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# Ultrasound Reference Range for Diameters of Posterior Atrium of Lateral Ventricles for Normal Nigerian Foetuses, at the University College Hospital (UCH) Ibadan, Nigeria: A Cross – Sectional Study

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***Authors' contributions***

*This work was carried out in collaboration between all authors. Authors OSB, AMA and EOB were involved in the conception and development of the study design. They also made significant contribution in data acquisition and write up of the paper together with author OAR. Authors AOA and SL were involved in statistical analysis and contributed to the write up. Author LL reviewed the statistical analysis and write up of the paper. All authors read and approved the final manuscript.*

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## ABSTRACT

**Aims:** The diameter of the posterior atrium of the lateral cerebral ventricles (PALV) does not vary substantially in size during foetal development and has thus become a stable marker for the identification of foetal ventriculomegaly in developed countries. Currently, the accepted upper limit of PADLV is 10 mm. Ventricular atrial diameters greater than 10mm require more radiological evaluation to rule out ventriculomegaly.
The aim of this study was to establish the normal range of values for the posterior atrium [PA] of foetal lateral ventricles in our environment and to determine a cut-off value for

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prenatal diagnosis of ventriculomegaly.
**Methods:** The mean of two measurements was obtained from the transverse diameter of the atrium of the lateral ventricles of foetuses that met the inclusion criteria, as part of the routine obstetric ultrasound scan at the antenatal clinic or ultrasound suite of radiology department of the University College Hospital (UCH), Ibadan. The SPSS version 15 was used to analyse the data obtained.
**Results:** The mean posterior atrial diameter [PAD] of the lateral ventricl was 6.5mm with standard deviation (SD) 1.3mm and mean ±2SD 3.9–9.1mm. Male foetuses had larger atrial diameters than female. Student's t-test and Pearson's correlation coefficient were used to explore association.
**Conclusion:** With the existing resources in our environment, prenatal screening for ventriculomegaly during routine obstetric scan is achievable. Measurement of 10mm is a reasonable upper limit of normal in our environment. Foetuses with larger values need further evaluation to rule out hydrocephalus.

*Key words: Foetal; ultrasound; lateral ventricle; prenatal; ventriculomegaly.*

## 1. INTRODUCTION

The cerebral lateral ventricles are complex shaped fluid filled tubular cavities, which develop as part of the ventricular system [1,2] within the brain at the 5$^{th}$ week of embryonic life [3]. These structures are seen on either side of the brain and differ in shape in the Frontal, Temporal and Occipital lobes. The body of the lateral ventricle is located in the parietal lobe of the brain and the horns are continuation or extension from the body into the corresponding lobes of the brain. The body of the lateral ventricles are surrounded by similar structures on either side of the brain and are often symmetrical. Posteriorly, the body of the ventricle curves inferiorly to continue as the posterior horn. The Posterior part of the body, up to the convexity constitutes the atrium or trigone of the lateral ventricle. The posterior horn of the lateral ventricles varies in most people and may be underdeveloped to variable degree [2]. The lateral ventricles also change in shape with the developing brain until they attain their permanent shape in the third trimester.

On ultrasound (USS), the lateral ventricles appear as anechoic tubular structure surrounded by the hypoechoic cerebral mantle with echogenic cortical rim in the first and early second trimesters. However in the late second and third trimester, the maturing cerebral mantle becomes isoechoic surrounding the anechoic lateral ventricles. The choroid plexus is an integral part of the ventricular system and is a major landmark in the evaluation of the lateral ventricles. It appears as an echogenic structure within the body and trigone of the lateral ventricles.

Objective imaging of the CNS is unreliable in the first trimester due to a number of errors which are prone to occur even with transvaginal ultrasound (USS) [4,5,6,]. However, CNS imaging is practicable from the second trimester. Transabdominal USS is the ideal modality in terms of ease of performance and cost benefit considerations. Sonographic inspection, measurement and characterization of the foetal cerebral ventricles are possible and reliable as early as the 14th week of gestation [7]. Though numerous and varied approaches have been studied for lateral ventricular evaluation, the measurement of the posterior atrial diameter has gained the most wide-spread acceptance [8]. This measurement is reported

among other benefits to remain constant throughout the 2nd and 3rd trimester of gestation and 10mm is usually considered the upper limit of normal size [9].

Though isolated ventriculomegaly often resolves spontaneously, several authors using the same procedure have documented the association of even mild degrees of ventriculomegaly with dramatic increases in perinatal morbidity and mortality [10]. In some studies, more than 88% of foetuses with sonographically detected central nervous system anomalies had an abnormally wide lateral ventricular atrium greater than 10mm [10]. The presence of mild dilatation of the lateral ventricular atrium might be a clue to subtle structural defects and unsuspected karyotypic anomalies [11]. Accurate recognition of ventricular abnormality is based on proper understanding of the normal ranges of size, shape and experience.

Anomalies of the central nervous system (CNS) are among the most common, yet devastating, of congenital anomalies. Infants with ventriculomegaly often survive but may be severely handicapped with a good number of these infants contributing to the perennial poor infant mortality rate that is usually reported in third world countries like Nigeria [12]. Interestingly, the diagnosis of foetal ventriculomegaly could be made as early as the 14th menstrual week of gestation. At this time, proper information and counselling on the outcome of the pregnancy could be achieved with less risk to the mother.

To the best of our knowledge, there has been no documented literature on normogram for foetal atrial lateral ventricle in sub-Saharan Africa. It is worthy to note that though similar studies have been done in developed countries, these have not created enough impact for a national guideline or policy to be developed for prenatal ultrasound scan in Nigeria. Hence most foetuses that could have had early intervention are born with these defects undetected. They often present late with complications and poor outcome, increasing perinatal and infant mortality rates in our environment. This study therefore, seeks to document the normal range of values for the PA of foetal ventricle, with a view to establishing a normogram for normal foetuses in the sub-Saharan Africa and also evaluate any association between the PAD of ventricles and other foetal parameters.

## 2. METHODOLOGY

This was a prospective study carried out among pregnant women attending routine antenatal clinic in the Obstetrics and Gynaecology Department of University College Hospital, Ibadan, from January to December 2010. The study was approved by Institutional Review Board [Ethical Committee] with Approval number: UI/EC/10/0025].

The inclusion criteria were;

- Pregnancies with ultrasound gestational age of 14 to 38 weeks which corresponded with patient's last menstrual period.
- Foetuses with symmetry of the lateral ventricles
- Foetuses without gross anomaly. The exclusion criteria were;
- Multiple pregnancies
- Pregnancies with uncertain date
- Pregnancies with maternal chronic medical diseases such as diabetes mellitus and hypertension
- Foetuses with central nervous system or gross anomaly [ventriculomegaly, separation of more than 3mm between the choroid plexus and the medial ventricular wall, anencephaly spinal bifida club foot among others]

A pretested questionnaire was administered to all the participants to obtain their biomedical data, past obstetric and medical history, presence of inter-current illness or complication of index pregnancy. A written consent was obtained from the patients and additional information was extracted from the antenatal booking record where necessary. Guardian provided consent for the few mothers who were minors at the time of the study.

Images were acquired with the Logic P5/A5 General Electric ultrasound machine, 2007 China or the ALOKA SSD 1700, 1996 Japan. A 2 to 5MHz curvilinear transducer was used for optimal visualisation of the foetal cranium depending on the patient's habitus. Values for biparietal diameter (BPD), head circumference (HC), femoral length (FL) and abdominal circumference (AC) were measured and the machine generated the ultrasound estimated foetal weight (EFW) and gestational age (GA) using the Hadlock IV equation [13]. Foetuses with gross anatomic defects were excluded from the study.

An axial image was obtained at the level of the lateral ventricles, with the ultrasound beam directed approximately perpendicular to the long axis of the ventricle, just above the trans-thalamic plane normally used for foetal biometry. The widest part of the posterior atrium [PA], where the glomus of the choroid plexus fills the PALV farthest from the transducer was measured in this study. The electronic callipers were positioned from the inner to inner margins of the ventricular wall. Two measurements were taken and a mean diameter calculated to minimize intra-observer errors. All scans were performed by the corresponding author to avoid inter-observer errors. At the transventricular plane reverberation artefact often obscures the PA nearest to the transducer [7,10] Fig. 1, hence the PA farthest from the transducer was measured in this study. Also the probability of which ventricle is measured is determined by nature since foetal presentation is random, this will naturally minimize the possibility of measuring only one ventricle during the study [10]. Fig. 1 shows how measurements were taken with electronic callipers on the luminal walls of the lateral ventricles.

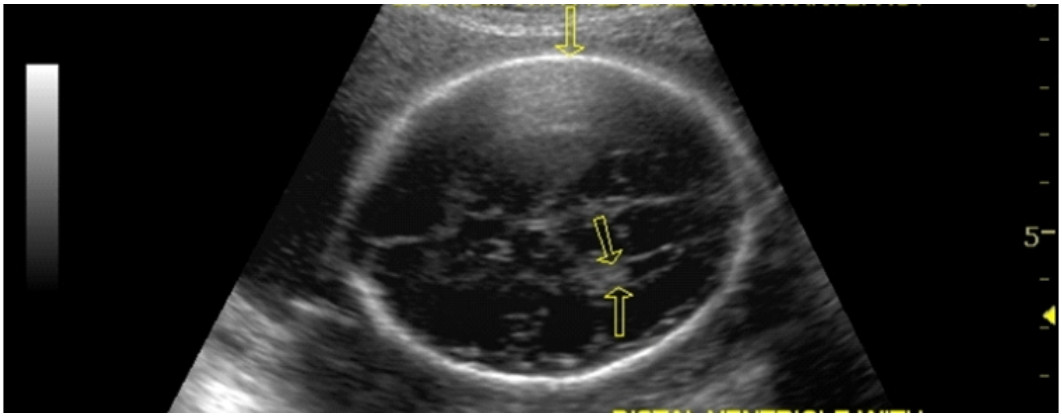


**Fig. 1. Transabdominal USS at the level of the atrium of the lateral ventricle. Single arrow shows cranial vault with reverberation artefact, double arrows show measurement of PADLV at the glomus of the echogenic choroid plexus in the distal lateral ventricle**

The data obtained was analysed using the statistical package for social sciences (SPSS, version 15) Inc, Chicago Illinois. The results are presented in tables, histograms and box

plots and associations were explored with the Student's t-test and Pearson's correlation coefficient. The level of significance was set at P≤0.05.

## 3. RESULTS AND DISCUSSION

A total of 404 pregnant women met the inclusion criteria and were included in this study. Table 1 shows the sociodemographic characteristics of the mothers. The age range of the respondents was 14 – 44 years with a mean age of 30.9 years (±4.6mm). The range in parity was 0- 9 with a median of 3. Most of the respondents had tertiary education 311(76.4%), only 5 (1.2%) respondents had no formal education. The studied foetuses were between 14 to 38 weeks gestational age (GA) with a mean GA of 30.52 weeks (Table 2). The mean PADLV in this study was 6.5mm (±1.3mm) [4.0-11.5mm], Fig. 2.

**Table 1. Maternal characteristics**

| Variable | Frequency (%) |
|---|---|
| **Age in years** | |
| 19 and below | 7 (1.7) |
| 20 – 29 | 137 (33.9) |
| 30 - 39 | 252 (62.4) |
| 40 and above | 8 (2) |
| Total | 404 (100) |
| **Level of Education** | 5 (1.2) |
| None | 24 (5.9) |
| Primary | 67 (16.6) |
| Secondary | 308 (76.2) |
| Tertiary | 404 (100) |
| Total | |
| **Parity** | |
| Primipara | 177 (43.8) |
| 1 – 4 | 224 (55.4) |
| 5 and above | 3 (0.7) |
| Total | 404 (100) |

**Table 2. Values of PADLV at different gestational ages**

| VARIABLES GA (inweeks) | N | Mean PADLV(mm) | Standard Deviation (SD) | Range(mm) | Mean±2SD |
|---|---|---|---|---|---|
| 14 – 19 | 26 | 6.6 | 1.2 | 4.5-10 | 4.2-9.0 |
| 20 -25 | 45 | 6.4 | 1.3 | 4.6–10.5 | 3.-9.0 |
| 26–30 | 102 | 6.2 | 1.4 | 4–11.5 | 3.4-9.0 |
| 31–35 | 114 | 6.5 | 1.4 | 4–11 | 3.7-9.3 |
| ≥36 | 117 | 6.7 | 1.2 | 4–10.5 | 4.3-9.1 |

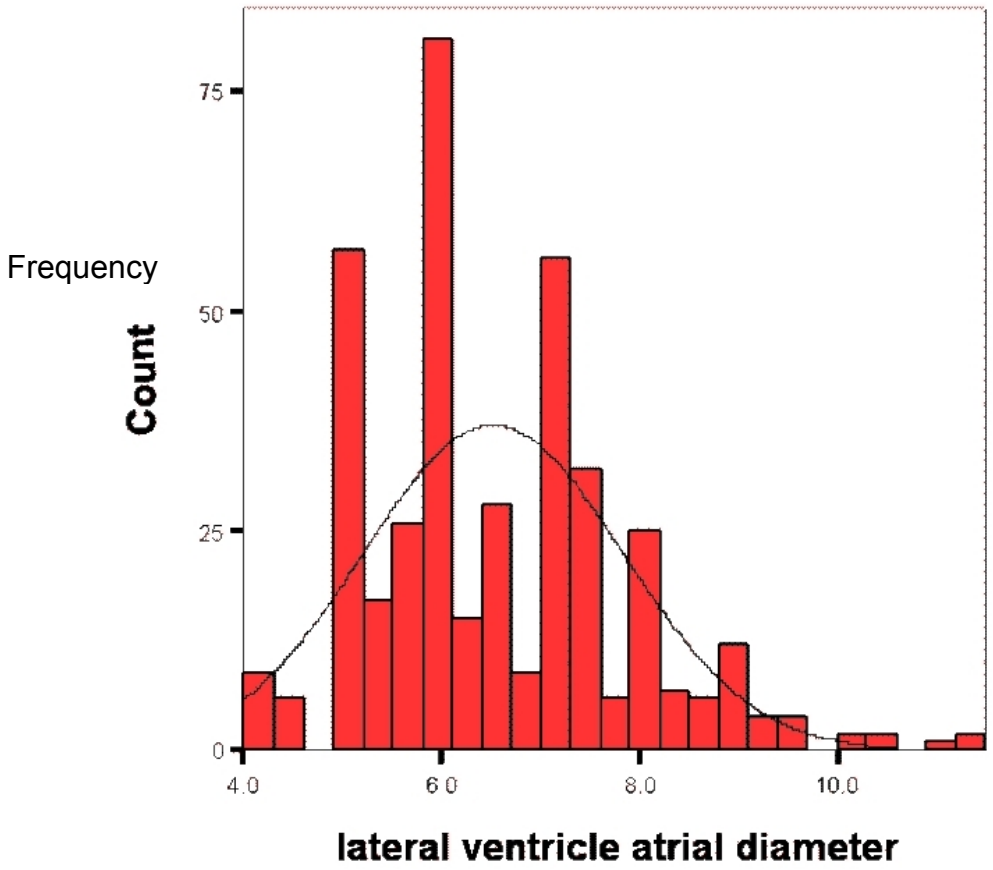


**Fig. 2. A histogram showing the distribution of PADLV in the foetuses**.

Most of the foetuses, 278 (68.8%) were scanned in the 3rd trimester of pregnancy. In the 3rd trimester the mean PAD was 6.5mm (±1.3mm) [4-11.5mm], while the mean PAD was 6.4mm (±1.3mm) [4 – 11.5mm] for the 2nd trimester.

Three hundred and ninety nine foetuses had PAD value ≤ 10mm while five patients had PAD >10mm (I0.5mm -11.5mm). The normal range of values (mean ±2SD) for the 2nd and 3rd trimester for which 95% of foetuses are expected to lie as shown in Table 3 is (3.76-9.12) and (3.92 -9.16) respectively. There was no significant difference between the PAD values for 2nd and 3rd trimester.

**Table 3. Values of PADLV in the 2nd and 3rd trimester**

| Variable | N (%) | Mean PADLV (mm) | SD (mm) | Range (mm) | Mean± 2SD | Mean ± 2.5SD |
|---|---|---|---|---|---|---|
| 2nd Trimester | 126 (31.1) | 6.44 | 1.34 | 4 – 11.5 | 3.76- 9.12 | 3.09-9.79 |
| 3rd Trimester | 278 (68.8) | 6.54 | 1.31 | 4 – 11.5 | 3.92-9.16 | 3.27-9.82 |

Foetal gender could be ascertained in only one hundred and seventy six (43.6%) of the foetuses scanned, one hundred and seven of these were male (60.7%) while sixty nine (39.2%) were female. The PAD values for males and female foetuses are shown in Table 4. The normal range of values for male foetuses (mean±2SD) was 4.1-9.3mm while 95% of female foetuses had PAD values between 3.6-8.8mm; the mean difference was 0.5mm

**Table 4. Values of PADLV in male and female foetuses**

| VARIABLE (gender) | N (%) | Mean PADLV (mm) | SD | Range | Mean±2SD | P-value |
|---|---|---|---|---|---|---|
| Male | 107 (60.7) | 6.7 | 1.3 | 4.5– 11.5 | 4.1-9.3 | 0.04 |
| Female | 69(39.2) | 6.2 | 1.3 | 4.0 – 9.5 | 3.6-8.8 | |

Figs. 4 and 5 are box plots showing the distribution of PAD in the 2nd and 3rd trimesters.

The five point's summary for the 2nd and 3rd trimesters are shown below;

Minimum value: 4mm, 4mm
25th percentile: 5.5mm, 5.5mm
Median: 6mm and 6.5mm
75th percentile: 7.5mm and 7.8mm
Maximum value 9.8mm and 10.5mm
There were three outliers with values of 10.1mm, 10.5mm and 11.5mm in the 2nd trimester and 11mm and 11.5mm in the 3rd trimester.

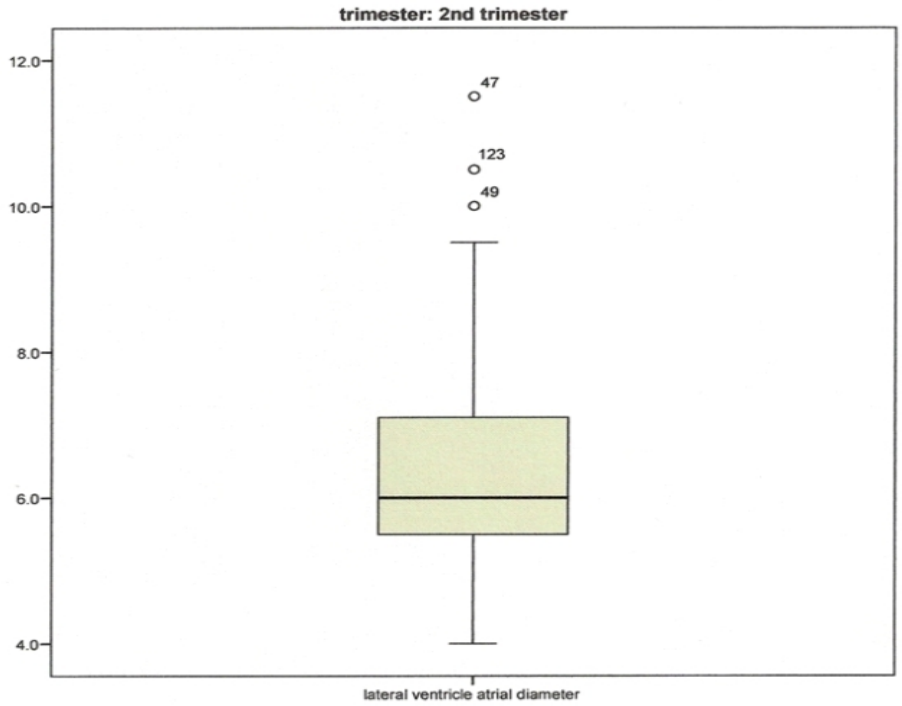


**Fig. 3. Box plot showing the distribution of ventricular sizes in the second trimester**

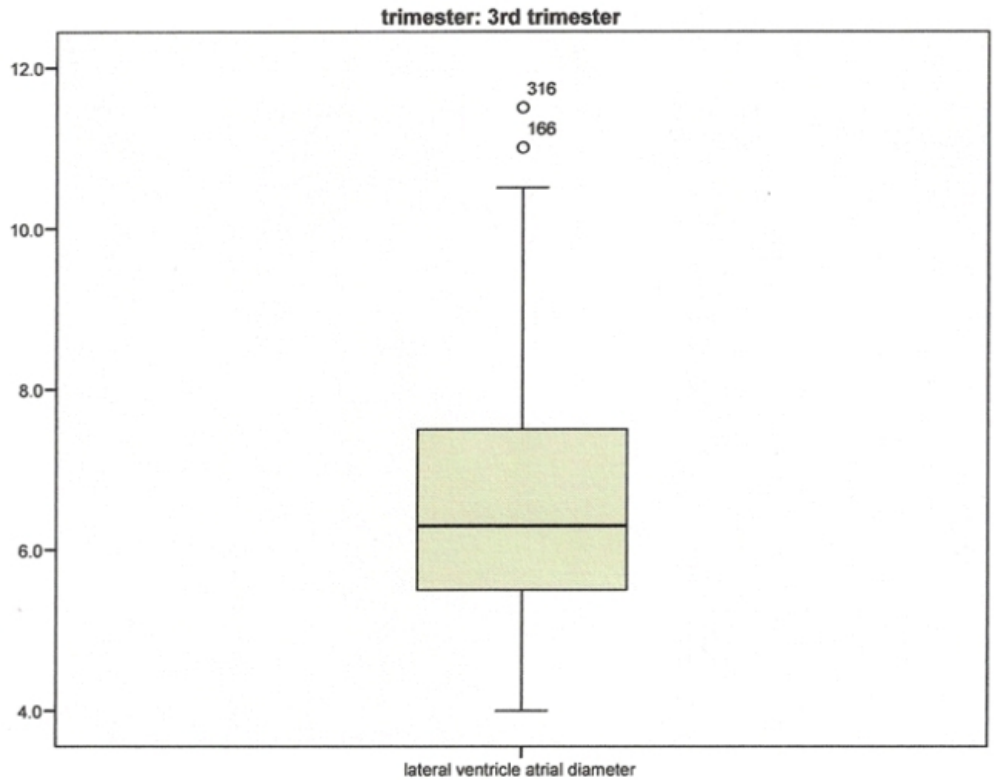


**Fig. 4. Box plot showing the distribution of ventricular sizes in the third trimester.**

In exploring the relationship between PADLV and GA, BPD and EFW [Table 5], Pearson's correlation coefficient reveals that there was no significant correlation between PADLV and these foetal parameters (P<0)

**Table 5. Pearson's Correlation Coefficient for ADLV and Foetal Characteristics**

| Variable | N | Pearson's R | P – Value |
|---|---|---|---|
| PADLV and GA | 404 | 0.092 | 0.068 |
| PADLV and BPD | 404 | 0.011 | 0.06 |
| PADLV and EFW | 404 | 0.064 | 0.27 |
| PADLV and EFW | 404 | 0.08 | 0.12 |

The scatter plots (Fig. 5) shows the diagrammatic representation of the relationship between PADLV and GA. The diagram shows that the line of best fit is relatively flat indicating no significant trend or association between GA and PADLV.

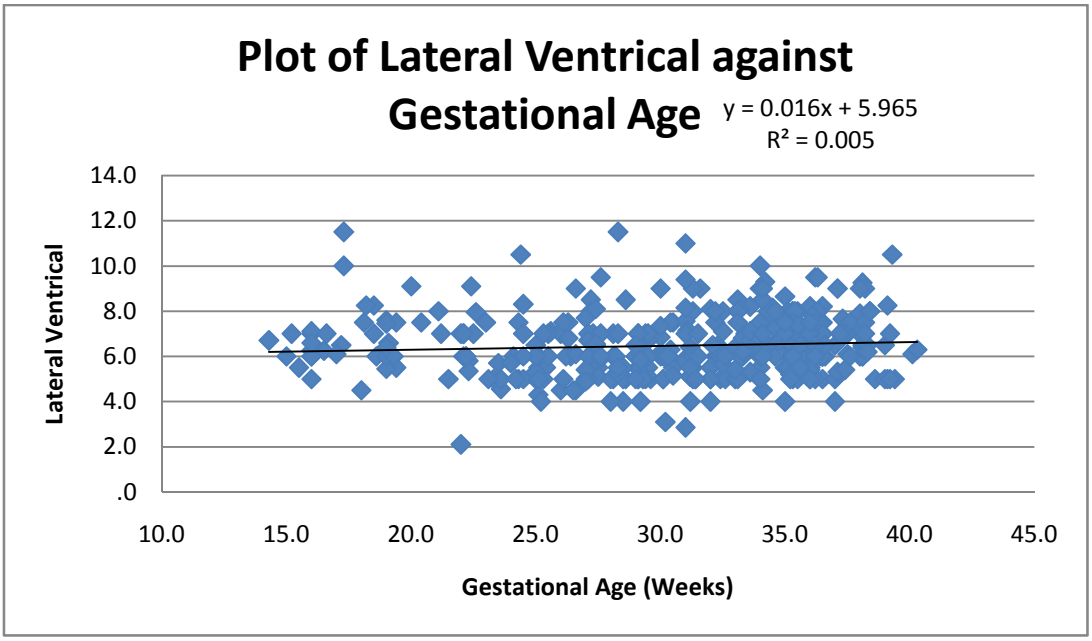


**Fig. 5. Scatter Plot showing the relationship between the GA and the Lateral Ventricle**

In our study the mean value of PADLV of 404 foetuses was 6.5mm (±1.3mm), and the mean plus 2.5 standard deviation was 9.8mm (Table 3). This result is similar to those of Heiserman et al. [9] (52 subjects), Ravi et al. [1] (500 subjects) and Achiron et al. [14] (5,400 subjects) who recorded mean values of 6.5mm (±1.3mm), 6.6mm (±1.4mm) and 6.6mm (±1.2mm) respectively in their prospective studies. However, Thomas et al. [7] in another prospective study of 739 foetuses in Durham USA recorded a mean value of 5.4mm (±1.2mm) which is lower than our value. Their study also considered PADLV of 8mm as the upper limit of normal for foetuses 17 weeks or less. No explanation is given for these differences so far. Cardoza et al [15] in their pioneering work on foetal ventricle proposed 10mm as the upper limit of normal for the PADLV. This value was arrived at from a mean value of 7.6mm plus 4 standard deviations (0.6mm). This has received wide acceptance by other investigators [6] because measurement of the PADLV is simple and reproducible as proposed by Cardoza et al. [15] and the echogenic choroid plexus is a stable and reliable landmark in this region [16,17].

Compared to Cardoza et al. [15] who recorded a mean value of 7.6mm (SD 0.6mm) and 10mm (mean +4SD) in their retrospective review of 100 foetuses; most prospective studies including ours recorded lower PADLV. It thus appears that the realistic mean for the atrium of the lateral ventricle would be significantly below the value proposed by Cardoza et al. [15], since most prospective studies where the criteria were set and followed properly by different investigators have constantly recorded mean PAD of 1mm or more lower than the 7.6mm recorded by Cardoza et al. [15]. However, despite the difference in the mean values obtained from the retrospective and prospective studies, previous investigators have accepted 10mm as a convenient upper limit of normal for PADLV. This is largely due to the fact that foetuses with PAD of 10mm and below without any associated anomaly have consistently show normal postnatal outcome.

The concept of mild idiopathic lateral ventricular dilatation (MILVD) has been proposed by some investigators because of the varying outcomes of MILVD dilatation with or without other associated foetal anomalies. Mahony et al. [18] in their study of 20 fetuses with mild ventriculomegaly, defined MILVD as the separation of more than 3mm-8mm between the echogenic choroid plexus and the wall of the lateral ventricle irrespective of the size of PADLV. On the other hand Goldstein et al [11] and Bromley et al. [19] in their study of 55 and 44 foetuses with mild ventriculomegaly respectively defined MILVD in terms of the size of PADLV. They considered measurements of 10-15mm as mild ventriculomegaly [19]. In the three studies quoted above, the investigators noted that the atrium of the lateral ventricle like any other biological medium may occasionally dilate [15]. Mild ventricular dilatation can be divided into three categories: (i) Those that are isolated with no other associated foetal anomaly which undergo spontaneous resolution before term and show good prognosis [20] as was seen in 100% of all their cases. (ii) Those cases of MILVD that remain stable throughout gestation, they show unpredictable outcome and (iii) Those with other associated foetal anomaly which consistently show poor prognosis, the outcome being dependent on the cause of the mild ventriculomegaly [18,21].

As in previous studies [1,14,17] the distribution of the PADLV varies with both the EFW and the BPD in an unpredictable way. The mean PADLV also varies both within and between the trimesters. This is demonstrated in this study, with poor Pearson correlation coefficient of 0.14 and 0.11 for EFW and BPD respectively. This outcome is also corroborated by the scattered plots which show no clustering of the PADLV along the line of best fit (Fig. 5), $R^2$ = 0.0055 indicating a very weak correlation for the GA.

Only few studies have so far showed the relationship between the ADLV and the foetal gender. In our study, gender was assignable to only 176 (43.6%) of the subjects, this low number of foetuses with assigned gender was largely due to the late presentation of most of the subjects. The mean value of PADLV for male 6.7mm (±1.3mm) was higher compared to the values for female 6.2mm (±1.29mm). The mean difference of 0.5mm was statistically significant (P= 0.04) but the clinical value of this difference is yet to be established as more studies are needed to evaluate the perinatal characteristics of neonates with regards to the ventricular size. However, this result is similar to the studies of Nadel and Benacerraf et al [8,10] in their prospective assessment of 543 foetuses; 316 (58.2%) male and 227 (41.2%) females. They recorded a total mean PADLV of 6.5mm (±1.4mm) with a mean value 6.7mm (±1.3mm) and 6.3mm (±1.3mm) for males and females respectively. Their mean difference of 0.4mm is similar to our study. Patel et al. [22] in their study recorded a mean difference of 0.6mm between male and female foetuses which is also similar to previous studies and ours. The absolute maximum values in this study were 11.5mm and 9.5mm for the male and female foetuses respectively. The 2mm difference in the absolute maximum values for the male and female foetuses has been reported to be far more significant statistically, than the mean difference [10,18]. This may presuppose that female foetuses with mildly dilated PADLV are more likely to have poor prognosis compared to their male counterpart [21,23].

## 4. CONCLUSION

This study has shown that with the existing resources in our environment, in-utero assessment of the foetal intracranial anatomy with a view to making prenatal diagnosis of ventriculomegaly is possible, as the PADLV remains stable in the second and third trimester of gestation. A Measurement of 10mm for the PADLV is a reasonable upper limit beyond which foetuses should be evaluated properly to rule out ventriculomegaly. The previously reported larger size of the PADLV in male foetus compared to their female counterpart is

also confirmed in our study population. However, further studies are needed to evaluate the significance of this difference with regards to the perinatal outcome of neonates in the study area.

## CONSENT

Not applicable.

## ETHICAL APPROVAL

The study was approved by Institutional Review Board [Ethical Committee] of University of Ibadan [UI] [and University College Hospital [UCH],Ibadan with Approval number: UI/EC/10/0025].

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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