%)
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)

Nulliparous, multiparous and primiparous women were 39%, 33% and 23% respectively. Two hundred and twenty-four (56%) women were in the second trimester of pregnancy (Table 1).

Maternal renal dimensions and estimated foetal weight

The mean renal bipolar length, renal width and antero-posterior diameter for the right kidney was 10.9 cm, 6.5 cm and 4.7 cm respectively, while that for the left kidney was 10.9 cm, 6.3 cm and 4.7 cm respectively (Table 2). There was no statistical difference ($p>0.05$) in the dimensions of the right and left kidneys. Figure 1 is a sonogram showing maternal renal dimensions. Estimated foetal weight ranged between 0.5 kg at 22 weeks' gestation and 4.5 kg at term with a mean of 1.85 kg and standard deviation of 0.93 kg (Figure 2).

Table 2: Comparing dimensions and volumes of the right and left kidneys.

Renal parameter	Renal Dimensions		T-test	P value
	Right kidney	**Left kidney**		
Renal bipolar length	10.9±1.0	10.9±1.1	0.14	0.887
Anterio-posterior diameter	4.7±0.6	4.7±0.5	1.08	0.282
Renal width	6.5±0.7	6.3±0.7	1.17	0.243
Renal volume	174 .4±46.9	174.0±42 .9	0.05	0.956

Table 3: Relationship between maternal renal dimensions and volume and estimated foetal weight.

Renal parameter	Correlation coefficient (r)	Adjusted R^2	P value
Right kidney			
Renal bipolar length	0.16	0.010	0.109
Renal antero-posterior diameter	0.31	0.077	0.010
Renal width	0.32	0.086	0.007
Right renal volume	0.32	0.086	0.007
Left kidney			
Renal bipolar length	0.20	0.022	0.068
Renal antero-posterior diameter	0.17	0.012	0.098
Renal width	0.38	0.129	0.002
Left renal volume	0.33	0.091	0.006

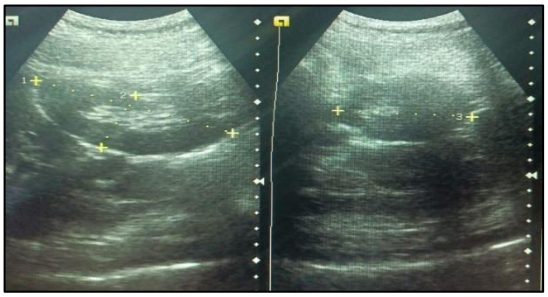

Figure 1: Sonogram showing maternal renal dimensions.

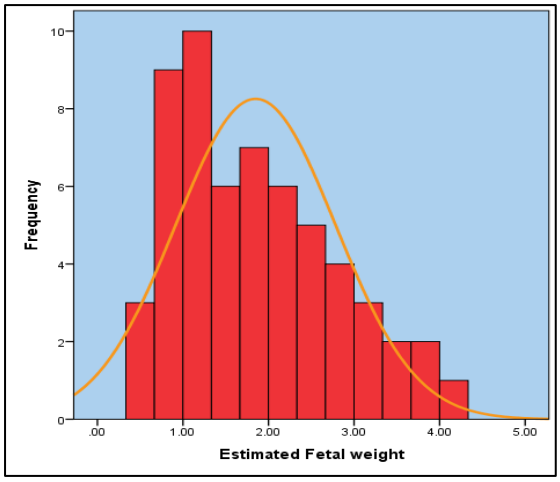

Figure 2: Histogram showing estimated foetal weight from ultrasonography.

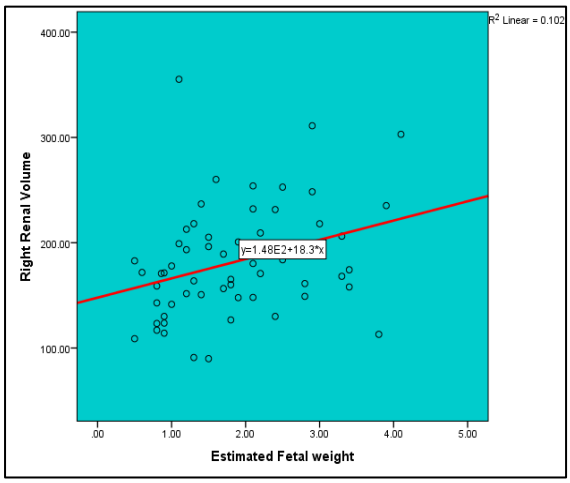

Figure 3: Scatter diagram and line of best fit between estimated foetal weight and right renal volume.

Relationship between maternal renal dimensions and volume and estimated foetal weight

There was a valid relationship between right renal antero-posterior diameter (ɾ = 0.32; p – 0.010), right renal width (ɾ = 0.32; p – 0.007), right renal volume (ɾ = 0.32; p – 0.007) and estimated foetal weight (Table 3). Table 3 further shows that for every unit change in estimated foetal weight, there was a 7.7% and 8.6% change in right renal antero-posterior diameter and renal volume respectively.

The left renal width and renal volume showed the same trend as the right parameters with slight differences in values. For every unit change in estimated foetal weight, there was a 12.9% change in maternal renal width, while 9.1% change is observed in the left renal volume (Table 3).

The regression coefficient between estimated foetal weight and renal dimensions and volume are shown in Table 4. The gradient of the straight-line equation (β 1) was 18.30 and 16.80 for the right and left renal volumes respectively, while the constant (β0) was 147.8 and 146.4 respectively (Figures 3 and 4). Equation 1 and 2 were the regression equation between estimated foetal weight and right and left maternal renal volume. Table 5 shows the estimates of right and left maternal renal volumes with corresponding estimated foetal weight in utero.

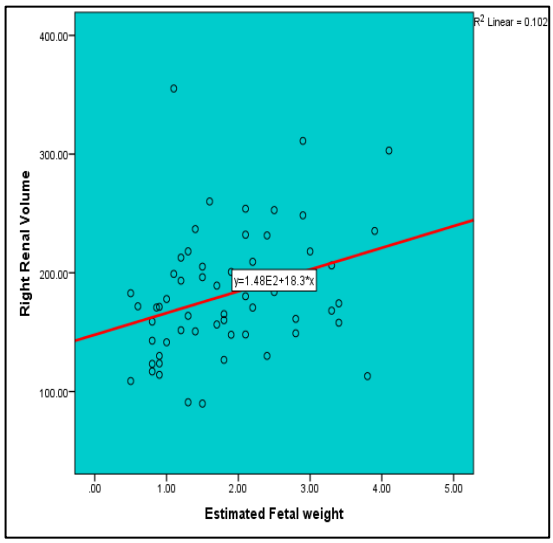

Figure 4: Scatter diagram and line of best fit between estimated foetal weight and left renal volume.

Table 4: Regression coefficient between estimated foetal weight and kidney parameters.

Renal parameter	β_0	95% CI for β_0		t-test (p-Value)	β_1	95% CI for β_1		t-test (p-value)
		Min	Max			Min	Max	
Right kidney								
Renal bipolar length	10.80	10.13	11.38	34.47 (0.001)	0.19	-0.12	0.49	1.24 (0.219)
Renal AP diameter	4.30	3.97	4.65	25.33 (0.001)	0.20	0.03	0.36	2.40 (0.020)
Renal width	6.10	5.62	6.53	26.63 (0.001)	0.28	0.06	0.50	2.52 (0.014)
Right renal volume	147.80	117.82	177.87	9.86 (0.001)	18.30	3.79	32.82	2.53 (0.014)
Left kidney								

Continued.

Renal parameter	β_0	95% CI for β_0		t-test (p-Value)	β_1	95% CI for β_1		t-test (p-value)
		Min	Max			Min	Max	
Renal bipolar length	10.70	10.03	11.27	34.38 (0.001)	0.23	-0.07	0.53	1.51 (0.137)
Renal AP diameter	4.60	4.21	4.96	24.61 (0.001)	0.12	-0.06	0.30	1.31 (0.197)
Renal width	5.70	5.27	6.16	25.67 (0.001)	0.33	0.12	0.55	3.07 (0.003)
Left renal volume	146.40	119.46	173.44	10.87 (0.001)	16.80	3.79	29.89	2.59 (0.012)

Table 6: Monograph showing maternal renal volume estimates with corresponding estimated foetal weight

Estimated foetal weight (in kg)	Right kidney			Left kidney		
	Renal volume estimate (cm^3)	95% CI for renal volume estimate		Renal volume estimate (cm^3)	95% CI for renal volume estimate	
		Min	Max		Min	Max
0.50	157.00	119.71	194.28	154.87	121.35	188.38
0.60	158.83	120.09	197.56	156.55	121.73	191.37
0.70	160.66	120.47	200.85	158.24	122.11	194.36
0.80	162.49	120.85	204.13	159.92	122.49	197.35
0.90	164.32	121.23	207.41	161.60	122.87	200.34
1.00	166.15	121.61	210.69	163.29	123.25	203.33
1.10	167.98	121.98	213.97	164.97	123.63	206.32
1.20	169.81	122.36	217.26	166.66	124.01	209.31
1.30	171.64	122.74	220.54	168.34	124.39	212.30
1.40	173.47	123.12	223.82	170.03	124.77	215.29
1.50	175.30	123.50	227.10	171.71	125.15	218.28
1.60	177.13	123.88	230.38	173.39	125.52	221.26
1.70	178.96	124.26	233.67	175.08	125.90	224.25
1.80	180.79	124.63	236.95	176.76	126.28	227.24
1.90	182.62	125.01	240.23	178.45	126.66	230.23
2.00	184.46	125.39	243.51	180.13	127.04	233.22
2.10	186.29	125.77	246.79	181.82	127.42	236.21
2.20	188.12	126.15	250.08	183.50	127.80	239.20
2.30	189.95	126.53	253.36	185.18	128.18	242.19
2.40	191.78	126.91	256.64	186.87	128.56	245.18
2.50	193.61	127.29	259.92	188.55	128.94	248.17
2.60	195.44	127.66	263.20	190.24	129.32	251.16
2.70	197.27	128.04	266.49	191.92	129.70	254.15
2.80	199.10	128.42	269.77	193.61	130.08	257.13
2.90	200.93	128.80	273.05	195.29	130.46	260.12
3.00	202.76	129.18	276.33	196.98	130.84	263.11
3.10	204.59	129.56	279.61	198.66	131.21	266.10
3.20	206.42	129.94	282.90	200.34	131.59	269.09
3.30	208.25	130.32	286.18	202.03	131.97	272.08
3.40	210.08	130.69	289.46	203.71	132.35	275.07
3.50	211.91	131.07	292.74	205.40	132.73	278.06
3.60	213.74	131.45	296.02	207.08	133.11	281.05
3.70	215.57	131.83	299.31	208.77	133.49	284.04
3.80	217.40	132.21	302.59	210.45	133.87	287.03

Continued.

Estimated foetal weight (in kg)	Right kidney			Left kidney		
	Renal volume estimate (cm^3)	95% CI for renal volume estimate		Renal volume estimate (cm^3)	95% CI for renal volume estimate	
		Min	Max		Min	Max
3.90	219.23	132.59	305.87	212.13	134.25	290.02
4.00	221.07	132.97	309.15	213.82	134.63	293.01
4.10	222.90	133.34	312.43	215.50	135.01	296.00
4.20	224.73	133.72	315.72	217.19	135.39	298.99
4.30	226.56	134.10	319.00	218.87	135.77	301.98
4.40	228.39	134.48	322.28	220.56	136.15	304.96
4.50	230.22	134.86	325.56	222.24	136.52	307.95

DISCUSSION

Pregnancy is associated with many physiological changes. The kidneys play a central role in responding and adapting to these changes that physiologically affect the pregnant woman and the foetus.[17]

The effect of pregnancy on renal physiology is widespread, involving all aspects of renal function. Our study revealed that change in maternal renal volume and dimensions for both kidneys was closely related to change in the estimated foetal weight. As the maternal renal volume and dimensions increased, the estimated foetal weight increased as well. The explanation for this is not readily available. More researches need to be carried out with a larger population of pregnant women; looking out for possible explanation for this occurrence. What is generally known is that the estimated foetal weight is affected by the foetal renal volume.[6–8] The foetal renal size and volume are reduced in foetuses with growth restriction. This is so because of the preferential blood flow to the brain in these foetuses.

This 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 in South-South, Nigeria, the 147.75±1.87 (right kidney); 172.53±2.13 (left kidney) reported by Ugochinyere et al in Enugu, South-East Nigeria, and the 105.77±27.29 (right kidney); 104.23±28.18 (left kidney) reported by Kamble et al in Central India.[10-12] This variation in maternal renal volumes may be due to the differences in the genetic makeups of people that live in the different geographical regions of the world.

The strength of our study is in the fact that it is prospective, and women with normal pregnancies were recruited. This removed confounding variables, like medical conditions in pregnancy, which may have affected the measurements of renal volume and dimensions and the estimated foetal weight. This study is also first of its kind in our region.

The limitation of this study is the fact that it is a hospital-based study, and may not reflect what is obtainable in the general population of pregnant women in our region.

CONCLUSION

The kidneys play a central role in responding and adapting to physiological changes that affect the pregnant woman and the foetus. This study revealed that estimated foetal weight increased with increase in maternal renal volume and dimensions.

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