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Ultrasound Assessment of Thyroid Volume in Pregnancy in the Niger Delta Region of Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author PCO designed the study, collated data, wrote the methodology and discussion. Author EKK conceptualised the study, carried out obstetric ultrasound scans and collected data. Author EGEK and OC managed literature search. Author AEU wrote the introduction. Author JUU did obstetric ultrasound scans. Authors PCO, PYB and IJA recruited patients from the antenatal clinics. Author ADA analysed data and wrote the results. All authors read and approved the final manuscript.

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ABSTRACT

Background: During normal pregnancy, the size of the thyroid gland and hormone production increase. There is increased thyroid stimulation in pregnancy, which leads to an increase in the size of the thyroid gland.

Objectives: To determine changes in thyroid volume (TV) in pregnancy and relationship with maternal age, parity, GA, weight, height and body mass index (BMI).

Subjects and Methods: This was a descriptive, cross-sectional study which was conducted at four health facilities in Bayelsa State, Nigeria, between November, 2022 and May, 2023. Statistical Product and Service Solutions for Windows® version 25, SPSS Inc.; Chicago, USA was used for data analysis. Descriptive statistics (mean, standard deviation, frequency, and percentages) were reported. Pearson correlation coefficient was used to determine the relationship between thyroid dimensions and volume and age, parity, GA, height, weight, and BMI. Statistical significance was set at P value <0.05.

Results: Thyroid volume increased significantly (p=0.001) with GA, with a mean TV of 3.80 ± 0.00 cm^3 at 20 weeks' GA and 7.75 ± 3.01 cm^3 at 40 weeks. Mean TV also showed significant positive correlations with maternal age (ɼ=0.15; p=0.003), parity (ɼ=0.42; p=0.009), weight (ɼ = 0.47; p=0.001) and BMI (ɼ = 0.38; p=0.001). Maternal height had no effect on TV (ɼ=0.08; p=0.143).

Conclusion: Our study revealed significant positive correlations between TV and maternal age, parity, GA, weight and BMI in normal pregnancy.

Keywords: Thyroid; ultrasound; thyroid volume; age; sex; height; weight, BMI.

1. INTRODUCTION

Maternal and foetal thyroid glands play important roles in foetal neurodevelopment and regulation of placentation in pregnancy [1]. Pregnancy alters maternal thyroid physiology. Elevated estrogen in normal pregnancy is associated with increased levels of thyroxine-binding globulin (TBG) and reduced TBG clearance. This results in an almost 50% increase in levels of both total thyroxine (T4) and triiodothyronine (T3) [2]. Associated with human chorionic gonadotropin (hCG) elevation and peak in the first trimester, are elevated levels of free T4 and T3, consequently transiently suppressing thyroid stimulating hormone (TSH) and thyrotropin releasing hormone (TRH) concentrations[1,2]. This hCG-induced thyroid stimulation is as a result of the structural similarity between hCG and TSH, both being glycoprotein hormones. Human chorionic gonadotropin therefore exerts thyrotropic activity by cross-stimulating TSH receptors [3].

Increase in renal glomerular filtration rate, which normally occurs in pregnancy, increases renal iodide clearance by 30-50%, necessitating an increase in dietary intake of iodine to maintain thyroid hormone levels [4]. In women with iodine deficiency, pregnancy may result in depletion of thyroid iodide stores, which may in turn lead to hypothyroidism, increased TSH levels, and increased thyroid volume (TV)[4]. Whereas some authors have reported that in women with sufficient iodine intake, the thyroid gland is able to adapt to the increase in thyroid hormone production in pregnancy without an increase in TV, others have reported a small (10-15%) increase in TV even in normally pregnant women with sufficient iodine intake [5–7]. This small increase, detectable only by ultrasound, is attributed to increase in intrathyroidal blood flow in pregnancy [5].

Data on the associations between TV and age and body weight are also conflicting. Whereas some authors have linked the association between TV and age to iodine status, with TV increasing up to 40 years of age and then plateauing in the presence of iodine deficiency while declining after the age of 40 years in iodine-sufficient subjects, others have found no correlation between TV and age[8–10]. While Gómez et al and Barrère et al., reported positive correlations between TV and weight, height, body mass index (BMI) and body surface area

(BSA), Rotondi et al., found no effect of body weight on TV but documented an increase in TV with parity [8,10,11]. Thyroid volume in pregnancy increases with gestational age (GA)/trimester, with the increase in iodine-deficient women being significantly higher than that in iodine-replete women [5,12].

This study sought to determine changes in TV determined by ultrasound in a population of normally pregnant women in a non-iodine deficient area in the Niger Delta region of Nigeria and correlate TV in pregnancy with maternal age, GA, parity, maternal weight, height and BMI. We utilized ultrasound for estimating TV in our study as it is considered the most reliable modality for determining TV [8].

2. SUBJECTS AND METHODS

Study design and setting: This was a descriptive, cross-sectional study which was conducted at the Niger Delta University Teaching Hospital, Okolobiri, Federal Medical Centre, Yenagoa, Silhouette Radiodiagnostic Consultants, Yenagoa, and Diete Koki Memorial Hospital, Yenagoa, all in Bayelsa State, Nigeria. The study was conducted between November, 2022 and May, 2023. These facilities offer specialised care services to the people of Bayelsa State and nearby Rivers and Delta States, all of which are located in the South-South geopolitical region of Nigeria.

Sample size calculation: This was calculated using the formula: $n = Z\alpha^2 \times \sigma^2 / \delta^2$ [13,14]

Where: Zα = 95% CI, which is 1.96, σ = mean of 17.20 mm from a previous study.[15] δ = level of precision for our study (σ/√30).

Calculation:

$n = (1.96)^2 \times 17.20^2 / \sigma/\sqrt{30}$
$n = 3.8416 \times 295.84 / 3.14$
$n = 1{,}136.5 / 3.14$
$n = 361.94$

Considering attrition of 5% (18.1%), n was adjusted to 380.

For this study, 380 consecutive pregnant women were enrolled. The study included consecutive patients who visited the Obstetric Units of the study centres.

Study population: Three hundred and eighty normally pregnant women.

Inclusion criteria: Healthy pregnant women without any clinical feature of thyroid disease or other medical condition.

Exclusion criteria: Pregnant women with any history suggestive of thyroid disease or family history of thyroid disease, irradiation, neck surgery or malignancy, history of diabetes mellitus, kidney or liver diseases, history of recent administration of iodinated radiographic contrast, amiodarone or lithium therapy, were excluded from the study.

Study procedure: The participants for this study were recruited voluntarily. Their sociodemographic information and a brief history were collected to rule out the presence of thyroid disease or any other medical conditions that may affect the results of the study. The GA was calculated from the last menstrual period, and confirmed with the use of first trimester ultrasound scan. The women were counselled on the study and investigative modality. Their height (in meters) and weight (in kilograms) were recorded. Body mass index was determined as the weight in kilograms (kg) divided by height in meters (m) squared. They were referred to the Radiology Units of the study institutions for ultrasound scan of the thyroid.

Procedure for ultrasound thyroid examination: The radiologists performed ultrasound examination of the thyroid gland on each patient**, u**sing a 2012 Philips HD11 device with a 3.5 MHz curvilinear probe. To ensure data quality, the consultant radiologists discussed the standard operating procedure for ultrasonography, evaluated it for interobserver variability and reliability, and came to an agreement before data collection started. Each woman was examined in supine position, with the neck slightly extended. The mediolateral dimension of both lobes was measured on the transverse image. The craniocaudal and the anteroposterior (AP) dimensions were measured on the longitudinal image. The volume of one lobe of the thyroid was expressed in ml and estimated using the formula by Turcios et al: volume of one lobe = length × depth × width × π/6.[16] The volume of each thyroid gland was obtained by collecting the volume of the right and left lobes. The volume of the isthmus was not included in this calculation.

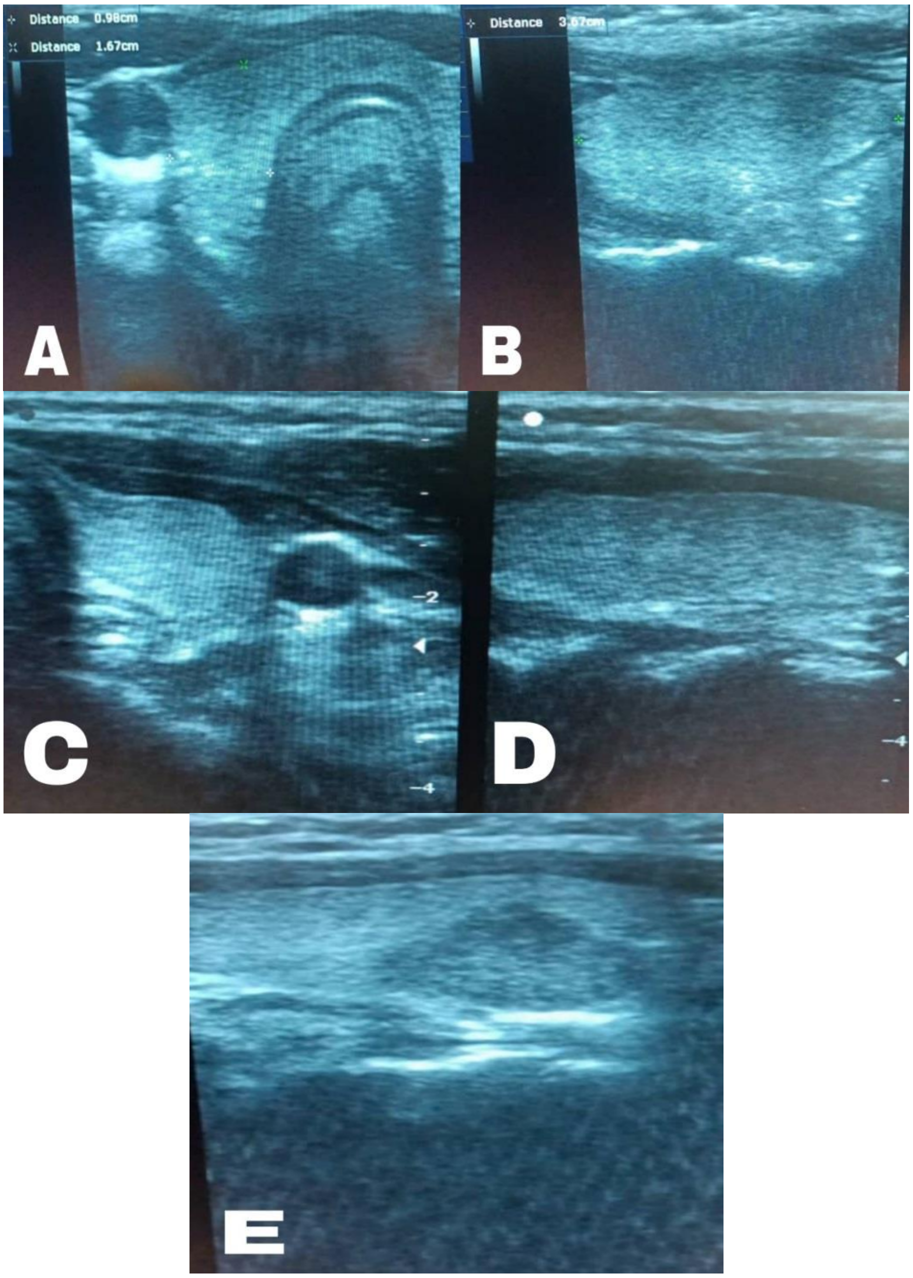

Fig. 1. Ultrasound image of the thyroid gland. A – measurements of AP diameter and width of the right lobe on transverse scan. B – measurement of height of the right lobe on longitudinal scan. C – measurements of AP diameter and width of the left lobe on transverse scan. D – measurement of height of the left lobe on longitudinal scan. E – incidental finding of a mass

Data analysis: The measurements were recorded using a pre-designed proforma. Statistical Product and Service Solutions for Windows® version 25, developed by SPSS Inc. in Chicago, USA, was used for data analysis. The analysis included descriptive statistics (mean, standard deviation, frequency, and percentages). Pearson correlation coefficient was used to determine the relationship between thyroid dimensions and volume and age, parity, GA, height, weight, and BMI. The intraclass correlation coefficient (ICC) was used to analyze the interobserver and intraobserver agreements among the four radiologists. These agreements were classified as poor (ICC 0.20), fair (ICC 0.20- 0.39), moderate (ICC 0.40- 0.59), significant (ICC 0.60- 0.79), and almost perfect (ICC 0.80). $P<0.05$ was chosen as the threshold for statistical significance.

Table 1. Maternal sociodemographic and obstetric characteristics

Characteristics	Frequency, n = 380	Percent
Age (years)		
20 – 24	56	14.7
25 – 29	149	39.2
30 – 34	107	28.2
≥ 35	68	17.9
Mean Age ± SD	29.4 ± 5.2	
Body mass index (kg/m^2)		
Underweight (< 18.5)	7	1.8
Normal (18.5 – 24.9)	153	40.3
Overweight (25.0 – 29.9)	70	18.4
Class I Obesity (30.0 – 34.9)	128	33.7
Class II Obesity (≥ 35.0)	22	5.8
Mean Weight ± SD (kg)	73.3 ± 15.5	
Mean Height ± SD (m)	1.6 ± 0.1	
Mean BMI ± SD (kg/m^2)	27.6 ± 5.9	
Parity		
Nulliparity	167	43.9
Primiparity	49	12.9
Multiparity	96	25.3
Grand-multiparity	68	17.9
Median (IQR) Parity	1 (0 – 2)	
Mean GA ± SD (weeks)	23.6 ± 11.1	

3. RESULTS

Maternal characteristics: There were 380 women in the study, with a mean age of 29.4 ± 5.2 years (Table 1). The modal age group was 25 – 29 years (149, 39.2%). The mean weight, height and BMI of the study participants were 73.3 ± 15.5 kg, 1.6 ± 0.1 m and 27.6 ± 5.9 kg/m^2, respectively (Table 1). About 2 of every 5 pregnant women in the study (153, 40.3%) had normal BMI (Table 1), while about a third (128, 33.7%) were categorized as Class 1 obese (Table 1). Majority of the women were nulliparous women (167, 43.9%), with a median parity of 1 (0 – 2) and mean GA of 23.6 ± 11.1 weeks (Table 1). Fourteen (3.6%) of our study participants had incidental finding of asymptomatic focal nodule in the thyroid gland.

Thyroid dimensions in study participants: At 20 weeks' gestation, mean right and left thyroid length were 4.50 ± 0.49 cm and 4.62 ± 0.12 cm, respectively, while mean right and left thyroid width were 1.07 ± 0.56 cm and 1.08 ± 0.07 cm, respectively, and mean right and left thyroid AP diameter were 1.78 ± 0.24 cm and 1.19 ± 0.10 cm, respectively (Table 2). The mean right TV was 4.49 ± 0.00 cm^3 at 20 weeks' gestation and 9.55 ± 3.43 cm^3 at 40 weeks' gestation; while the mean left TV at 20 weeks' gestation was 3.11 ± 0.00 cm^3 and 5.94 ± 2.58 cm^3 at 40 weeks' gestation. The mean TV was 3.80 ± 0.00 cm^3 at 20 weeks' gestation and 7.75 ± 3.01 cm^3 at 40 weeks' gestation. Overall, the mean right TV was 5.61 ± 2.18 cm^3, while that of the left was 4.07 ± 2.08 cm^3, with an overall mean volume of 4.84 ± 1.94 cm^3. The different dimensions of the thyroid gland with increasing GA of pregnancy are as shown in Table 2.

Relationship between thyroid dimensions and maternal age, parity and GA among pregnant women: As shown in Table 3, maternal age, parity and GA showed significant positive relationships with all thyroid dimensions in pregnancy ($p < 0.05$). The relationship between maternal age and TV was however a weak one, with correlation coefficient (ɽ) ranging from 0.11 to 0.32. Right thyroid length showed the strongest relationship with a correlation coefficient of 0.32 and p-value of 0.001. Relationship between maternal age and thyroid dimensions showed correlation coefficient ranging between 0.11 for left thyroid length, right thyroid width and 0.19 for right TV.

Relationship between parity and thyroid dimensions showed stronger relationship reflected in correlation coefficient of 0.42 between parity and mean TV. Relationship between parity and left TV (ɽ = 0.35; p=0.001) and right TV was also 'fairly strong' and

Table 2. Right, left thyroid and isthmic dimensions at different GA among the study participants

GA in weeks	Right thyroid dimensions in cm				Left thyroid dimensions in cm			TV in cm^3		
	Length	¶AP Diameter	Width	Isthmus	Length	¶AP Diameter	Width	Right Volume	Left Volume	Mean Volume
20	4.50 ± 0.49	1.78 ± 0.24	1.07 ± 0.56	0.22 ± 0.00	4.62 ± 0.00	1.19 ± 0.10	1.08 ± 0.07	4.49 ± 0.00	3.11 ± 0.00	3.80 ± 0.00
21	4.00 ± 0.67	1.83 ± 0.27	1.37 ± 0.37	0.27 ± 0.00	4.54 ± 0.00	1.55 ± 0.00	1.44 ± 0.28	4.90 ± 1.64	5.32 ± 2.48	5.28 ± 2.05
22	4.34 ± 0.32	1.49 ± 0.10	1.62 ± 0.27	0.35 ± 0.00	4.66 ± 0.00	1.17 ± 0.00	1.14 ± 0.18	5.48 ± 0.29	3.26 ± 0.56	4.37 ± 0.78
23	4.34 ± 0.12	1.49 ± 0.11	1.62 ± 0.76	0.35 ± 0.00	4.66 ± 0.00	1.17 ± 0.00	1.14 ± 0.00	5.49 ± 0.98	3.26 ± 0.12	4.37 ± 0.87
24	4.34 ± 0.19	1.49 ± 0.09	1.62 ± 0.77	0.35 ± 0.00	4.66 ± 0.00	1.17 ± 0.00	1.14 ± 0.00	5.59 ± 0.67	3.26 ± 0.89	4.37 ± 0.76
25	4.80 ± 0.19	1.46 ± 0.24	1.56 ± 0.30	0.39 ± 0.03	4.79 ± 0.38	1.62 ± 0.27	1.65 ± 0.17	5.73 ± 1.58	6.71 ± 0.96	6.22 ± 0.81
26	4.12 ± 0.45	1.52 ± 0.15	1.36 ± 0.31	0.41 ±0.01	4.67 ± 0.93	1.49 ± 0.22	1.38 ± 0.22	5.57 ± 0.00	5.03 ± 0.00	4.75 ± 0.00
27	4.29 ± 0.42	1.58 ± 0.21	1.59 ± 0.18	0.38 ± 0.09	4.57 ± 0.00	1.08 ± 0.00	1.39 ± 0.37	5.65 ± 1.45	4.41 ± 2.61	4.62 ± 2.02
28	4.02 ± 0.33	1.72 ± 0.12	1.55 ± 0.16	0.43 ± 0.06	4.67 ± 0.11	1.48 ± 0.21	1.29 ± 0.27	5.61 ± 0.00	4.67 ± 0.00	5.14 ± 0.00
29	4.55 ± 0.62	1.81 ± 0.19	1.22 ± 0.32	0.42 ± 0.00	4.09 ± 0.00	1.03 ± 0.00	1.38 ± 0.00	5.88 ± 0.00	3.05 ± 0.00	4.15 ± 0.00
30	4.16 ± 0.59	1.59 ± 0.11	1.45 ± 0.13	0.47 ± 0.06	4.66 ± 0.53	1.30 ± 0.08	1.47 ± 0.11	5.99 ± 0.00	4.66 ± 0.00	4.84 ± 0.00
31	4.50 ± 0.32	1.63 ± 0.04	1.56 ± 0.18	0.38 ± 0.00	4.88 ± 0.00	1.58 ± 0.00	1.65 ± 0.00	5.99 ± 1.05	6.66 ± 0.46	6.33 ± 0.29
32	4.06 ± 0.69	1.79 ± 0.11	1.55 ± 0.26	0.38 ± 0.04	4.61 ± 0.24	1.47 ± 0.52	1.36 ± 0.38	6.50 ± 3.48	4.83 ± 2.73	5.36 ± 3.11
33	4.45 ± 0.34	1.63 ± 0.26	1.67 ± 0.16	0.61 ± 0.20	4.71 ± 0.16	1.57 ± 0.46	1.62 ± 0.14	6.73 ± 3.51	6.27 ± 2.07	6.31 ± 278
34	4.45 ± 0.77	1.87 ± 0.29	1.58 ± 0.72	0.39 ± 0.00	4.93 ± 0.00	1.58 ± 0.00	1.34 ± 0.00	6.93 ± 0.56	5.47 ± 1.16	6.28 ± 0.89
35	4.98 ± 0.43	1.57 ± 0.09	1.36 ± 0.29	0.40 ± 0.00	4.47 ± 0.00	1.29 ± 0.00	1.25 ± 0.00	6.65 ± 0.00	3.78 ± 0.00	4.67 ± 0.00
36	4.78 ± 0.39	1.57 ± 0.12	1.82 ± 0.45	0.42 ± 0.76	4.86 ± 0.00	2.01 ± 0.00	1.75 ± 0.00	6.47 ± 0.10	8.95 ± 0.65	7.71 ± 0.79
37	4.78 ± 0.39	1.42 ± 0.12	1.82 ± 0.45	0.42 ± 0.00	4.86 ± 0.00	2.01 ± 0.00	1.75 ± 0.00	6.47 ± 0.10	8.95 ± 0.65	7.71 ± 0.79
38	4.45 ± 0.67	2.22 ± 0.08	1.71 ± 0.41	0.41 ± 0.00	4.57 ± 0.00	1.08 ± 0.00	1.95 ± 0.00	8.85 ± 0.00	5.04 ± 0.00	6.94 ± 0.02
39	4.28 ± 0.87	2.28 ± 0.45	1.63 ± 0.31	0.58 ± 0.00	4.57 ± 0.00	1.34 ± 0.00	1.74 ± 0.00	8.33 ± 0.00	5.58 ± 0.00	6.96 ± 0.00
40	5.32 ± 0.54	1.89 ± 0.18	1.80 ± 0.27	0.49 ± 0.03	4.09 ± 0.69	1.64 ± 0.50	1.69 ± 0.39	9.55 ± 3.43	5.94 ± 2.58	7.71 ± 3.67

significant (Table 3). The right thyroid AP diameter (ɼ = 0.45; p=0.001), isthmus (ɼ = 0.45; p=0.001) and left thyroid width (ɼ = 0.60; p=0.001) showed the strongest relationship with GA among all thyroid parameter assessed in the study (Table 3). The relationship between TV and trimester of pregnancy is presented in Table 4.

Relationship between thyroid dimensions and maternal anthropometric measurements among pregnant women: As shown in Table 5, maternal weight and BMI were significantly (p <0.05) related to thyroid dimensions among pregnant women in the study. Maternal weight had 'fairly strong' relationship with right TV (ɼ=0.44; p=0.001), left TV (ɼ=0.41; p=0.001) and mean TV (ɼ=0.47; p=0.001). The right thyroid width had the strongest relationship (ɼ=0.51; p=0.001) with maternal weight (Table 5).

The relationship between BMI and thyroid dimensions showed a similar pattern as the relationship with maternal weight (Table 4). The relationship between BMI and right TV (ɼ=0.41; p=0.001), left TV (ɼ=0.32; p=0.001) and mean TV (ɼ=0.38; p=0.001) were 'fairly strong' and significant (Table 4). Maternal height was however not significantly (p > 0.05) related to thyroid dimensions except right (ɼ=0.13; p=0.012) and left (ɼ=0.18; p=0.001) thyroid length (Table 5). The interobserver and intraobserver correlation coefficients were 0.99 (95% CI 0.52–0.99) and 0.98 (95% CI 0.55–0.99), respectively.

Table 3. Correlation between thyroid dimensions and maternal age, parity and GA

Kidney parameters	Correlation coefficient (ɼ)	Square of correlation coefficient ($ɼ^2$)	p-value
Maternal Age			
Right TV	0.19	0.01	0.002*
Left TV	0.14	0.02	0.007*
Mean TV	0.15	0.02	0.003*
Right thyroid width	0.11	0.01	0.033*
Right thyroid AP diameter	0.13	0.01	0.009*
Right thyroid length	0.32	0.10	0.001*
Isthmus	0.15	0.02	0.003*
Left thyroid width	0.21	0.04	0.001*
Left thyroid AP diameter	0.10	0.01	0.032*
Left thyroid length	0.11	0.01	0.032*
Parity			
Right TV	0.39	0.15	0.023*
Left TV	0.35	0.12	0.014*
Mean TV	0.42	0.18	0.009*
Right thyroid width	0.14	0.02	0.009*
Right thyroid AP diameter	0.31	0.10	0.001*
Right thyroid length	0.17	0.03	0.001*
Isthmus	0.23	0.05	0.001*
Left thyroid width	0.14	0.02	0.009*
Left thyroid AP diameter	0.13	0.02	0.010*
Left thyroid length	0.18	0.03	0.001*
GA			
Right TV	0.35	0.123	0.001*
Left TV	0.20	0.040	0.001*
Mean TV	0.30	0.090	0.001*
Right thyroid width	0.24	0.058	0.001*
Right thyroid AP diameter	0.45	0.203	0.001*
Right thyroid length	0.37	0.136	0.001*
Isthmus	0.45	0.203	0.001*
Left thyroid width	0.60	0.036	0.001*
Left thyroid AP diameter	0.29	0.084	0.001*
Left thyroid length	0.30	0.090	0.001*

Table 4. Thyroid volumes across trimesters of pregnancy among study participants

Characteristics	Trimester of pregnancy			p-value
	First N = 105	**Second N = 127**	**Third N = 148**	
Right TV (cm^3)				
Mean ± SD	4.31 ± 1.21	5.96 ± 2.17	6.22 ± 2.34	0.001*
Range	1.90 – 6.11	3.31 – 10.12	2.99 – 13.41	
Left TV (cm^3)				
Mean ± SD	3.17 ± 1.07	4.32 ± 2.62	4.53 ± 1.76	0.001*
Range	1.73 – 4.84	1.83 – 7.11	1.38 – 13.00	
Mean TV (cm^3)				
Mean ± SD	3.74 ± 0.90	5.25 ± 1.80	5.57 ± 2.27	0.001*
Range	2.19 – 5.48	2.62 – 8.61	2.65 – 13.20	

Table 5. Correlation between thyroid dimensions and maternal anthropometric measurements

Anthropometric parameters	Correlation coefficient (r)	Square of correlation coefficient (r^2)	p-value
Height (m)			
Right TV	0.06	0.004	0.229
Left TV	0.08	0.006	0.139
Mean TV	0.08	0.006	0.143
Right thyroid width	0.09	0.008	0.097
Right thyroid AP diameter	0.03	0.001	0.543
Right thyroid length	0.13	0.017	0.012*
Isthmus	0.10	0.010	0.048*
Left thyroid width	0.04	0.001	0.109
Left thyroid AP diameter	0.02	0.001	0.747
Left thyroid length	0.18	0.032	0.001*
Maternal weight (kg)			
Right TV	0.44	0.194	0.001*
Left TV	0.41	0.168	0.001*
Mean TV	0.47	0.221	0.001*
Right thyroid width	0.51	0.260	0.001*
Right thyroid AP diameter	0.33	0.109	0.001*
Right thyroid length	0.16	0.026	0.002*
Isthmus	0.41	0.168	0.001*
Left thyroid width	0.46	0.212	0.001*
Left thyroid AP diameter	0.37	0.137	0.001*
Left thyroid length	0.19	0.036	0.003*
BMI (kg/m^2)			
Right TV	0.41	0.17	0.001*
Left TV	0.32	0.10	0.001*
Mean TV	0.38	0.14	0.001*
Right thyroid width	0.48	0.23	0.001*
Right thyroid AP diameter	0.35	0.12	0.001*
Right thyroid length	0.16	0.03	0.002*
Isthmus	0.49	0.24	0.001*
Left thyroid width	0.33	0.11	0.001*
Left thyroid AP diameter	0.30	0.09	0.001*
Left thyroid length	0.15	0.02	0.003*

4. DISCUSSION

Our study revealed a mean TV of 3.80 ± 0.00 cm^3 at 20 weeks' gestation and 7.75 ± 3.01 cm^3 at 40 weeks' gestation, with an overall mean volume of 4.84 ± 1.94 cm^3. This overall mean value was higher than the 3.82 ± 0.98 cm^3 observed by Olarewaju et al. in Lagos, Nigeria[17], but lower than 8.6 ± 2.9 cm^3, 11.3 ± 3.1 cm^3 and 17.20 ± 1.2 cm^3 observed by Elebrashy et al.[18], Fister et al.[19], and Özdikici[15], respectively. This may be attributed to the fact that the normal range of TV and functions during pregnancy vary between ethnic groups[18].

Our study observed a weak relationship between maternal age and thyroid dimensions and volume. This may be related to the finding of Elebrashy et al.[18], who observed no significant correlation between maternal age and TV. It is possible that the physiological changes and alterations in the dimensions of the thyroid gland during pregnancy may not significantly differ amongst reproductive age women of different age groups. In this study, the volume of the thyroid increased with parity. The reason for this is not readily understood. However, it is possible that the physiological thyroid changes that occur in pregnancy may be more pronounced with increasing parity.

Maternal thyroid dimensions and volume progressively increased with GA in our study. Evidence on TV changes with pregnancy is conflicting. While some authors have opined that TV does not change during pregnancy except in iodine-deficient areas [6], others have reported an increase in TV by up to 15% even in iodine-sufficient locations[6,20,21] or when iodine supplements are taken[22,23]. Our observation is in agreement with the findings of Okafor et al.[24] in Nnewi, Nigeria, Smyth et al.[25] in Ireland, and Glinoer *et al*[26]. This however, contrasts the findings of Olarewaju et al.[17] and Knudsen et al.[27], who observed no correlation between TV and GA. Varying environmental and nutritional factors may be plausible explanations for these differences in findings of the various studies. Genetic predisposition and geographical location have also been documented to be some other plausible explanations for these differences.[7,28] Increase in thyroidal blood flow during pregnancy has also been implicated in the increase in TV as pregnancy advances[19].

Fourteen (3.6%) of our study participants had incidental finding of asymptomatic focal nodule in the thyroid gland. This is in consonance with the 0.1 – 3.5% pathological thyroid findings in pregnancy[29,30]. Our study revealed a positive correlation between maternal weight/BMI and TV. This is in consonance with the findings of Elebrashy et al.[18], Fister et al.[19], Duarte et al.[28], and Sahin et al.[7], who observed that changes in TV were associated with changes in maternal weight and BMI. In fact, Fister et al.[19] observed that BMI was an independent predictor of TV increase during pregnancy. A number of physiological changes, including expansion of the plasma volume, increase in extracellular fluid and total body water, characterise normal pregnancy[31]. These physiological changes have been shown to positively correlate with TV[8]. Maternal weight and consequently BMI, increase as a result of extracellular water retention[32].

In order to reduce intraobserver and interobserver variability, the ICC was used in this study to evaluate thyroid dimensions and volume. When evaluating the consistency of measurements for the same parameter, both interobserver variability and the variance of all measurements are taken into consideration [33,34]. Given that the typical range is 0 to 1, a value greater than 0.8 denotes almost perfect agreement [35,36]. The results of our study's inter- and intraobserver variance indicated practically perfect agreement, with values of 0.99 and 0.98, respectively.

This study's strength derives from its multicenter design, with only healthy pregnant women recruited for the study. Hence, confounding factors (such as overt thyroid disease and other co-morbidities) that might have altered the assessment were eliminated. The limitation is that since this study was hospital-based, it might not exactly reflect what is obtainable in the general population of healthy pregnant women in the study location.

5. CONCLUSION

Our study revealed positive correlations between TV and maternal age, parity, GA, weight and BMI. This study also revealed that some thyroid conditions can be asymptomatic in normal pregnancy. More robust researches are recommended as there is a paucity of published literature on the subject in our subregion.

CONSENT

As per international standard or university standard, patient(s) written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

The protocol for this study was approved by the Research and Ethics Committee of the Federal

Medical Centre, Yenagoa, Bayelsa State, Nigeria.

COMPETING INTERESTS

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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