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ORIGINAL STUDY

Anterior-Posterior Thigh Diameter Measured by Two-Dimensional Sonography

Indicator of Fetal Age at 18 to 28 Weeks Gestation ?

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قياس قطر الفخذ الامامي الخلفي بواسطة جهاز التخطيط التصواتي

مؤشر عمر الجنين بين عمر 28-18 اسبوعا من الحمل ؟

الملخص: الهدف: تقييم مدى الاستفادة من قياس قطر فخذ الجنين الامامي – الخلفي . والعلاقة المباشرة بين ذلك وعمر الجنين أثناء الحمل الطبيعي بين الاسبوع 18 – 28. بواسطة استعمال جهاز التَخْطيطٌ التَصْوَاتِيّ (تَخْطيطٌ بالأَمْوَاجِ فَوقَ الصَّوتية) ثنائي البعد. **ألطريقة:** هذه دراسة استباقية شملت 55 مريضة في مستشفى عام متطور في البيرتا (كندا) . تم قياس القطر الامامي الخلفي للفخذ بواسطة حهاز التَخْطيطٌ التَصْوَاتِيّ . والمدى الطبيعي لكل اسبوع من الحمل تم حسابه خمس مرات للتأكد من المُعَوَّلِيَّة (الاعتمادية) . **النتائج:** لوحظ أن هناك ترابط كبير بين قطر الفخذ الامامي – الخلفي وعمر الجنين (بين عمر 18 – 28 اسبوعا) حسب التحليل الاحصائي (مُعامِلُ التّحَوُّف) مع حَدُّ الثِّقَةِ بنسبة 99% . هناك ترابط بين 1 ملم من القطر الامامي – الخلفي للفخذ لكل اسبوع من الحمل . الخطأ المعياري للحساب كان متدنيا جدا من الناحية الاحصائية (الاحتمالية أقل من 0.0001). وأكدت المَصْدوقِيَّة ايضا احصائيا برسم الانتشار المتبقي . **الخلاصة:** أثبت هذا البحث أن قياس القطر الامامي – الخلفي للفخذ مُعَوَّل عليه ومَصْدُوْق في قياس عمر الجنين أثناء الحمل الطبيعي . وبصورة خاصة حين يتعذر الحصول على القياسات الاخرى . كما يمكن جمع مختلف القياسات الخاصة بالجنين لمعرفة نموه ولتحديد أدق لموعد الولادة . وبقياس الفخذ المذكور كذلك يمكن معرفة مشاكل النمو عند الجنين .تعتبر هذه الطريقة فعالة جدا وذلك لقوة الدلالة الاحصائية لها .

المفردات المفتاحية : عمر الجنين، قطر الفخذ الامامي – الخلفي، قياسات

ABSTRACT ***Objective:*** Little published research exists in the area of fetal thigh biometry, specifically in the use of the anterior-posterior fetal thigh diameter (APTD). A continuing review of existing practices needs to be coupled with evaluation of alternate or additional methodology. This study evaluated the usefulness and direct correlation of a simple, new method of predicting fetal age by measurement of the anterior-posterior thigh diameter (APTD) in a normal 18-to 28 week pregnancies using two-dimensional sonography. ***Methods:*** This was a quantitative prospective study of 55 patients in the High Level General Hospital, Alberta, Canada. Anterior-posterior thigh diameters (APTD) were sonographically measured and the normal range for each week of pregnancy was determined five times for reliability. ***Results:*** Significant correlation was found between (APTD) and fetal age from simple line regression analysis, with >99.9% confidence intervals at each week from 18 to 28 weeks gestation. There was a correlation of 1 mm APTD per 1 week of fetal age. The standard error of estimation was very low at (0.08664) in edition (r>0.9993) and (p < than 0.0001). The residual scatter plots confirmed the APTD validity. ***Conclusion:*** APTD is a reliable and valid method for assessing fetal age in a normal pregnancy and may be particularly useful when other parameters are unable accurately to predict fetal age. An accurate linear measurement of multiple fetal parameters allows a more complete profile of fetal growth and estimated date of delivery (EDD). APTD may also be useful in identifying fetal growth problems. All of the values of fetal age lie directly on the "best-fit" regression line. Since the coefficient of determination (Rsq) is very high, this model is very effective.

Keywords: Fetal age, APTD, anterior-posterior thigh diameter, parameters

There is no existing literature comparing fetal thigh diameter with fetal age and estimated dates of delivery (EDD). However, femur length in the 18 to 38 weeks fetus has been shown to have a relationship to subsequent blood pressure in childhood.[1] There are many parameters

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that can be tested by sonography, including biparietal diameter (BPD), abdominal circumference (AC), head circumference (HC) and femur length (FL). It is important to find a new parameter for measuring fetal growth that correlates with fetal age so that fetuses that are not growing well can be identified and treated. The Taner et al.[2] study has shown that there is a relationship between femur length (FL) and fetal age, however the measurement of femur length has a potential technical error factor involving the non-visible epiphyses, which is often not considered.[2] Multiple factors may influence the fetal biometry including, for example, pathological factors that affect the fetal head meauserments.[3] Fetal organ sizes remains small during early pregnancy, followed by a period of rapid growth with rate and time vary for individual organs.[4] Barker's[5,6] studies have shown that this critical period of growth can be affected by external and internal factors.

Fetal malnutrition

There is evidence that poor nutrition can reduce the number of beta cells in the pancreas causing glucose intolerance.[7] Kurmanvicius'[8] studies have shown fetal biometric accuracy in predicting suspected fetal malnutrition to be overestimated. Many factors contribute to fetal weight differences: maternal factors (race, stature), environmental factors (altitude, nutrition, and smoking), physiological factors (glucose metabolism), pathological factors (hypertension, uterine pathology), and complications of pregnancy (diabetes mellitus, pre-eclampsia).[9-16] Most published methods for fetal weight assessment are significantly subject to predictive errors.[17, 18]

Intrauterine growth restriction (IUGR

At a simplistic level, intrauterine growth restriction is a problem caused by restricted oxygen and nutrient delivery to the fetus, leading to a failure of normal intrauterine growth.[19, 20] Among the many factors that can influence IUGR are maternal disease (eg, hypertension), poor maternal nutrition (eg, smoking, substance abuse), anatomical factors (eg, placental site and function) and fetal disorders (eg, genetic disorders).[19, 21, & 22]

The reliability of multiple parameters

Yoshida et al.[23] studies have supported the use of multiple parameters to improve the accuracy of fetal age and weight estimation. A birth weight of less than

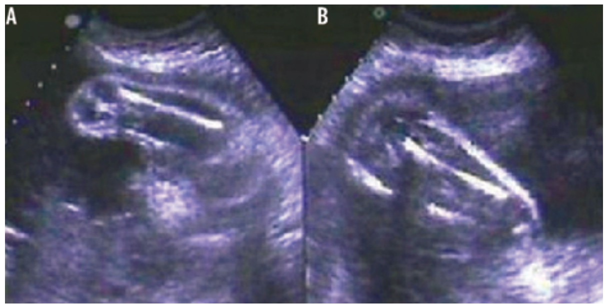


Figure 1: ***Label A is showing the wrong way to measure fetal thigh (coronal) and Label B is showing the correct way to measure the anterior-posterior thigh diameter (APTD) in the sagittal plane (profile).***

2500g, or greater than 4,700g, are risk factors for fetal and delivery complications.[24] Taylor et al.[25] studies have provided a logical explanation of why it is necessary to measure the fetal leg. It suggested that some times measuring the fetal head is impossible, for example when it is too low in the pelvic cavity, and therefore alternate methods must be used. Taylor et al.'s [25] formula of femur length, multiplied by the square root of the cross sectional area of thigh, has shown a significant correlation with fetal weight. The validity of estimated fetal weight is reported to be either below or above the normal limits by using fetal biometry formulas as described in Cheng et al.'s method.[26] Ratanasiri et al.'s[27] formulas of fetal weight showed more accuracy than other fetal weight formulas. The Nahum et al.[28] study has indicated that there is no substantial correlation between maternal obesity and fetal weight gain at term pregnancy and it is reported clinically insignificant. Fetal thigh calf circumference ratios showed excellent results in evaluating fetal growth in high-risk patients in late pregnancy, with unknown due dates.[29] Zelop et al.'s [30] studies have shown that race and ethnicity do not affect the regression line of long bones and fetal head biometries. Jeanty et al.'s [31] studies have indicated that using more than one fetal biometry parameter can increase the reliability and accuracy in determining fetal age and the estimated date of delivery, especially when using long bone biometry from 12 to 40 weeks gestation. Jeanty et al.'s[32] study has found limb volume to be a reliable predictor of intrauterine growth restriction and correlates strongly with fetal age. Flanagan et al.'s [39] study has indicated that there is no relationship between birth size and insulin sensitivity or insulin secretion in women. Chitkara et al.'s [33] studies have shown that a short fetal ear length is indicative of high-risk chromosomal abnormality. Fetal alcohol syndrome is a threat to the fetus, caused by the mother drinking alcohol during pregnancy, and may cause the fetus to have a lower body weight and smaller body size.[34]

Fetal pathology and biometry

With the use of fetal measurements, wide ranges of pathological conditions can be discovered.[35] Among these are chromosomal abnormalities (trisomy 21, fetal nasal pathology).[35] The ratio of femur to foot length has proven a useful parameter in assessing dysplastic limb reduction and fetal growth.[36, 37, 38] Goldstein, et al.'s [39] studies have shown that there is significant correlation between femur length (FL) and orbital diameter (OD) and this may aid in future research regarding fetal orbital abnormalities. Konje et al.'s[40] studies have shown that the fetal kidney length, in the 24 to 38 weeks gestational period, is a more accurate fetal biometry than biparietal diameter (BPD) and head circumference (HC). Mercer et al.'s[41] studies have shown that fetal hand and foot lengths as predictors of fetal age are reliable parameters to use. Chen et al.'s[26] studies have shown that biparietal diameter (BPD), head circumference (HC) and femur length (FL), if used as a single parameter, are not as specific when compared to abdominal circumference (AC), which has been shown to be the best single parameter in predicting macrosomia. Chen et al.'s [26] studies have indicated that a combination of more than one parameter should be used to increase the reliability, sensitivity, and accuracy of fetal biometry. Fetal growth accuracy is extremely important, especially when using fetal long bone biometry to predict the risk for trisomy 21 in the second trimester and to determine the need for genetic amniocentesis.[42] Congenital and hereditary bone disorders can affect the bone length and in turn will affect fetal biometry.[43]

Maternal age, genetic disorders, and other factors

Difficulty in conception increases after age 35 years but can be treated successfully.[44] Women over the age of 35 years were excluded from the study of normal fetal biometry because Salihu et al.'s[45] studies have shown that maternal age may increase the risk of genetic disorders. Pregnant teenagers are at greater risk for fetal death, anaemia, premature labour, still birth, and high blood pressure, especially in those who neglect prenatal medical care.[46] Overgrowth in the fetus (large for dates, macrosomia) can be caused by diabetes mellitus.[47] Poor fetal weight increase may program the fetus and cause chronic disease later in life by lessening the lean body mass and increasing the risk of obesity.[49, 50] Since 1950, maternal smoking has been recognized as a risk factor for fetal growth restriction and reduced birth weight.[51, 52] Murphy et al.'s[53] studies have found that maternal smoking affects the fetal biparietal diameter (BPD) and can cause a reduction in birth weight. Studies on twin pregnancies have shown lower infant birth weights in maternal smokers than in single pregnancies.[54] Accurate measurement of fetal age is the most useful contribution ultrasound has made to obstetric practice.[2] So far crown rump length (CRL), biparietal diameter (BPD) and femur length (FL) are considered the measurements of choice.[55] All these measurements were acquired before 1985 and in some cases before electronic calipers were available, resulting in a need to update these procedures by using new sonographic equipment.

Figure 2: ***The white arrow is showing the double line of the fetal thigh. The correct measurement of the anterior-posterior thigh diameter would be the second line marked by the number (1) arrow in the real anterior wall of the fetal thigh, as this is the true skin line. The second line marked by number (2) arrow is part of the thigh tissue as the sound waves travels through the convex area, and can be corrected by scanning in a good sagittal plane.***

Limitations

Before a new parameter can be used, it must be shown to correlate with fetal age in normal pregnancies. Robinson et al.'s [55] study has indicated that the major limitation on crown rump length (CRL) is that it can only be used effectively in the first trimester. Many pregnancies are not referred for ultrasound assessment until the second trimester, and so any new measurements will be a welcome addition to the biparietal diameter (BPD) and femur length (FL).[56] Neilson et al.'s[56] studies have indicated that the limitations of BPD were found in the measurement of macrencephalic heads. Confusion may also exist in expressing gestational age.

Figure 3: ***The sagittal section of the fetal thigh is showing the measurement of the femur length. The arrow is showing the fetal knee. Magnification can be a helpful tool***

Yagel et al.'s [57] studies have shown that radiologists and physicians round the measurements up or down to the nearest week; for example, a fetal age of 18 weeks and 5 days is reported as 19 weeks and this can lead to a systematic half-week difference between otherwise identical curves. Some fetal positions can reduce the ability to measure specific areas of the fetal body; for example in the occipital anterior or occipital posterior position, it will not be possible to obtain a biparietal diameter (BPD). Serial measurements of biparietal diameter and or head circumference alone are of no value because of the "brain sparing" effect.[58, 59] Benson et al.'s [60] study has indicated that the reliability of the ratio of head circumference to abdominal circumference to predict intrauterine growth restriction is limited.[60] There are situations, for example pre-term labour, diabetes, breech presentation or previous caesarean section, when it is important for the attending physician to have a single estimate of the fetal size or weight at one point in time. All formulas of fetal biometry tend to overestimate the weight of the small fetus and underestimate the weight of the large fetus; this is clearly undesirable.[61, 62] Gestational diabetes mellitus (GDM) can be associated with high birth weight and therefore

Figure 4: ***Sagittal plane of the fetal thigh show the femur length with one of the calipers in the mid point of the femur length***

can effect overall fetal measurements.[63] Femur length (FL) is a reliable measurement, but it can be affected by skeletal dysplasias and it is best measured after 14 weeks.[64] Studies have indicated that the use of multiple predictors of fetal biometry improve the accuracy of fetal age estimation, and reduces the potential for error if only a single fetal biometry had been used.[65, 66]

METHODS

Fifty-five uncomplicated pregnancies were studied prospectively and quantitatively in the High Level General Hospital (North-Western Health Centre), Alberta, between March 21 2005 and May 10, 2005. The author's data and tables agreed favourably with the Dr. Hadlock's tables for femur length.[67, 68] The growth of the fetal anterior-posterior thigh diameter (APTD), outer to outer skin surface was sonographically measured at the middle point of the fetal femur in sagittal section and compared with the fetal age from 18 to 28 weeks gestation. The selection of the second trimester period was chosen because soft tissue accretion of the fetal thigh begins to accelerate towards the end of this period. The inclusion criteria for this study were: singleton uncomplicated pregnancies with a normal fetus and an informed consent form, read and signed by the patients and approved by the hospital and the Charles Sturt University ethical committee. The patients' ages ranged between 18 and 35 years, with a mean age of 26.5. The study population was a mix of different ethnic groups (eg, Caucasians, Germans, native Indians, Mennonites, Irish, Hispanics, Ukrainians and East Indians). The radiologists reported major congenital malformations, chromosomal abnormalities and maternal complications, such as gestational diabetes, drug, and tobacco user. The author did not release any pathological information to the patients and patients were asked to obtain their reports from their physicians. Routine transabdominal sonography was done, including femur length (FL), biparietal diameter (BPD), abdominal circumference (AC), and head circumference (HC). In addition, the author measured the fetal anterior-posterior thigh diameter (APTD), from the middle point of the fetal femur in sagittal section of the fetal thigh using the femur length as a landmark. The anterior-posterior thigh diameter (APTD) measurements were analyzed and compared with fetal age using the Hadlock's tables for femur length.[67, 68] The equipment use in this study was ATL and Philips. The fetal age of each patient was determined by using

Figure 5: ***The first caliper is moved to the real outer skin of the anterior wall of the fetal thigh***

Dr. Hadlock's measurements of the femur length (FL). [67, 68] The comparison was made between the anterior posterior thigh diameter and the fetal age. The correct diameter of the fetal thigh was measured in the same portion of fetal thigh every time by measuring the mid point of the femur. Eleven groups were studied, each group having 5 patients with all 5 patients in the same gestational period, from 18 to 28 weeks.

TECHNIQUE

Starting with the transducer at the fetal abdominal circumference

1. Move transducer inferiorly to transect the fetal bladder.
2. Rotate transducer 30 degrees to view the fetal femur.
3. Rotate transducer until a sagittal view of the fetal thigh be obtained [Figure 1].
4. Exclude the distal femoral epiphyses (usually present after 32 weeks gestation).
5. The tibia is at times mistaken for the femur (make sure to identify the fetal knee).
6. If a double line is seen in the fetal thigh, measure the inner line or repeat the scan until a smooth (sagittal) line of the fetal thigh is obtained [Figure 2]. This double line can be corrected by obtaining a perfect sagittal view of the fetal thigh. Otherwise the curve of the thigh adds an extra false line to the real outer skin surface of the fetal thigh in the lateral or medial section. The thigh is convex in the anterior part and concave in the posterior part, so geometrically we are dealing with a cylinder and not a flat surface.
7. Use real-time sonographic equipment with 3.0, 3.5, and 5.0 MHz transducers frequencies to obtain the images.
8. Freeze-frame and electronic calipers are more sensitive tools to provide accurate measurements of the fetal thigh.
9. Using the zoom capability to outline the fetal thigh (outer skin surface) will increase sensitivity of this measurement
10. Using Dr. Hadlock's tables for femur length,[67, 68] to compare with anterior-posterior thigh diameter (APTD) or posterior-anterior thigh diameter (PATD).

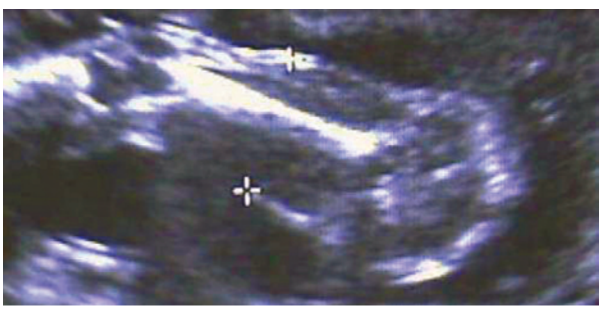


Figure 6: ***The second caliper is moved to the posterior wall of the fetal thigh. Enter and log the measurement of the anterior posterior thigh diameter (APTD)***

MEASUREMENTS

1. Scan the femur length (FL) at the sagittal view [Figure 1& 2].
2. Measure the femur length, then bring the first caliper to the exact middle point of the fetal femur; for example, if the femur length was 2.4 cm (24mm), then bring the first caliper until the measurement reads 1.2 cm (12 mm), [Figure 3] and [Figure 4].
3. Carefully move the first caliper to the outer surface of the fetal anterior thigh [Figure 5]. Measure the real skin surface and not the extra double line created by the sound waves travelling through the convex part of the thigh in parasagittal planes. Scanning the fetal thigh in the sagittal plane can make a correction and smooth the skin surface of the fetal thigh.
4. Move the second caliper to the outer posterior surface of the fetal thigh, then enter and log the measurement.

CALCULATIONS

Each one millimetre (1mm) of the anterior-posterior thigh diameter (APTD), or the posterior-anterior thigh diameter (PATD) measurements, will be equal to one-week (1 w); For example, 1.90 cm (19 mm) will be equal to 19 weeks gestation, and 2.80 cm (28 mm) will be equal to 28 weeks gestation. 1.428 will multiply any fraction of a millimetre, 1.428 obtained from (10 mm divided by 7 days), for example, APTD of 2.68 cm equal to (26.8 mm) calculates to 26 weeks plus (0.8 x

Table 1: ***The Correlation between anterior-posterior thigh diameter (APTD-CM) and fetal age (GA-WK) 50th percentile values for fetal femur length are shown below, (n=55).***

Femur Length (cm) From Hadlock Table[67, 68]	Fetal age (wk) using Hadlock Table	APTD (Cm)	APTD (wk/days)	Femur Length (cm) From Hadlock Table [67,68]	Fetal age (wk) using Hadlock Table	APTD (Cm)	APTD (wk/days)
2.70	18.0	1.80	18.0	4.38	2.37	2.37	23.9
2.73	18.0	1.82	18.2	4.40	24.1	2.42	24.2
2.76	18.1	1.81	18.1	4.50	24.5	2.45	24.6
2.80	18.2	1.82	18.2	4.55	24.7	2.47	24.9
2.90	18.6	1.86	18.8	4.60	24.9	2.47	24.9
3.00	19.0	1.90	19.0	4.60	24.9	2.47	24.9
3.10	19.2	1.92	19.2	4.68	25.0	2.50	25.0
3.16	19.2	1.93	19.4	4.70	25.3	2.53	25.4
3.20	19.6	1.96	19.8	4.80	25.7	2.55	25.6
3.30	19.9	1.97	19.9	4.82	25.7	2.56	25.8
3.36	20.0	2.00	20.0	4.84	25.8	2.56	25.8
3.40	20.3	2.03	20.4	4.90	26.1	2.63	26.4
3.43	20.4	2.04	20.5	4.92	26.1	2.63	26.4
3.45	20.5	2.05	20.6	4.94	26.2	2.64	26.5
3.50	20.7	2.06	20.8	5.00	26.5	2.65	26.6
3.60	21.0	2.10	21.0	5.04	26.6	2.66	26.8
3.70	21.4	2.13	21.4	5.10	27.0	2.71	27.1
3.76	21.5	2.14	21.5	5.20	27.4	2.75	27.6
3.80	21.8	2.16	21.8	5.26	27.6	2.77	27.9
3.80	21.8	2.17	21.9	5.30	27.8	2.77	27.9
3.90	22.1	2.22	22.2	5.36	27.9	2.77	27.9
3.94	22.1	2.22	22.2	5.40	28.2	2.83	28.4
3.96	22.3	2.23	22.4	5.45	28.4	2.83	28.4
4.00	22.5	2.26	22.8	5.46	28.5	2.86	28.8
4.10	22.9	2.27	22.9	5.48	28.6	2.86	28.8
4.20	23.3	2.33	23.4	5.50	28.7	2.87	28.9
4.30	23.7	2.35	23.6				
4.31	23.7	2.36	23.8				
4.35	23.8	2.36	23.8				

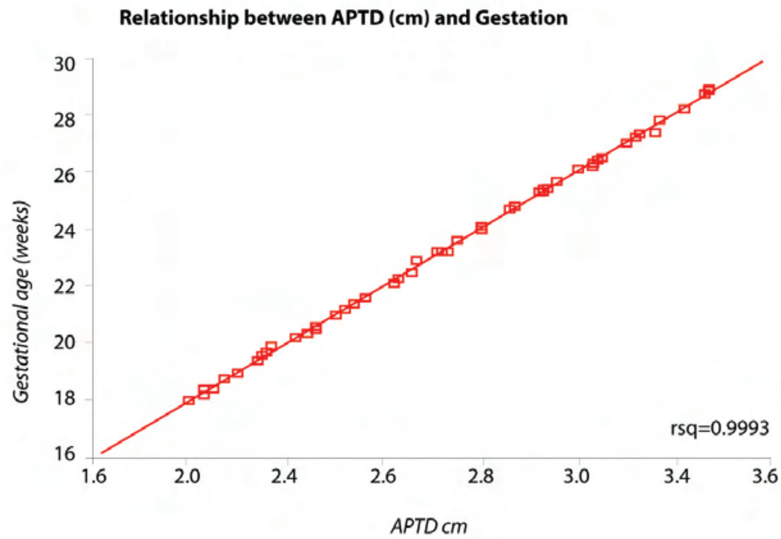
1.428) = 0.1424 day, this will be added to the 26 weeks equalling 27.0 weeks and 1.4 day. The anterior-posterior thigh measurement (APTD) was found to be relatively constant, one mm equal to one week. Serial measurements should be obtained. The measurements should be repeated with zooming capability and electronic calipers; the serial measurements range should be less than 1 mm. If these measurements don't match the fetal age obtained by using the Hadlcok's tables for femur length[67, 68] a follow-up scan is recommended.

STATISTICAL ANALYSIS

Regression – APTD (cm) and fetal age (weeks)

The standard error of estimation (SEE) is very low at (0.08664.) This indicates the good 'fit' of this model. The 'spread' of values for the dependent variable (fetal age) around the mean value of the independent variable is very narrow. About 70% of the values of fetal age will lie+/- 0.08664 from the mean of APTD.

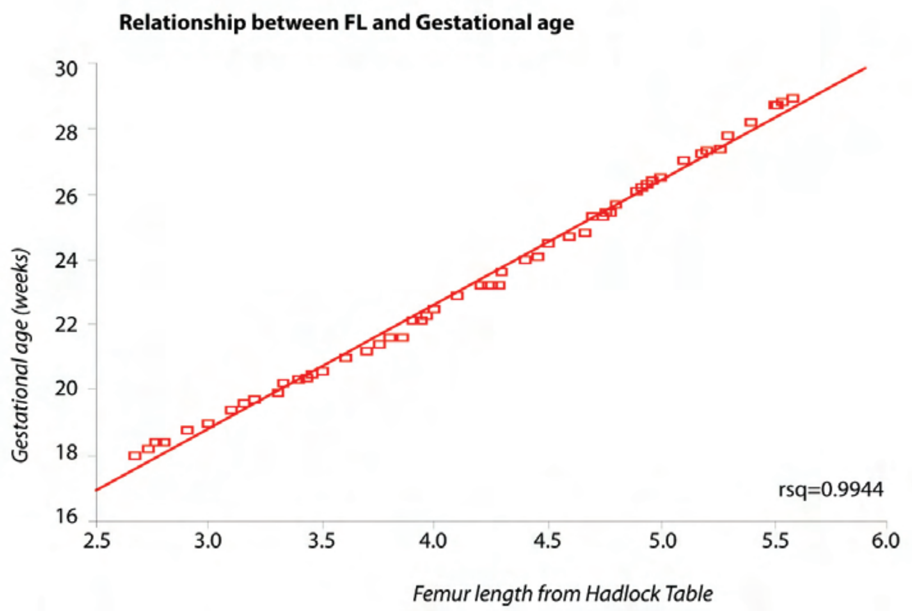
Graph 1: *The Regression Line for APTD*



ANOVA[b]

	Model	Sum of Squares	df	Mean Square	F	*p* Value
1	Regressions	559.954	1	556.954	9383.824	0.000[a]
	Residual	3.146	53	0.059		
	Total	560.099	54			

a. Predictors: (Constant). APTDcm
b. Dependent Variable: Gestational age (weeks)

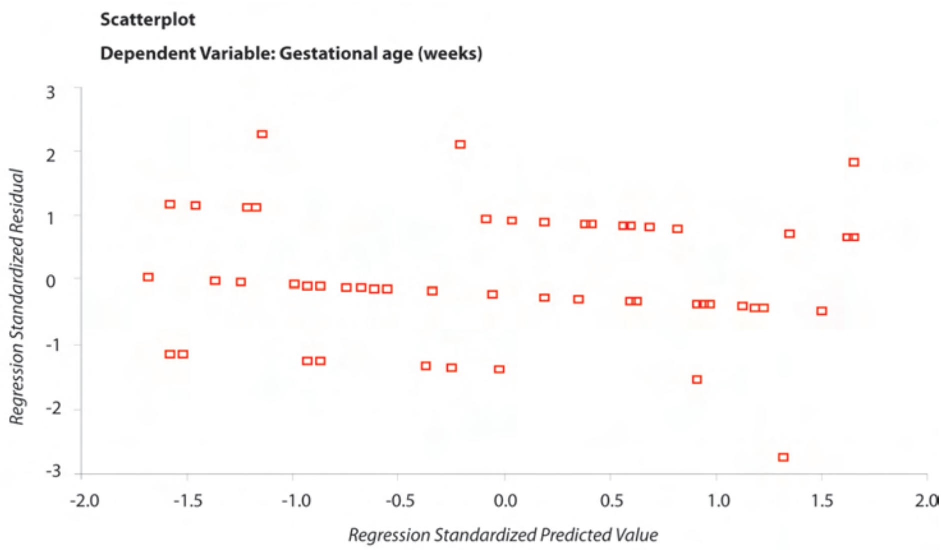


Coefficients[a]

	Model	Sum of Squares	df	Mean Square	F	*p* Value
1	Regressions	559.954	1	556.954	9383.824	0.000[a]
	Residual	3.146	53	0.059		
	Total	560.099	54			

a. Dependent Variable: Gestational age (weeks)

Graph 3: *The residual (Error), Scatter plot and Validity of the (APTD)*

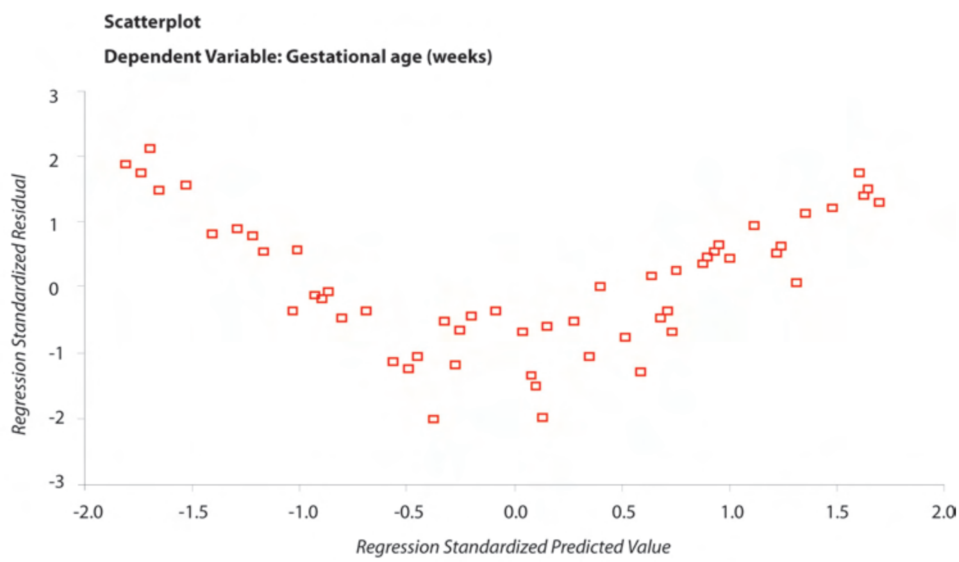


ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	*p* Value
1	Regressions	559.954	1	556.954	9383.824	0.000[a]
	Residual	3.146	53	0.059		
	Total	560.099	54			

a. Predictors: femur from Hadlock table
b. Dependent Variable: Gestational age (weeks)

Graph 4:*The Residual (Error) Scatter plot – Femur Length from Dr. Hadlock table* [67]



Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	*p* Value
		B	Standard Errors	Beta		
1	Regressions	559.701	0.168	0.997	44.387	0.000
	Residual	0.398	0.039		96.870	0.000
	Total	560.099				

a. Dependent Variable: Gestational age (weeks)

RESULTS

Measurements of femur lengths from the 55 patients who met the criteria were correlated with the anterior-posterior thigh diameter (APTD) and used to construct tables and graphs. There was significant correlation between the anterior-posterior thigh diameter (APTD) and fetal age. Using a simple linear regression for this study, more than 99.993 % confidence intervals were found at each week of the eleven groups from 18 to 28 weeks gestation (Rsq > 0.9993), and (p less than 0.0001). The anterior-posterior thigh diameter was positively correlated with fetal age [Table 1] and [Graphs 1, 2, 3 & 4]. Eleven gestational periods from 18 to 28 weeks were analyzed, each period including 5 different measurements of the femur lengths compared to the fetal age and to the anterior-posterior thigh diameter with mean +/-2SD. Femur length measured from 2.70 centimetre (cm) to 5.50 cm over all gestational periods, the mean being 4.31-4.35. Fetal weight ranged between 310 grams and 1400 grams, the mean being 629 grams. The anterior-posterior thigh diameter (APTD) ranged between 1.80 to 2.87 cm, with the mean at 2.36 cm. Linear growth was obtained in each gestational period from 18 to 28 weeks, and compared favourably with the Dr. Hadlock's tables.[67, 68] In addition, linear growth of fetal weight was observed. The anterior-posterior thigh diameter, converted to millimetres and compared with the fetal age, was found to be a consistent and valid measurement by using the scatter plots [Graph 2 & 3]. The standard errors of estimates using anterior-posterior thigh diameter (APTD) were significantly lower (at 0.08664) than that using femur length at 0.2436. The variability estimates from Dr. Hadlock et al.'s [67] table for femur length versus fetal age from 18 to 30 weeks have indicated ± 1.8 weeks to 2.4 weeks. The APTD table in this study shows ± 3 days variability. The adjusted R square (variance) was >.99 for both models.

DISCUSSION

The simplicity of the application found by this study is really its greatest advantage. Accuracy of fetal age, weight and estimated delivery date (EDD) will be improved if multiple predictors are used,[27, 31, 57] especially when it is difficult to obtain fetal head biometry (for example, when the head is too low in the pelvis or there is hydrocephalus, anencephaly, or fetal renal disease). Reliable methods for estimating fetal body weight and fetal age without head measurement are therefore required. Reliable new methods of fetal biometry can be very beneficial in reducing overall fetal biometry errors and increasing the reliability of the fetal biometry.[30, 37, 44] The results of this study show that anterior-posterior thigh diameter (APTD) predicts second trimester growth with high validity and reliability. The very simple correlation in this study of 1 mm APTD per week of fetal age is new and useful information. Taylor et al.'s [25] study has shown that measuring the thigh parameter can be a convenient method for determining fetal growth in the second trimester. The APTD may have a role in quality control of second trimester ultrasound examinations and may help in the diagnosis of fetal growth abnormalities. The accuracy of fetal biometry is extremely important, especially when using fetal long bone biometry.[56] Studies have shown that there are relationships between intrauterine growth restriction (IUGR), smaller fetal biometry, and smaller thigh circumference.[10, 11] The APTD may be used as an indicator of fetal biometric disturbance, thus enabling the physician to manage the pregnancy better. Diabetes mellitus is one cause of intrauterine growth restriction (IUGR) [51, 52] and may affect the femur length (FL). [51, 52] Diabetes mellitus may also affect the fetal body mass and consequently the abdominal circumference and fetal thigh [13-19, 21] Hence, the anterior-posterior thigh diameter may be used not only as indictor for fetal age but also to detect IUGR. Renal pathology, such as hydronephrosis or congenital renal malformation, can affect the fetal abdominal circumference, making this measurement unreliable as an indicator of fetal age. The use of combined parameters may be superior to the use of each measurement alone as a marker of trisomy 21.[42] In addition, it can be difficult in practice to obtain a good fetal thigh circumference, or fetal hands, feet and ears to obtain fetal biometry. This study shows that the fetal APTD provides an accurate linear measurement of the fetus, thus generating a more complete profile of the fetus. Significant correlations of APTD with fetal age indicate that this is a reliable method and is particularly useful when other fetal parameters may not accurately predict fetal age or if they are difficult to obtain. If the age predicted from the APTD does not match the age using the femur length, other factors such as intrauterine growth restriction or maternal and fetal nutrition deficits should be considered. The soft tissue accretion of the fetal thigh also depends on the generalized nutritional status of the infant, but such an increase in soft tissue is usually more marked after 30th weeks gestation. The APTD measurements that were obtained from the 11 groups correlated perfectly with the fetal age. They were repeated five times for each gestational group between 18 and 28 weeks. Racial differences in the population should not be neglected. The variability estimates from Dr. Hadlock et al.'s [67,68] tables for femur length versus gestational age from 18 to 30 weeks were ± 1.8 to ± 2.4 weeks, while the variability estimates in the APTD table was ± 3 days. Researchers should check this measurement with different racial groups, to produce a universally applicable measurement. Both models predict the fetal age very well, but compared to FL, using APTD produces a model with better 'fit' based on differences in the SEE between the two of them on the analysis of both models. The 'spread' of values for the dependent variable is narrower around the mean of the independent variable in the APTD model and wider in the FL model. The standard error of estimates (SEE) of 0.2436 obtained for FL versus gestational age is higher than that obtained in the analysis with APTD. This indicates a weaker 'fit' of this model. The 'spread' of values for the dependent variable around the mean value of the independent variable is wider. 68% of the values of fetal age will lie +/- 0.2436 from the mean of APTD. Model statistics (F, t, and standardized Beta) are significant for both models. Beta (APTD)=10.0 (SEE=0.037), Beta (FL)=3.79 (SE=0. 039). T=273.07 for GA x APTD Model=96.87 for GA x FL Model.

CONCLUSION

APTD was found to be a valid and reliable index for estimating fetal age. Further research to study the relationship between APTD versus fetal weight and IUGR is needed.

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