

# Estimation of fetal bilateral thalamic volume in normal fetuses using 2-D ultrasound

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## ABSTRACT

- Background:** Thalamic volumetric estimation is rarely done. But it is potentially useful in thalamic abnormalities. The fetal thalamic volume may predict the occurrence of the disorders and syndromes related to the thalamus. This study aims to establish nomograms of fetal thalamic volume using 2-D ultrasound. It also intends to correlate fetal thalamic volume and fetal gestational age in Indian cohort.
- Methods:** Fetal thalami from both sides were measured using 2-D ultrasound in 725 normal, singleton fetuses at 20 - 35 weeks of gestation. It is a cross sectional community based study carried over a period of 1 year.
- Results:** It was found that both gestational age and thalamic volume had linear correlation. Charts for 90th, 50th and 10th percentile were obtained. A regression equation was derived: Thalamic Volume (ml) =  $0.3594(\text{Gestational Age in weeks}) - 5.8454$
- Conclusion:** Thalamic volume is very well correlated to gestational age. The increase in thalamic volume with gestation can be predicted accurately.

**Key words:** Fetal thalamic volume, 2-D ultrasound, Antenatal screening, ultrasonography, nomogram

**Abbreviations:** AGA - Appropriate for gestational age; IUGR - Intrauterine growth retardation

## Introduction

Thalamus is important in cognitive neurosciences [1] because sensory, motor and cognitive systems depend upon it. The thalamic volume has been investigated in adult population with reference to generalized and partial epilepsy [2,3], schizophrenia [4], Huntington's disease [5], Parkinson's disease [6] and Alzheimer's disease [7]. Drawing analogies, measurement of fetal thalamic volume may be useful in the diagnosis and prediction of disorders pertinent to thalamus. However, thalamic volumetric estimation is rarely done in fetuses and hence nomograms are not available for clinical reference. This study aims to establish nomograms of fetal thalamic volumes in Indian cohort.

## Methods

The present study is prospective, cross-sectional, community based and approved by institutional ethics committee. The study was carried out between June 2013 and June 2014 during which period 725 fetuses of gestational age of 20 weeks to 35 weeks were studied.

Volume estimation is always superior to linear or 2-dimensional measurements as the former is 3-dimensional. It is calculated by multiplying length, breadth and depth which are obtained by 2-dimensional (2-D) ultrasound. Fetal brain volume was serially measured starting from 20 weeks of gestation to 35th week of gestation. Fetal weight was calculated in percentile by Hadlock-4 criteria [8]. Hadlock-4 uses biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC) and femur length (FL) for calculating the fetal weight. Measurements between 90th to 10th percentiles were included in the study.

No data pertinent to the sex of the fetus was collected because of legal (Pre-conception and Prenatal diagnostic techniques act) restrictions. [9] Excluded from the study were (1) fetuses with congenital abnormalities, (2) twin gestations, (3) mothers with chronic illness and/or long term medications, (4) mothers suffering from pre-eclampsia or gestational diabetes, (5) maternal

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oligohydraminos or polyhydraminos, (6) maternal history of radiation exposure, (7) mothers who refused to consent, (8) abnormal fetal position that precluded satisfactory measurement of anatomical landmarks and (9) fetuses with estimated gestational weight lying outside 10<sup>th</sup> percentile and 90<sup>th</sup> percentile by Hadlock-4 criteria [8]

Sonoace X8LV sonographic machine (Medison, South Korea) with convex 2-5MHz probe was used to measure fetal dimensions. Three orthogonal measurements (Fig. 1) were used to calculate thalamic volume: (1) With the fetal head imaged in head-circumference plane, transverse diameter of thalamus was measured from ambient cistern to crural cistern on either side (A-B); (2) In head-circumference plane, antero-posterior diameter was measured from the posterior end of cavum septum pellucidum to the hiatus of tentorium (C-D); (3) With fetal head imaged in mid-sagittal plane, vertical diameter of thalamus was measured by drawing a perpendicular line from bright echogenic choroid plexus to the skull base (F-E). To exclude inter-observer variations, two measurements were made at an interval of 1 hour.

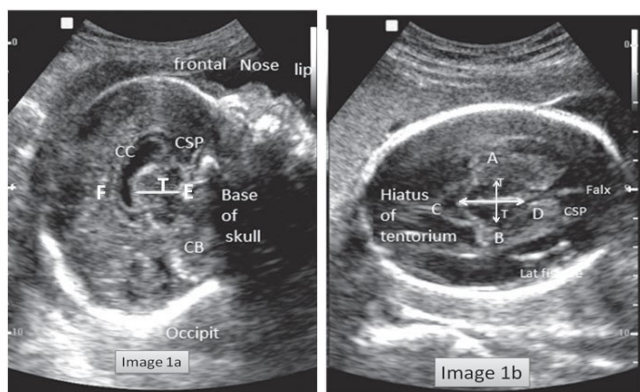


Fig. 1: Landmarks for measuring thalamic dimensions Volume measurement: (A) shows landmarks of measuring antero-posterior and transverse diameters in axial plane (B) shows landmarks of measuring vertical diameter in mid-sagittal plane

The statistical data analysis was done using the SPSS (Statistical Package for Social Sciences) version-16 for Microsoft Windows. ANOVA (Analysis of variance), correlation, and regression analysis were done. Data of Thalamic volume was compared and correlated with fetal gestational age by Pearson's correlation coefficient and prediction characteristics were computed. Regression formula for each measurement was derived. ANOVA was used to determine if the mean of one or more samples are equal and to calculate sample variances. In these tests relative variances were the most important information. A probability value less than 0.05 was accepted as the level of statistical significance. Paired data were compared with Student's T-test.

## Results

### Correlation between thalamic volume and gestational age

Paired of quantitative data of gestational age and thalamic volume were analyzed using Pearson's correlation coefficient. The two variables have a correlation coefficient (r) of 0.82 (P <0.0001). Unfortunately, no Indian studies are available for comparison.

### Regression analysis of thalamic volume versus gestational age

Relationship of gestational age and thalamic brain volume were also analyzed quantitatively as shown in the Fig-2. The F value was 1593.4, which was statistically significant (p<0.0001). Table 1 summarizes the computed percentile chart of thalamic volume with respect to gestational age.

Thalami from both sides of fetus were found have significant correlation with gestational age. A linear relationship was observed between the two variables. (Fig 3) A regression equation was also developed based on the observation which is as follows: Thalamic Volume = 0.3594(GA) - 5.8454

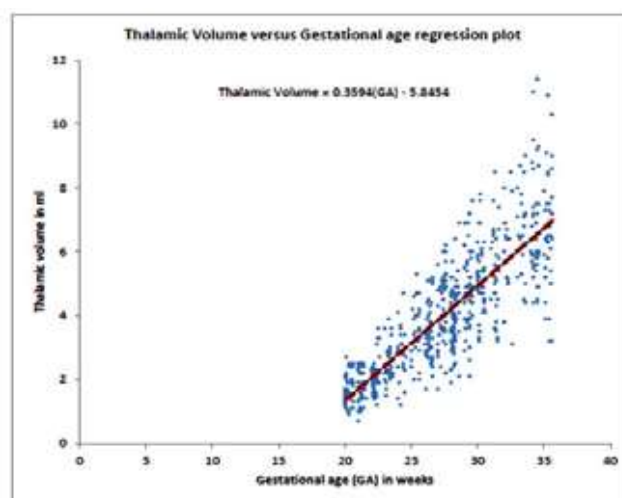


Fig 2. Regression plot of gestational age and thalamic volume

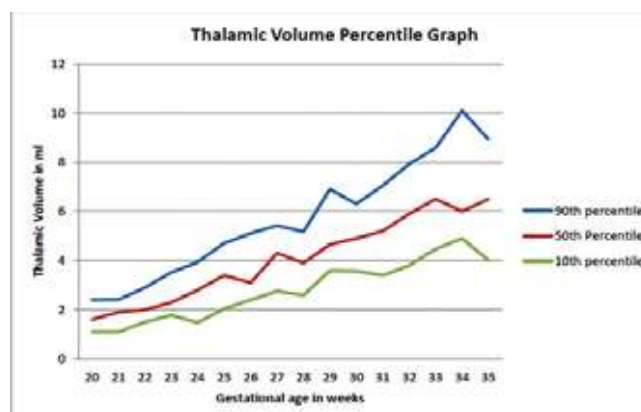


Fig 3. Percentile chart of thalamic volume

**Table 1: Normal range of thalamic volume in various gestational ages**

Gestational age (weeks)	Thalamic volume (ml)		
	90 <sup>th</sup> percentile	50 <sup>th</sup> percentile	10 <sup>th</sup> percentile
20	2.40	1.60	1.10
21	2.41	1.9	1.09
22	2.9	2.00	1.50
23	3.52	2.30	1.78
24	3.94	2.80	1.48
25	4.70	3.40	2.04
26	5.10	3.10	2.40
27	5.42	4.30	2.76
28	5.17	3.90	2.59
29	6.90	4.65	3.60
30	6.30	4.90	3.58
31	7.05	5.20	3.40
32	7.93	5.90	3.80
33	8.58	6.50	4.46
34	10.10	6.00	4.90
35	8.92	6.50	4.00

## Discussion

Benavides-Serralde et al [10] compared the dimensions of intracranial structures in IUGR and fetuses appropriate for gestational age. They found that the thalamic volume was increased in IUGR fetuses as compared with AGA fetuses. They included patients with 28-34 weeks of gestation and the mean thalamic volume was found to be  $1.5 \pm 0.9 \text{ cm}^3$  (range 0.8 -  $4.5 \text{ cm}^3$ ) in the AGA fetuses. Sotiriadis et al [11] measured fetal thalamic volumes in 122 normal fetuses by using 3-D sonography and Virtual Organ Computer-aided AnaLysis (VOCAL). In their study, it was observed that the thalamic volume increases with gestational age and there was no difference in the volumes of right and left thalami. The mean volume of each thalamus increased from 0.45ml at 20 weeks, to 1.39ml at 28 weeks and 2.17ml at 34 weeks. As compared to these published values, thalamic volume of our study appears to be greater. The 90<sup>th</sup> and 10<sup>th</sup> percentile for 28 weeks of gestation is 5.17ml and 2.59ml respectively while for 34 weeks it is 10.1ml and 4.9ml respectively.

There are few limitations in measuring thalamic volume. Before 20 weeks of gestation thalamus is not very well developed and therefore suboptimal volume may be seen. After 35 weeks of gestation fetal position may not be suitable for volumetric measurements. There may be some technical difficulty in differentiating echogenic adjacent structures from that of thalamus. This might be due to lack adequate image contrast in ultrasound as compared to magnetic resonance imaging. Despite these limitations

ultrasonography is practical, easily available and cost-effective than magnetic resonance imaging. Nomogram of fetal thalamic volume established in this study needs to be verified by further studies. It may prove to be useful in predicting fetal anomalies pertinent to thalamus.

**Conflicts of Interest** : Nil

**Ethics** : Compliance with ethical principles declared

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## References

- 1 Basso MA, Uhlich D, Bickford ME. Cortical function: a view from the thalamus. *Neuron* 2005; 45: 485-488.
- 2 Gong G, Concha L, Beaulieu C, Gross DW. Thalamic diffusion and volumetry in temporal lobe epilepsy with and without mesial temporal sclerosis. *Epilepsy Res.* 2008; 80: 184-193
- 3 Pulsipher DT, Seidenberg M, Morton JJ, et al. MRI volume loss of subcortical structures in unilateral temporal lobe epilepsy. *Epilepsy Behavior* 2007; 11: 442-449.
- 4 Adriano F, Spoletini I, Caltagirone C, Spalletta G. Updated meta-analyses reveal thalamus volume reduction in patients with first-episode and chronic schizophrenia. *Schizophr Res* 2010; 123: 1-14
- 5 Douaud G, Gaura V, Ribeiro MJ, et al. Distribution of grey matter atrophy in Huntington's disease patients: a combined ROI-based and voxel-based morphometric study. *NeuroImage* 2006; 32: 1562-1575
- 6 McKeown MJ, Uthama A, Abugharbieh R, et al. Shape (but not volume) changes in the thalami in Parkinson disease. *BMC Neurol* 2008; 8: article 8
- 7 Jong LW, Hiele K, Veer IM, et al. Strongly reduced volumes of putamen and thalamus in Alzheimer's disease: an MRI study. *Brain* 2008; 131: 3277-3285.
- 8 Hadlock FP, Harrist RB, Sharman RS, et al. Estimation of fetal weight with the use of head, body, and femur measurements-a prospective study. *Am J Obstet Gynecol* 1985; 151: 333-337.
- 9 Ministry of Health & Family Welfare, Government of India. New Delhi [Available <http://www.pndt.gov.in/index1.asp?linkid=25>] Accessed on 18 January 2013.
- 10 Benavides-Serralde A, Hernández-Andrade E, Fernández-Delgado J, et al. Three-dimensional sonographic calculation of the volume of intracranial structures in growth-restricted and appropriate-for-gestational age fetuses. *Ultrasound Obstet Gynecol* 2009; 33: 530-537.
- 11 Sotiriadis A, Dimitrakopoulos I, Eleftheriades M, et al. Thalamic volume measurement in normal fetuses using three-dimensional sonography. *J Clin Ultrasound.* 2012; 40: 207-213.

