Reappraisal of Fetal Abdominal Circumference in an Asian Population: Analysis of 50,131 Records

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SUMMARY

Objective: Fetuses from different populations may show different growth patterns. In obstetrics, fetal abdominal circumference (AC) is a very useful index for assessing fetal growth. In this study, we attempted to establish the normal fetal growth curves of AC in an Asian population in South Taiwan.

Materials and Methods: We reviewed our computer ultrasound database of fetal AC records from January 1991 to December 2006. During the study period of 16 years, only the fetuses examined by ultrasonography with gestational age between 14 and 41 weeks were included. We excluded extreme bilateral records after initial analysis. Eventually, 50,131 records of AC were included for final analysis.

Results: The observed gestation-specific AC values and the predicted AC values were calculated. The best-fit regression equation of AC versus gestational age is a second-order polynomial equation. In general, fetal AC values in our population showed similar patterns to those in Western populations. Besides, we established a table of the predicted AC values based on specific gestational age, including the 5^{th}, 10^{th}, 50^{th}, 90^{th} and 95^{th} centiles, for clinical reference.

Conclusion: To the best of our knowledge, our series is the largest sample of AC reported in the medical literature. We believe that the gestational age-specific nomogram of fetal AC is important for further clinical assessment of fetal growth. [*Taiwan J Obstet Gynecol* 2008;47(1):49–56]

Key Words: abdominal circumference, Asian population, fetus, pregnancy

Introduction

Among the common fetal growth parameters, such as abdominal circumference (AC), biparietal diameter and femur length, AC is the most sensitive single indicator of restricted or accelerated fetal growth [1–3]. To date, many reports have presented reference ranges for AC versus gestational age (GA) from various populations, especially Caucasian populations in Western countries [1,4–10]. Fetuses from different populations may show different growth patterns, and fetal AC values are different in previous reports [1,4–10]. Moreover, no fetal AC values in Taiwanese have been officially reported in the medical literature. In this series, we attempted to investigate whether the fetal AC values in Taiwanese are different from those in the Western populations [1,4–7,9]. In addition, we also established a GA-specific nomogram of Taiwanese fetal AC for clinical reference.

Materials and Methods

We retrospectively reviewed our computer ultrasound database of fetal AC records from January 1991 to December 2006. The analysis data included the examination date, GA, and fetal AC assessed by ultrasonography. During the study period of 16 years, only fetuses with GA ranging from 14 to 41 weeks were included.

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Initially, 53,723 records were included for calculation of mean and standard deviation (SD) values for each specific gestational week (Figure 1). Then, we excluded the extreme bilateral records, which were larger or smaller than the mean ± 1.66 SD. Finally, 50,131 records of AC were included for final analysis.

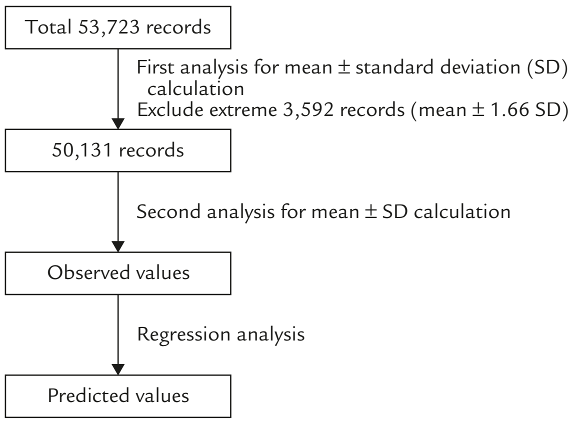

Figure 1. Flow chart of data analysis.

All examinations were performed using conventional ultrasound scanners with a 3.5-MHz real-time abdominal probe, including equipments manufactured by Aloka (Tokyo, Japan), Medison-Kretz (Zipf, Austria), and Toshiba (Tokyo, Japan). The ultrasound measurements followed a previous method reported by Tamura et al [1]. The anteroposterior (AD1) and transverse (AD2) diameters were measured, and AC was calculated from the formula: $3.14 \times (AD1 + AD2)/2$. The mean and SD values of AC for each gestational week were calculated. Using GA as the independent variable and AC as the dependent variable, the linear regression analysis and the polynomial regression analysis (up to the fourth order) were undertaken to find the best-fit regression equations for predicted values and age-related variances [4]. In addition, we used the best-fit polynomial regression equations of GA versus AC to establish a GA-specific nomogram for clinical use.

Table 1. The gestational age (GA)-specific mean and standard deviation (SD) for abdominal circumference

GA (wk)	Original records			Observed values		
	Mean (mm)	SD (mm)	Numbers	Mean (mm)	SD (mm)	Numbers
14	88.6	14.3	133	89.2	13.9	130
15	97.5	13.0	385	96.9	9.3	361
16	106.0	14.2	869	106.0	9.0	830
17	117.0	13.4	948	117.0	9.4	877
18	127.0	15.2	881	127.0	10.6	818
19	139.0	34.9	849	138.0	14.0	839
20	152.0	13.7	2,049	153.0	9.9	1,933
21	162.0	22.8	5,592	162.0	10.6	5,545
22	170.0	12.6	5,568	171.0	9.0	5,152
23	178.0	13.9	2,783	178.0	10.1	2,587
24	188.0	16.1	1,782	188.0	11.9	1,640
25	198.0	16.9	1,688	200.0	12.3	1,543
26	208.0	17.8	1,349	209.0	12.5	1,239
27	219.0	20.3	1,257	220.0	13.9	1,162
28	231.0	18.7	1,373	232.0	13.9	1,269
29	242.0	20.1	1,567	242.0	14.4	1,462
30	251.0	21.3	1,809	252.0	14.9	1,703
31	262.0	21.7	1,692	263.0	15.4	1,577
32	271.0	20.2	1,992	271.0	15.0	1,819
33	280.0	21.9	1,974	281.0	15.7	1,827
34	290.0	22.9	2,120	290.0	16.4	1,952
35	300.0	22.4	2,218	300.0	16.4	2,027
36	309.0	23.0	2,546	309.0	17.3	2,309
37	319.0	23.6	2,983	319.0	17.1	2,752
38	327.0	21.1	3,015	327.0	16.0	2,739
39	332.0	25.2	2,474	333.0	17.7	2,369
40	337.0	20.8	1,433	337.0	15.8	1,321
41	335.0	20.7	393	336.0	15.8	356
Total			53,723			50,131

Results

Table 1 presents the sample size and the observed values of the mean and SD of AC for each GA in the initial 53,723 data and in the final 50,131 eligible data.

Using GA as the independent variable and AC as the dependent variable, we underwent the polynomial regression analysis up to the fourth order. The result showed that the second-order polynomial regression was the best-fit polynomial regression equation: $AC = -0.0653\ GA^2 + 13.368\ GA - 90.932$ ($R^2 = 0.9983$). The best-fit equation for SD was: $SD = -0.0028\ GA^2 + 0.5326\ GA + 1.9693$. We used the second-order polynomial regression to calculate the predicted values and established a table and a figure of predicted values for further clinical reference (Table 2 and Figure 2).

To compare our AC data with other previous series in the medical literature, Tables 3–5 and Figures 3–5 are listed to show the comparisons and depict the trends of 5th, 50th and 95th centiles in our population and in the other populations from previous reports.

Discussion

Several cross-sectional and longitudinal studies have documented racial variations in fetal growth [9,11]. Previous studies involving one Korean population have found that biometric parameters, including fetal AC, in the Korean population during pregnancy were smaller than those in Caucasian populations [10]. When compared with the 5th percentile measurements, our predictive values were similar to other references (Table 4 and Figure 3). For the 50th percentile measurements, our predictive values were similar to other series from 14 to 32 weeks and smaller than the Western series after 33 weeks (Table 3 and Figure 4). However, for the 95th percentile measurements, the difference appeared

Table 2. The gestational age (GA)-specific predicted values of abdominal circumference

GA (wk)	Abdominal circumference (mm)							
	5th percentile	10th percentile	25th percentile	50th percentile	75th percentile	90th percentile	95th percentile	SD
14	69.0	72.4	77.7	83.4	89.2	94.4	97.9	8.7
15	79.8	83.4	88.9	94.9	100.9	106.4	110.0	9.1
16	90.5	94.3	100.0	106.2	112.5	118.2	122.0	9.5
17	101.1	105.0	110.9	117.5	124.0	129.9	133.8	9.9
18	111.5	115.6	121.8	128.5	135.3	141.4	145.5	10.2
19	121.9	126.1	132.5	139.5	146.5	152.9	157.1	10.6
20	132.1	136.5	143.1	150.3	157.5	164.1	168.5	11.0
21	142.2	146.7	153.5	161.0	168.5	175.3	179.8	11.3
22	152.2	156.8	163.9	171.6	179.3	186.3	190.9	11.7
23	162.0	166.8	174.1	182.0	189.9	197.1	201.9	12.0
24	171.8	176.7	184.1	192.3	200.4	207.9	212.8	12.4
25	181.4	186.5	194.1	202.5	210.8	218.5	223.5	12.7
26	190.9	196.1	203.9	212.5	221.1	228.9	234.1	13.0
27	200.2	205.6	213.6	222.4	231.2	239.2	244.6	13.4
28	209.5	215.0	223.2	232.2	241.2	249.4	254.9	13.7
29	218.6	224.2	232.6	241.8	251.1	259.4	265.0	14.0
30	227.6	233.3	241.9	251.3	260.8	269.3	275.1	14.3
31	236.5	242.3	251.1	260.7	270.4	279.1	284.9	14.6
32	245.3	251.2	260.2	270.0	279.8	288.7	294.7	14.9
33	253.9	260.0	269.1	279.1	289.1	298.2	304.3	15.2
34	262.4	268.6	277.9	288.1	298.3	307.6	313.8	15.5
35	270.8	277.1	286.6	297.0	307.3	316.8	323.1	15.7
36	279.1	285.5	295.1	305.7	316.3	325.9	332.3	16.0
37	287.3	293.8	303.5	314.3	325.0	334.8	341.3	16.3
38	295.3	301.9	311.8	322.8	333.7	343.6	350.2	16.5
39	303.2	309.9	320.0	331.1	342.2	352.3	359.0	16.8
40	311.0	317.8	328.1	339.3	350.6	360.8	367.6	17.0
41	318.7	325.6	336.0	347.4	358.8	369.2	376.1	17.3

SD = standard deviation.

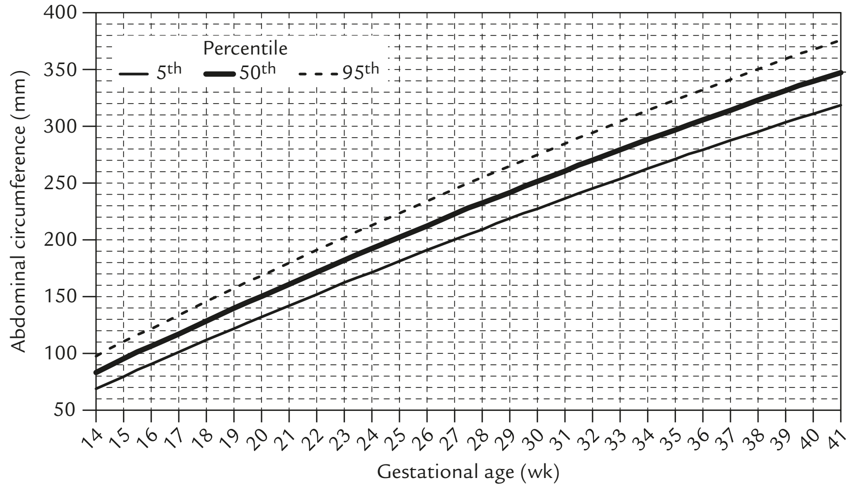

Figure 2. The gestational age-specific nomogram of fetal abdominal circumference.

Table 3. The comparison of 50th percentile for gestational age (GA)-specific abdominal circumference

GA (wk)	50th percentile for GA-specific abdominal circumference						Predicted values of this report
	Tamura et al [1]	Snijders et al [5]	Chitty et al [4]	Kurmanavicius et al [6]	Smulian et al [7]	Salomon et al [9]	
14		90.0	78.9	79.8	79.0	93.8	83.4
15		99.0	90.3	91.3	94.0	102.5	94.9
16		108.0	101.6	102.7	107.0	111.7	106.2
17		118.0	112.9	114.0	116.0	121.2	117.5
18	131.0	128.0	124.1	125.3	128.0	131.1	128.5
19	144.0	139.0	135.2	136.4	139.0	141.2	139.5
20	154.0	149.0	146.2	147.5	150.0	151.6	150.3
21	170.0	161.0	157.1	158.5	159.0	162.2	161.0
22	180.0	172.0	168.0	169.3	172.0	172.9	171.6
23	193.0	183.0	178.7	180.0	182.0	183.6	182.0
24	205.0	195.0	189.3	190.6	193.0	194.5	192.3
25	213.0	207.0	199.8	201.1	204.0	205.3	202.5
26	221.0	219.0	210.2	211.5	215.0	216.0	212.5
27	237.0	231.0	220.4	221.7	226.0	226.7	222.4
28	253.0	243.0	230.6	231.8	236.0	237.2	232.2
29	269.0	254.0	240.5	241.7	246.0	247.4	241.8
30	274.0	266.0	250.4	251.5	258.0	257.5	251.3
31	280.0	277.0	260.1	261.1	268.0	267.2	260.7
32	287.0	287.0	269.7	270.6	278.0	276.6	270.0
33	290.0	297.0	279.1	279.9	289.0	285.6	279.1
34	301.0	307.0	288.4	289.0	299.0	294.2	288.1
35	322.0	316.0	297.5	298.0	309.0	302.3	297.0
36	333.0	324.0	306.4	306.8	317.0	309.8	305.7
37	344.0	332.0	315.1	315.4	329.0	316.8	314.3
38	357.0	339.0	323.7	323.8	340.0	323.1	322.8
39	359.0	345.0	332.1	332.0	352.0	328.7	331.1
40	361.0		340.4	340.0	359.0	333.7	339.3
41	371.0		348.4	347.8	366.0	337.8	347.4

as early as 30 weeks (Table 5 and Figure 5). Given the above comparison, there seems to be a trend that our fetuses had smaller AC in the third trimester, especially for the upper limits at the 95th centile. Although there were some differences in AC centiles among these references, there is, in fact, no appropriate statistical method to examine whether there is a significant difference between our report and other reports. Future

Table 4. The comparison of 5th percentile for gestational age (GA)-specific abdominal circumference

GA (wk)	5th percentile for GA-specific abdominal circumference						Predicted values of this report (50,131 cases)
	Tamura et al [1] (197 cases)	Snijders et al [5] (1,040 cases)	Chitty et al [4] (425 cases)	Kurmanavicius et al [6] (5,807 cases)	Smulian et al [7] (10,070 cases)	Salomon et al [9] (19,647 cases)	
14		78.0	70.1	66.8	62.4	82.7	69.0
15		86.0	80.5	77.5	75.7	90.4	79.8
16		94.0	90.8	88.1	88.7	98.5	90.5
17		103.0	100.9	98.6	99.4	106.9	101.1
18	103.0	112.0	111.2	109.1	111.4	115.7	111.5
19	116.0	122.0	121.3	119.5	122.4	124.8	121.9
20	126.0	130.0	131.3	129.8	131.7	134.1	132.1
21	142.0	141.0	141.2	140.0	140.7	143.6	142.2
22	152.0	151.0	151.1	150.0	153.7	153.2	152.2
23	165.0	160.0	160.8	159.9	162.1	162.9	162.0
24	177.0	171.0	170.4	169.7	174.7	172.6	171.8
25	185.0	181.0	179.9	179.4	185.7	182.4	181.4
26	193.0	192.0	189.3	189.0	193.4	192.1	190.9
27	209.0	203.0	198.5	198.4	204.4	201.6	200.2
28	225.0	214.0	207.7	207.7	214.4	211.1	209.5
29	241.0	223.0	216.6	216.9	224.4	220.3	218.6
30	246.0	234.0	225.5	225.9	236.4	229.2	227.6
31	252.0	244.0	234.2	234.7	244.8	237.9	236.5
32	259.0	252.0	242.8	243.4	256.4	246.2	245.3
33	262.0	260.0	251.2	251.9	264.1	254.2	253.9
34	273.0	269.0	259.5	260.2	274.1	261.7	262.4
35	294.0	277.0	267.6	268.4	282.4	268.7	270.8
36	305.0	284.0	275.5	276.4	288.8	275.1	279.1
37	316.0	292.0	283.2	284.2	300.8	281.0	287.3
38	329.0	298.0	290.8	291.9	310.1	286.3	295.3
39	331.0	303.0	298.2	299.3	318.8	290.9	303.2
40	333.0		305.5	306.5	330.8	294.7	311.0
41	343.0		312.5	313.5	339.4	297.8	318.7

Table 5. The comparison of 95th percentile for gestational age (GA)-specific abdominal circumference

GA (wk)	95th percentile for GA-specific abdominal circumference						Predicted values of this report
	Tamura et al [1]	Snijders et al [5]	Chitty et al [4]	Kurmanavicius et al [6]	Smulian et al [7]	Salomon et al [9]	
14		102.0	87.7	92.8	95.6	104.9	97.9
15		112.0	100.1	105.1	112.3	114.7	110.0
16		122.0	112.4	117.3	125.3	124.9	122.0
17		133.0	124.9	129.4	132.6	135.5	133.8
18	159.0	144.0	137.0	141.5	144.6	146.5	145.5
19	172.0	156.0	149.1	153.3	155.6	157.7	157.1
20	182.0	168.0	161.1	165.2	168.3	169.1	168.5
21	198.0	181.0	173.0	177.0	177.3	180.8	179.8
22	208.0	193.0	184.9	188.6	190.3	192.5	190.9
23	221.0	206.0	196.6	200.1	201.9	204.4	201.9
24	233.0	219.0	208.2	211.5	211.3	216.3	212.8
25	241.0	233.0	219.7	222.8	222.3	228.1	223.5
26	249.0	246.0	231.1	234.0	236.6	240.0	234.1
27	265.0	259.0	242.3	245.0	247.6	251.7	244.6
28	281.0	272.0	253.5	255.9	257.6	263.2	254.9
29	297.0	285.0	264.4	266.5	267.6	274.6	265.0
30	302.0	298.0	275.3	277.1	279.6	285.7	275.1
31	308.0	310.0	286.0	287.5	291.2	296.5	284.9
32	315.0	322.0	296.6	297.8	299.6	307.0	294.7
33	318.0	334.0	307.0	307.9	313.9	317.1	304.3
34	329.0	345.0	317.3	317.8	323.9	326.7	313.8
35	350.0	355.0	327.4	327.6	335.6	335.9	323.1
36	361.0	364.0	337.3	337.2	345.2	344.5	332.3
37	372.0	372.0	347.0	346.6	357.2	352.5	341.3
38	385.0	380.0	356.6	355.7	369.9	359.9	350.2
39	387.0	387.0	366.0	364.7	385.2	366.6	359.0
40	389.0		375.3	373.5	387.2	372.6	367.6
41	399.0		384.3	382.1	392.6	377.8	376.1

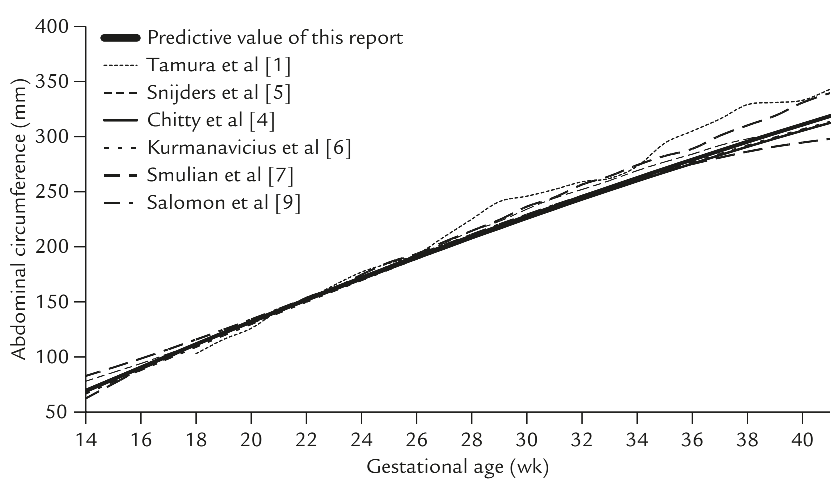

Figure 3. The comparison of 5th percentile for gestational age-specific abdominal circumference.

international collaborative studies are warranted to confirm whether there is a significant difference in AC between our population and those of other reports.

To the best of our knowledge, the data presented in our AC nomogram is based on the largest sample size reported in the medical literature. There is a trend that recent reports have larger and larger sample sizes than previous reports (Table 4). The larger and larger sample sizes indicate the attempt of investigators to avoid type II error in statistics, i.e. insufficient sample size. However,

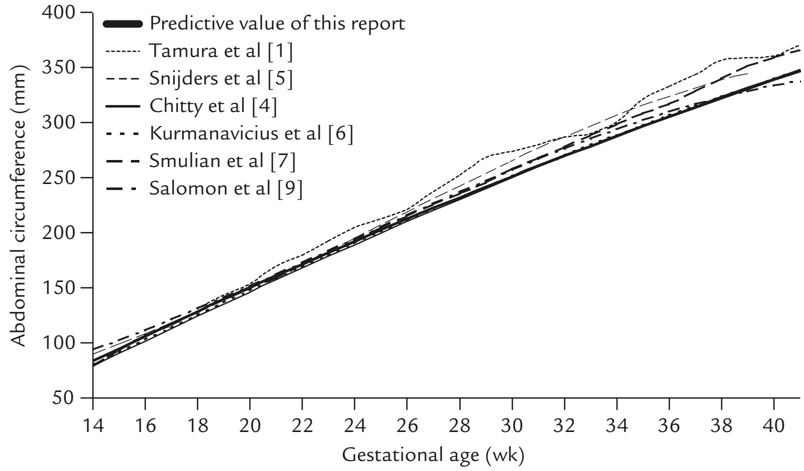

Figure 4. The comparison of 50^{th} percentile for gestational age-specific abdominal circumference.

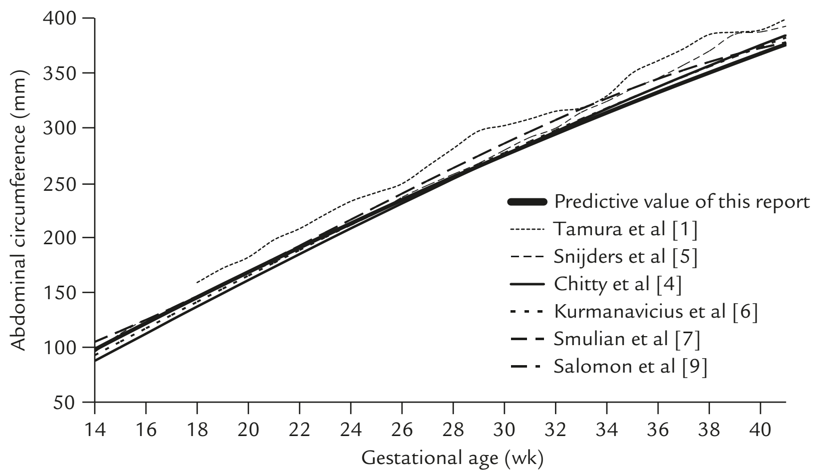

Figure 5. The comparison of 95^{th} percentile for gestational age-specific abdominal circumference.

it is not an easy task to undertake a clinical study with a sample size of more than 50,000 records. In this series, we endeavored to establish our computer database of fetal AC records between 1991 and 2006, i.e. a study period of 16 years. With standardized operation procedure and computerized digital data management, we have taken great effort during the 16 years to collect the data. Eventually, 50,131 records of AC which fit the criteria were included for final analysis. With our sample size which is believed to be the largest in the medical literature, our AC data should be a good representation of fetal AC in Taiwanese.

In conclusion, our study provides new reference equations, tables and figures of fetal AC in an Asian population in South Taiwan. These novel reference equations, tables and figures of fetal AC should be very useful in the screening, diagnosis and management of fetal abnormal growth, such as fetal growth restriction, large-for-gestational-age, macrosomia, in prenatal care. We are now undergoing a clinical study to test the efficacy of fetal AC in screening fetal abnormal growth using the fetal AC references from this report. We will report our results in the near future.

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