
OBSTETRICS

Normal Values For Fetal Thoracic Parameters.

Dhiraphongs Charoenvidhya MD,
Boonchai Uerpairojkit MD,
Yuen Tannirandorn MD,
Saknan Manotaya MD,
Somchai Tanawattanacharoen MD.

Division of Maternal-Fetal Medicine, Department of Obstetrics and Gynecology, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand

ABSTRACT

Objective To determine nomograms for fetal thoracic measurements during the second and third trimesters.

Design Prospective study

Setting Division of Maternal-Fetal Medicine, Faculty of Medicine, Chulalongkorn University.

Subjects Normal pregnant women between 18 and 40 weeks of gestation, having their first antenatal visit during first trimester of pregnancy at King Chulalongkorn Memorial Hospital between December 1996 to October 1997 were recruited into this study. All pregnancies were singleton with known date of the beginning of the last normal menstrual period and confirmed by first trimester ultrasound. Patients with suspected anomalies, intrauterine growth restriction, fetal macrosomia, or severe oligohydramnios were excluded. The thoracic measurements obtained for each fetus were thoracic circumference and thoracic area. Thoracic circumference measurements were made according to the method of Nimrod et al.

Results 134 normal pregnant women were evaluated. Nomograms for fetal thoracic circumference and thoracic area with respect to gestational age from 18 to 40 weeks were developed.

Conclusion Nomograms for thoracic circumference and thoracic area with respect to gestational age were developed for the Thai population. These data might be helpful to establish normal values for fetal thoracic growth, in order to evaluate abnormal lung development in prolonged premature rupture of membranes, and in association with certain fetal abnormalities.

Key words : thoracic circumference, thoracic area, nomograms

Antenatal ultrasonography now permits the measurement of numerous parts of the fetal body and nomograms have been developed that help to distinguish normal from abnormal fetal biometry. Nomograms for fetal thoracic measurements (thoracic diameter, thoracic circumference and thoracic area) have been reported previously.⁽¹⁾ Other investigators have used thoracic measurements relative to the biparietal diameter or head circumference to predict fetal intrauterine growth restriction and macrosomia.⁽²⁾ It was necessary to carry out a longitudinal prospective study to establish normal values for fetal thoracic growth, in order to evaluate abnormal lung development in prolonged premature rupture of the membranes and in association with certain fetal abnormalities. The aim of this study was to determine nomograms for fetal thoracic measurements during the second and third trimesters of pregnancy according to well-defined anatomic planes of measurement.

Materials and Methods

Fetal thoracic measurements were prospectively obtained on 134 pregnant women between 18 and 40 weeks of gestation at the Division of Maternal fetal medicine, Department of Obstetrics and Gynecology, Faculty of Medicine, Chulalongkorn University over a 11 month period from December 1996 to October 1997.

Patients with suspected anomalies, intrauterine growth restriction, fetal macrosomia, or severe oligohydramnios were excluded. All patients gave oral consent to participate in the study.

The study group consisted of pregnant women chosen on the basis of the following criteria.

1. A history of regular menses.
2. Known date of the beginning of the

last normal menstrual period and confirmed by first trimester ultrasound.

3. Absence of maternal disease known to affect normal fetal growth, such as diabetes mellitus, chronic hypertension or heavy smoking.

4. Single gestation.

All examinations were performed by single operator using linear-array real time system ALOKA SSD 2000 (either 5 or 3.5 MHz curvilinear transducer).

Thoracic measurements obtained in each fetus were thoracic circumference and thoracic area.

Thoracic circumference measurements were made according to the method of Nimrod et al.^(3,4)

A transverse section of the thorax was obtained at right angles to the fetal spine at the level of the atrioventricular valves. This section should be as "round" as possible and should contain the four chambers of the fetal heart. The circumference and area were obtained by direct measurement with electronic calipers excluding the fetal skin and subcutaneous tissue.

All pregnant women were reviewed by ultrasound every 4 weeks if they had not been delivered and were stratified into 4 groups (A, B, C and D)

Groups A,B,C,D were scanned at 18, 19, 20, 21 week gestational age and then 4 weekly apart respectively

To assess for appropriate growth for gestational age, the fetal biometric measurements were routinely obtained during every scan and included biparietal diameter, head circumference, abdominal circumference, humerus length and femur length.

The newborns were normal and weighted between the 10th and 90th percentile for our standard.

Table 1. Normative data of fetal thoracic circumference (mms.) across gestational ages

GA (week)	Mean	SD	Percentile			Count
			5 th	50 th	95 th	
18	119.2	9.4	104.3	118	138.4	32
19	127.8	10	112.6	126.5	142.6	38
20	133.9	11.3	113.9	133.5	156.6	38
21	142.6	9.4	124.2	142	167.4	23
22	157	11.1	139	159	175.8	41
23	162.7	12.4	147	161	192	39
24	171.3	12.1	149.7	171	195.9	33
25	176.2	12.4	156.2	175	203	24
26	193	16	164	192	220.1	41
27	198.8	25.4	166.6	198.5	225.6	40
28	208	15	179	204	238.2	33
29	217.2	27.8	140.2	217	261.2	24
30	230.3	20.7	189.6	234	270.6	31
31	233.2	21.2	205.9	230	282.3	36
32	236	18.2	204.8	238	263.4	31
33	240.4	18.9	196.8	243	275.2	26
34	251.4	21.4	205.6	249.5	290.2	30
35	257.6	18.9	215.6	260	289.7	32
36	261.7	23.6	215.3	263.5	307	28
37	269	25.7	234	265	321	19
38	251.1	23.9	204	248.5	299	14
39	255.1	20.7	215	215	291	18
40	262.7	35.5	221	261.5	-	4

Table 2. Normative data of fetal thoracic area (cm.²) across gestational age

GA (week)	Mean	SD	Percentile			Count
			5%	50%	95%	
18	11.3	1.8	8.4	11	15.1	32
19	13	2	10.1	12.8	16.1	38
20	14.3	2.3	10.4	14.1	19.4	38
21	15.8	2.4	10.6	15.7	22.2	23
22	19.6	2.7	15.3	20	24.5	41
23	20.9	3.1	16.9	20.3	29.4	39
24	23.9	3.5	18.1	23.6	31.3	35
25	24.9	4.2	15.5	23.9	34.7	24
26	29.4	4.4	21	29.2	35.6	39
27	31.2	3.4	25.6	31.2	37.2	38
28	33.7	7.1	19.4	33.1	45	33
29	39.2	7	28.6	38.2	54.4	24
30	43	9.8	28.3	43.4	66.3	31
31	43.2	8.2	32.8	41.3	63.3	36
32	44.4	6.8	33.3	45.6	54.7	31
33	46.2	7.1	30.8	46.8	60.3	26
34	51.4	8.3	36.7	49.6	67.3	31
35	52.6	7.5	36.6	53.7	66.6	32
36	55.5	9.2	37.3	55.2	75.1	28
37	57.7	11.2	43.2	55.5	82	19
38	58.5	6.9	48.3	59.5	69.3	16
39	55.4	9.7	40.5	55.9	70.5	16
40	55.5	14.9	38.8	54.2	-	4

Table 3. Normal fetal Thoracic circumference derived from regression equation

GA (week)	Smoothed percentiles (mm.)		
	5 th	50 th	95 th
18	118.4	127.2	136
19	123.9	134.6	145.3
20	129.3	142	154.6
21	134.7	149.3	163.9
22	140.2	156.7	173.2
23	145.6	164.1	182.5
24	151.1	171.4	191.8
25	156.5	178.8	201.1
26	161.9	186.2	210.4
27	167.4	193.5	219.7
28	172.8	200.9	229
29	178.3	208.3	238.3
30	183.7	215.6	247.5
31	189.1	223	256.8
32	194.6	230.4	266.1
33	200	237.7	275.4
34	205.5	245.1	284.7
35	210.9	252.4	294
36	216.3	259.8	303.3
37	221.8	267.2	312.6
38	227.2	274.5	321.9
39	232.6	281.9	331.2
40	238.1	289.3	340.5

Table 4. Normal fetal Thoracic area derived from regression equation

GA (week)	Smoothed percentiles (mm.)		
	5 th	50 th	95 th
18	9.79	9.91	10.03
19	11.25	12.34	13.43
20	12.71	14.78	16.84
21	14.18	17.21	20.24
22	15.64	19.64	23.65
23	17.11	22.08	27.05
24	18.57	24.51	30.45
25	20.03	26.95	33.86
26	21.50	29.38	37.26
27	22.96	31.81	40.67
28	24.43	34.25	44.07
29	25.89	36.68	47.47
30	27.35	39.12	50.88
31	28.82	41.55	54.28
32	30.28	43.98	57.69
33	31.75	46.42	61.09
34	33.21	48.85	64.49
35	34.67	51.29	67.90
36	36.14	53.72	71.30
37	37.60	56.15	74.71
38	39.07	58.59	78.11
39	40.53	61.02	81.51
40	41.99	63.46	84.92

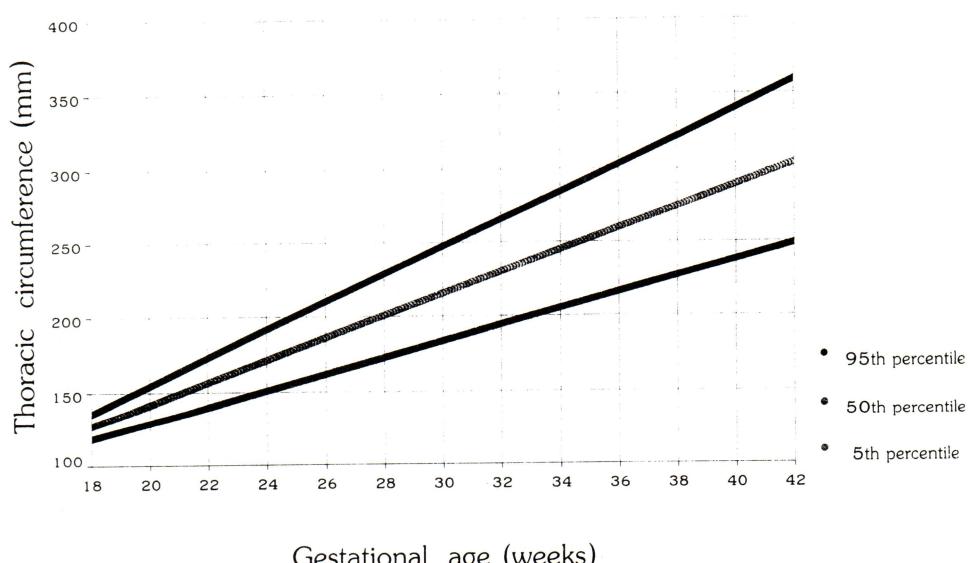


Fig. 1. Normogram for thoracic circumference derived from regression equation.

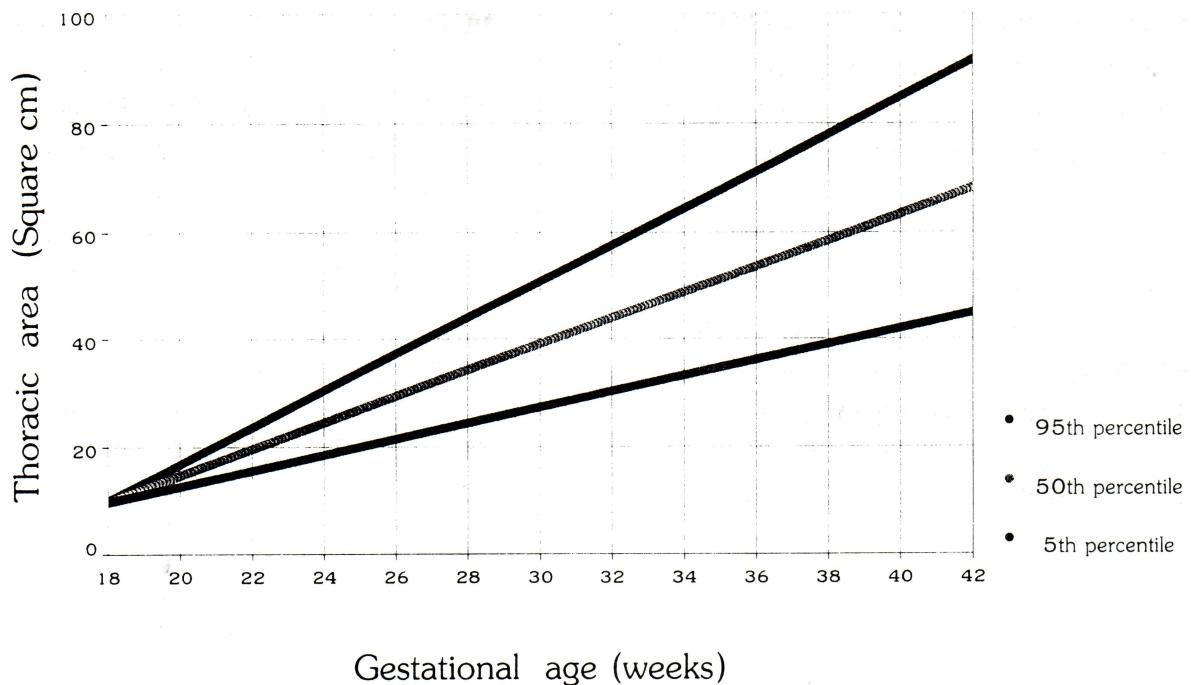


Fig. 2. Normogram for thoracic area derived from regression equation.

Results

One hundred and thirty four normal pregnant women were evaluated in this study. Nomograms for fetal thoracic circumference and thoracic area with respect to gestational age from 18 to 40 weeks were developed (Table 1 and 2). The number of measurements at each gestational week ranged from 14 to 40. The relationships of thoracic circumference and thoracic area to gestational age were observed to be linear (Fig 1 and 2).

The regression equation obtaining from random sampling of single measurement from each patient is presented as

$$\text{Thoracic circumference (TC)} = 7.3657 \times \text{GA (week)} - 5.3516, r = 0.92$$

$$\text{Thoracic area (TA)} = 2.434 \times \text{GA (week)} - 33.904, r = 0.90$$

For each gestational week the mean increase for thoracic circumference was estimated to be 0.64 cm and 2.099 cm² for thoracic area.

The result were stratified by weeks of gestation and presented with the mean, SD, 5th, 50th, and 95th percentile (Table 1 and 2).

The median, 5th and 95th centiles of TC and TA derived from regression equation were given in Table 3 and 4

Discussion

In this report we have defined sonographically derived thoracic measurements in (Chulalongkorn Hospital) normal fetuses from 18 to 40 weeks of gestation. Our data suggest that thoracic circumference and thoracic area demonstrate linear growth throughout gestation (Thoracic circumference = 0.6 cm/wk, thoracic area = 2.099 cm²/wk).

Ultrasound offers the hope of prenatal detection of pulmonary hypoplasia and associated conditions.⁽⁴⁾ Therefore, in the appropriate clinical setting (ie. prolonged rupture of membranes, intrauterine growth restriction, or associated fetal

abnormalities suggesting the possibility of compromised lung development) sonographic diagnosis or confirmation of abnormally small lungs indicative of pulmonary hypoplasia may be useful.⁽⁴⁾

Since the fetal thorax normally grows at a regular rate from 16 to 40 weeks, a linear correlation exists between thoracic size and gestational age.⁽⁵⁻⁷⁾ The reported measurements for thoracic circumference (TC) vary among different series, probably because of differences in the plane of section and in the amount of tissue included in the measurement. For example, some series apparently included the skin and subcutaneous tissue of the thorax in measurements of thoracic circumference, while others measured the TC at the outer, mid or inner perimeter of the rib cage. We chose to measure the TC in the axial view at the level of the four-chamber view of the heart. We excluded the skin and subcutaneous tissues in TC measurements because abnormalities which adversely affect the thorax, for example thanatophoric dysplasia, achondrogenesis, etc which may produce thickening of the subcutaneous tissues. The implications of fetal breathing activity during the sonographic examination remain controversial with regard to the prenatal diagnosis of pulmonary hypoplasia and the prediction of fetal outcome.⁽⁴⁾ An absolute thoracic circumference measurement less than the 5th percentile for expected values has been suggested as evidence for pulmonary hypoplasia.^(5,7-9) Since the number of patients in the last four weeks was quite small because the majority of the patients had been delivered. A smooth percentile derived from regression equation in table 3, 4 should be better employed.

It was suggested that thoracic measurements would be more clinically useful in the antenatal detection of fetuses at risk for anomalies specific to the fetal lungs and chest (eg. pulmonary hypoplasia). In conclusion, we have established nomograms for Chulalongkorn fetal thoracic circumference and thoracic area between 18 to 40 weeks' gestation, which shows an increase in variability of the normal range with increasing gestational age.

References

1. Varma TR, Taylor H, Bridges C. Ultrasound assessment of fetal growth. *Br J Obstet Gynaecol* 1979 ; 86 : 623-32.
2. Wladimiroff JW, Bloemsma CA, Wallenberg HCS. Ultrasonic diagnosis of the large for dates infant. *Obstet Gynecol* 1978 ; 52 : 285-8.
3. Nimrod C, Valena-Gittings F, Machin G, Campbell D, Wesenberg R. The effect of very prolonged membrane rupture on fetal development. *Am J Obstet Gynecol* 1984 ; 148 : 540.
4. Nimrod C, Davies D, Iwanicki S, Harder J, Persaud D, Nicholson S. Ultrasound prediction of pulmonary hypoplasia. *Obstet Gynecol* 1986 ; 68 : 495-7.
5. Fong K, Ohlsson A, Zaler A. Fetal thoracic circumference. A prospective cross-sectional study with realtime ultrasound. *Am J Obstet Gynecol* 1988 ; 158 : 1154-60.
6. Chitkara U, Rosenberg J, Chervanak FA, Berkowitz G, Levine R, Fagerstrom RM, et al. Prenatal sonographic assessment of the fetal thorax : Normal values. *Am J Obstet Gynecol* 1987 ; 156 : 1069-74.
7. DeVore GR, Horenstein J, Platt LD. Fetal echocardiography : Assessment of cardiothoracic disproportion. A new technique for the diagnosis of thoracic hypoplasia. *Am J Obstet Gynecol* 1986 ; 155 : 1066-71.
8. Johnson A, Callan NA, Bhutani VK, Colmorgen GHC, Weiner S, Bolognese RJ. Ultrasonic ratio of fetal thoracic to abdominal circumference : An association with fetal pulmonary hypoplasia. *Am J Obstet Gynecol* 1987 ; 157 : 764-70.
9. Songster GS, Gray DL, Gane JP. Prenatal prediction of lethal pulmonary hypoplasia during ultrasonic fetal chest circumference. *Obstet Gynecol*. 1989 ; 73 : 261-6.