A comparative study between Johnson formula and Hadlock formula for estimating fetal weight in term gestation – At A Tertiary Care Institute

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ABSTRACT

Background: The perinatal and maternal outcome grossly depends upon the fetal weight at term gestation. In urban setup, ultrasound is easily available for birth weight estimation. In rural setup USG are not easily available and clinical methods are still used for birth weight estimation as it don't require any costly equipment and they are easy to use and give immediate estimation of expected birth weight.

Methods: It is a Hospital based observational study done between August 2019 to December 2021 conducted at the Department of Obstetrics and Gynaecology of Dr Vasantrao Pawar Medial College, hospital and research center, Nashik, Maharashtra. All subjects with singleton pregnancy with reliable gestation scan with no fetal anomalies were included. Estimated fetal weight (EFW) was calculated by Johnson's formula as clinical method and Hadlock formula using Ultrasound was used. EFW were compared with the actual birth weight.

Results: 198 patients were included during the study period. Mean age was 26.65 years; mean Gestational Age (B/D) was 38.63 weeks. Mean EFW by Johnsons formula was 3147.55 gms, mean EFW by Hadlocks formula was 3067.83gms and mean actual birth weight was 2952.07gms. Mean error was 183.4gms in Johnson's formula and mean error was 317.15gms in Hadlocks formula.

Conclusions: Clinical estimation method is as accurate as routine USG estimated in average birth weight. It can be of great value in developing countries like ours, where ultrasound is not available at many health care centers especially in a rural area.

Keywords: Johnson's formula, Fetal weight, Hadlock formula, Ultrasound.

INTRODUCTION:

The perinatal and maternal outcome grossly depends upon the fetal weight at term gestation. Fetal weight in conjunction with gestational age is an important indicator of pregnancy outcome. During the last decade, estimated fetal weight has been incorporated into standard routine antepartum evaluation of high-risk pregnancies and deliveries. Also, when dealing with anticipated preterm delivery, perinatal counselling on the likelihood of survival, the intervention to be undertaken to postpone preterm delivery, optimal route of delivery, or the level of hospital where delivery should occur may be based wholly or in part on the estimation of expected birth weight.[i,ii]

Categorization of fetal weight into either small or large for gestational age may lead to timed obstetric interventions that collectively represent a significant departure from routine antenatal care. It is very important for the prevention of prematurity, evaluation of pelvic disproportion before induction of labor and detection of labor and detection of intrauterine growth restriction.[iii]

Knowledge of the weight of the fetus in-utero is important for the obstetrician to decide whether to deliver or not to deliver the fetus and also to decide on the mode of delivery. Estimation of fetal weight is being done clinically, which has been criticized as less accurate because of observer variations. But Sherman (1998)[iv] et al, Baum (2002)[v] et al and Titapant (2001)[vi] et a have found clinical estimation quite reliable.

Ultrasonography involves measurement of multiple fetal biometric parameters, after which fetal weight is computed by the ultrasound scanner using a regression algorithm. But ultrasonography has proven itself to be simple, important and non-invasive diagnostic tool to measure fetal weight. The ultrasound method is, however believed to be more accurate than the clinical method, hence >20% of all pregnant women now undergo a third-trimester ultrasound examination specifically for the assessment of fetal growth and fetal weight estimation.[vii]

Estimated fetal weight is incorporated as standard routine ante-partum evaluation to rule out high risk pregnancy. Management of diabetic pregnancy, vaginal birth after previous caesarean section and breech presentation are guided by the estimated fetal weight. Precise fetal weight estimation helps to anticipate complications and leads to successful management of labor.[viii,ix]

In developing countries, ultrasonography may be unavailable or may not be affordable by patients. That is why measurement of fundal height using inexpensive and easily available nonelastic tapes has been recommended as a means of assessing birth weight in low-resource countries.

Various clinical formulas like Johnson's formula, Dawn's formula and Dare's formula are used for fetal weight estimation. The available techniques can be broadly classified as clinical methods where tactile assessment of fetal size, clinical risk factor estimation, maternal self-estimated fetal weight and prediction equations of birth weight are included into imaging methods that include sonography.[x]

In urban setup, ultrasound is easily available for birth weight estimation. In rural setup such imaging modality are not easily available and clinical methods are still used by health workers for birth weight estimation as clinical methods of birth weight estimation don't require any costly equipment and they are easy to use and give immediate estimation of expected birth weight.

Hence a study was planned to compare the accuracy of Johnson's formula and compare with ultrasound estimated fetal weight and actual birth weight.

METHODS:

It is Hospital based prospective observational study and was conducted in the Department of Obstetrics and Gynaecology at Dr Vasantrao Pawar Medical College, Hospital and Research center, Nashik from August 2019 to December 2021 with sample size of 198 patients.

ELIGIBILITY CRITERIA

INCLUSION CRITERIA:

- Patients with confirmed gestational age i.e. 37-42 weeks
- Willing to participate in the study
- Patient with reliable gestational scan
- Ability to give informed consent

EXCLUSION CRITERIA:

- Preterm
- Multiple gestations
- Congenital fetal anomaly
- Intrauterine fetal death
- Premature rupture of membrane
- Pregnancy with uterine fibroid or any abdominal mass

Methodology

Collection of data:

The relevant parameters were recorded in a pre-designed proforma, which included identification data, demographic characteristics, general physical examination and obstetrical examination.[xi]

Procedure:

For Hadlock Formula:

Apparatus used in the set-up for ultrasonography are:-

1. Siemen's Acuson x-500 sr.no- LAZ1181.

2. Siemen’s sonoline G-50 sr.no-GEE 0488.

3. Siemens Acuson x-300PE sr.no-347221.
4. Wipro GE LOGIQ F8 sr.no-612358 WXO.
5. Wipro GE BT 15 Voluson P8 sr.no-500216 sus.

Hadlock formula 4 was used :

Log10EFW=1.3596-0.00386(ACXFL)+0.0064(HC)
+0.00061(BPDXAC)+0.0424(AC)+0.174(FL)

Parameters that were used are BPD, AC, FL:-

1) Biparietal Diameter (BPD) was measured on the frozen image from the outer edge of the proximal skull to the inner edge of the distal skull table, with electronic calipers placed on a line perpendicular to mid line echo.[xii]

2) Abdominal circumference (AC) was measured from a transverse axial image of the fetal abdomen at the level of the liver. The major landmark in this section is the umbilical portion of the left portal vein deep in the liver, with the fetal stomach representing a secondary landmark. It was measured using ellipse method.[xiii]

3) Femur Length (FL) was measured from greater trochanter to external condyle, excluding femoral head.

The shaft of the femur was the easiest fetal long bone to visualise and measure.[xiv]

Then standard tables stored in the equipment was calculate the EDD, for cardiac activity, number of fetuses, congenital anomalies and placental localization and amniotic fluid index.

And for Johnson formula:

After emptying the bladder, patient was placed in the supine position. After correction of dextrorotation, measurement of height of the fundus from the upper edge of the symphysis-pubis following the curvature of the abdomen was taken with centimeter tape. The upper hand was placed firmly against the top of the fundus, with the measuring tape pressing between the index and middle finger.

Station of presenting part was assessed by abdominal examination and by vaginal examination when in labor.

The measurements obtained using parameters viz. BPD, HC, AC, FL & syphmphysiofundal height was entered in "Microsoft Excel" which contain Johnson formula and Hadlock formula and EFW. [Bajaj P et al]

Predicted estimated fetal weight by each method was Compared with respective neonatal actual birth weight using weighing scale. Statistical analysis of the difference between calculated EFW and actual birth weight was done in both methods.[xv]

Outcome that was measured were:

- Actual birth weight and ultrasound predicted birth weight at term.
- Actual birth weight and Johnson formula predicted birth weight.

- Which formula is near accurate in estimating the fetal birth weight?
- To find regional population specific mean birth weight.

RESULTS:

The data entered in the spreadsheet was extracted into the Statistical Package for Social Sciences 1 (SPSS) software version 16 .0 for further analysis. Accuracy of the Johnson's method or Hadlock's method for determination of fetal weight versus (Vs) the actual birth weight was measured using percentage error, absolute error and proportion of estimates within 10% of actual birth weight (birth weight ± 10%). Percentage error of the method was calculated using the formula – percentage error = x/ A X 100; where x = error in grams, A = actual birth weight. The errors in predicting fetal weight were expressed as a percentage of actual weight by means of the following method:

Error (%) = (estimated weight – actual weight) ÷ actual weight x 100

Table no 1: Descriptive Statistics of the study

	Minimum	Maximum	Mean	Std. Devi
Age	**19**	**39**	**26.65**	**4.405**
Gestational Age (B/D)	**37**	**41**	**38.63**	**1.100**
Gestational Age (B/S)	**37**	**41**	**38.88**	**1.025**
Symphysio-fundal height (cm)	**27**	**39**	**31.55**	**3.070**

Mean age was 26.65 years, mean Gestational Age (B/D) was 38.63 weeks, Gestational Age (B/S) was 38.88 weeks and Symphysiofundal height was 31.55 cm (Table no 1)

Table no 2:Age wise distribution of the study

	Frequency	Percent
20-25	**84**	**42.4**
25-30	**74**	**37.4**
30-35	**36**	**18.2**
>35	**4**	**2**
Total	**198**	**100**

20-25 years age was found in 42.4% patients, 25-30 years age was found in 37.4% patients, 30-35 years age was found in 18.2% patients and >35 years age was found in 2% patients.(Table no 2)

	Frequency	Percent
G2	34	17.1
G3	40	20.2
G4	12	6.1
G5	1	.5
Primi	77	39
Total	198	100.0

Table no 3:Gravida score wise distribution of the study

Primi gravida was 39% and multiple gravida was 61%. (Table no 3)

Table no 4:Head engagement wise distribution of the study

	Frequency	Percent
1/5th	19	9.6
2/5th	68	34.4
3/5th	64	32.3
4/5th	44	22.2
5/5th	3	1.5
Total	198	100.0

2/5th, 3/5th and 4/5th head engagement were recorded higher 34.4%, 32.3% and 22.2% respectively. (Table no 4)

Table no 5:Station wise distribution of the study

	Frequency	Percent
-1	66	33.3
-2	68	34.3
-3	45	22.7
1	19	9.6
Total	198	100.0

1 station was 9.6% , -1 station was 33.3%, -2 station was 34.3% and -3 station was 22.7%. (Table no 5)

Table no 6:Birth weight wise distribution of the study

	Minimum	Maximum	Mean	Std. Deviation
EFW by Johnsons formula	**1800**	**4030**	**3147.55**	**464.275**
EFW by Hadlocks formula	**2325**	**4185**	**3067.83**	**466.367**
Actual birth weight	**2105**	**3901**	**2952.07**	**439.936**

mean EFW by Johnsons formula was 3147.55gms, mean EFW by Hadlocks formula was 3067.83gms and mean actual birth weight was 2952.07gms (Table no 6)

Table no 7:Inter groups comparison of different type of birth weight

		Mean Difference	P value	95% Confidence Interval	
				Lower Bound	Upper Bound
Actual birth weight	**EFW by Johnsons formula**	**-195.48**	**.000 (S)**	**-305.76**	**-85.21**
	EFW by Hadlocks formula	**-115.76**	**.03 (S)**	**-226.04**	**-5.49**
EFW by Johnsons formula	**Actual birth weight**	**195.48**	**.000 (S)**	**85.21**	**305.76**
	EFW by Hadlocks formula	**79.72**	**.249**	**-30.55**	**190.00**
EFW by Hadlocks formula	**Actual birth weight**	**115.76**	**.03 (S)**	**5.49**	**226.04**
	EFW by Johnsons formula	**-79.72**	**.249**	**-190.00**	**30.55**

mean EFW by Johnsons formula was 3147.55 gms, mean EFW by Hadlocks formula was 3067.83 gms and mean actual birth weight was 2952.07 gms (Table no 7)

Table no 8:Intra groups comparison of different type of birth weight

		Mean Difference	P value	95% Confidence Interval	
				Lower Bound	Upper Bound
Actual birth weight	EFW by Johnsons formula	-195.48	.000 (S)	-305.76	-85.21
	EFW by Hadlocks formula	-115.76	.03 (S)	-226.04	-5.49
EFW by Johnsons formula	Actual birth weight	195.48	.000 (S)	85.21	305.76
	EFW by Hadlocks formula	79.72	.249	-30.55	190.00
EFW by Hadlocks formula	Actual birth weight	115.76	.03 (S)	5.49	226.04
	EFW by Johnsons formula	-79.72	.249	-190.00	30.55

Actual birth weight was showed statistically significant results with Johnsons formula and Hadlocks formula (Table no8)

Table no 9: mean error of different type of formula

	Johnsons formula	Hadlocks formula
Mean error	183.4±185.6	317.15±214.23
Maximum error	+789-381	+851-473
Minimum error	+31.7-11.7	+18-11

Mean error was 183.4 gms in Johnsons formula and mean error was 317.15 gms in Hadlocks formula (Table no 9)

DISCUSSION:

Estimation of fetal weight by ultrasonography (USG) is in increasing trend in the urban areas of our country whereas the clinical birth weight estimation is practiced only in the health facilities manned by paramedics and midwifery or in the outreach clinics under the public health services of the country.

Present study showed that the majority of subjects (42.4%) were seen in 20-25 years of age group. The mean age of patients was 26.65 years which was similar to the study conducted by Maria RT (2008)[xvi] et al 26.7**,** Japarath Prechapanich (2004)[xvii] et al 26.4, Akinola S. Shittu (2007)[xviii] et al 30.5**.**

The mean birth weight of the babies born to the study population was 2952.07 kg which was lesser when compared to the studies conducted by Maria RT et al 3360 gms**,** Japarath Prechapanich et al 2980 gms, Akinola S. Shittu et al. 3250 gms and this is due to maximum number of distribution of study population among 2000 gms-3900 gms.

As per the numerous approaches of the estimation of fetal weight, different results were noticed for the accuracy estimation. Some studies of the EFW presented the ultrasound has been the finest EFW method, particularly in preterm fetuses,[xix,xx] but further studies had not determined any difference amid of the given methods.[xxi,xxii]

Despite the differences in study design, present findings are in consonance with those reported by others that the accuracy of clinical estimation of birthweight is similar if not better than that of ultrasonic estimation. The studies by Hendrix (2002)[xxiii] et al and Raman (1992)[xxiv] et al showed that clinical estimation was significantly more accurate than sonographic prediction. Similar results as obtained by Sharman (1998)[xxv] et al. and Titapant (2001)[xxvi] et al. who observed that ultrasonic estimation was more accurate only when there is low birthweight but in their own studies, both the methods underestimated birthweight by more than 400 g. Watson (1988)[xxvii] et al. found no significant difference between the two methods even at extremes of birthweight at term.

At term other studies have been conveyed imperfect precision of ultrasound EFW, mainly in macrosomic fetuses.[xxviii] Baum et al. at term determined that no benefit ultrasound offered over clinical approximations of fetal weight.[xxix] Equally validation is viewed for the Clinical estimation, especially for realistic in the light of the requirement, attainable standards. Differing outcomes have been seen about the precision of the numerous techniques of fetal bodyweight estimation.

Present study showed that the mean birth weight of hadlock (3067.83) is closest to the mean of actual birth weight (2952.07) in comparison with the Johnson's formula (3147.55). But there is no significant difference between mean of Hadlock and Johnson formulae. The mean of Hadlock is 3213.85 ±371.472 grams which is comparable to Ayoola et[xxx] study with mean birth weight of 3238±452grams. The mean weight of Johnson is 3227.548 ±401.1 gms which

is comparable to Watchree et al[xxxi] study i.e. 3318.16±351.72 gms. This indicates that both formulae are highly significant in obtaining the mean birth weight but not when taken individually.

Several studies comparing estimated birth weights by Johnson's and Hadlock's method exhibit varying results, some showing no significant advantage of Hadlock's method over Johnson's methods[xxxii,xxxiii] whereas some favouring Hadlock's method.[xxxiv,xxxv]

Symphysiofundal height measurement is one of the important parameters to be considered for estimating fetal weight as in Abdominal Girth (AG) X Symphysiofundal height (SFH)method, Johnson's formula, Dawn's formula and the formula developed by Mhaskaret al[xxxvi] .This study corresponds to their findings as we observed Johnson's method for estimation of fetal weight to be more precise. This outlines the fact that Johnson's method clearly had an edge to Hadlock's method for estimation of fetal weight. Additional advantage to Johnson's method of fetal estimation is that it is convenient and cost effective on pragmatic terms. This is a method that allows the clinicians to assess the growth of the baby in the womb and the nutritional status of the mother during pregnancy but the chances of interobserver variation or bias cannot be ruled out. Though Hadlock's method has been found to be inferior compared to Johnson's method the use of USG has been routinely practiced intervention for the determination of fetal weight and its well-being.

The overall variation from actual birth weight is studied by finding the mean difference between actual birth weight and expected birth weight using two formulae. The mean error of the Hadlock formula was 317.15 gms and the mean error of the Johnson's formula was 183.4 gms. The mean error of the Hadlock formula is least because Hadlock formula uses four parameters and Johnson's formula uses only one parameter (SFH) for estimating fetal weight. The mean error of Johnson formula is 202.148gms which is in correlation with that of Watchree et al and Bhandary et al study. But in a study of Tiwari and Sood mean error is more than that of our study. The mean error of the Hadlock formula is 188gms which is less than that of Bhandary et al and Ayoola OO et al study.

Two dimensional ultrasound is routinely used, and the estimated fetal weight is calculated using appropriate tables or integrated computer programmes. The most frequently used parameters include the biparietal diameter, abdominal circumference and femur length. There is a cumulative error inherent in each of the fetal dimensions measured. This requires expertise; lack of necessary skills might lead to measurement errors. Ultrasound formula measurements can be inaccurate as they are not representative of the genetic background. Besides acoustic shadowing inhibits anatomical vision.[xxxvii]

Most pregnant mothers with access to modern health facilities opt for USG if possible. With its increased trend dependence on USG findings has been observed among the clinicians for further clinical management. Availability of USG services facilities are mostly found in private health care sector and government facilities above secondary level. Considering its cost and the financial status of general population in our country; recognition of USG as a primary routine investigation needs to be really thought upon on strategic terms before the formulation of national policy. Thus, cost effective clinical method like Johnson's method which has been found to be precise compared to Hadlock's method needs to be well promoted by the government for routine antenatal checkup.

The accuracy of EFW is compromised by large intra and interobserver variability. Efforts must be made to minimise this variability if EFW is to be clinically useful. This may be achieved through averaging of multiple measurements; improvements in image quality; uniform calibration of equipment; careful design and refinement of measurement methods; acknowledgement that there is a long learning curve and regular audit of measurement quality. Further work to improve the universal validity and accuracy of foetal weight estimation formulae is also required.

CONCLUSION :

It can be concluded that among various standard formulae used Hadlock method and Johnson's method were found to be a good predictor of birth weight. Thus it was found that different populations needed different formulae for reliably estimation of fetal birth weight. Cost effective methods like Johnson's method should be included in the training programs targeted to paramedics and female community health workers as skilled health workers to these kinds of methods will yield better outcomes with no financial implications. The use of sophisticated interventions like ultrasound requires trained human resources, regular maintenance with period updates of the devices which can be a burden for the health system. Thus, it should be routinely practiced by all the health workers working in the antenatal out-patients or ward to avoid overdependence on the use of electronic devices for the estimation of fetal weight as these facilities are limited in developing countries.

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[i] Lanowski J, Lanowski G, Schippert C, Drinkut K, Hillemanns P, Staboulidou I. Ultrasound versus Clinical Examination to Estimate Fetal Weight at Term. Geburtshilfe Frauenheilkd 2017;77(3):276–283.

[ii] Fuchs F, Bouyer J, Rozenberg P, Senat MV. Adverse maternal outcomes associated with fetal macrosomia: What are the risk factors beyond birth weight? BMC Pregnancy Childbirth 2013;13:90

[iii] Ugwu EO, Udealor PC, Dim CC, Obi SN, Ozumba BC, Okeke DO, et al. Accuracy of clinical and ultrasound estimation of fetal weight in predicting actual birth weight in Enugu, Southeastern Nigeria. Niger J Clin Pract 2014;17:270-5.

[iv] Sherman DJ,Joseph SA, TovbinJ et al. A comparison of clinical and ultrasonic estimation of fetal weight. Obstet Gynecol 1998;91:212-7.

[v] Baum JD, Gussman D, Wirth JC 3rd. Clinical and patient estimation of fetal weight vs ultrasound estimation. J Reprod Med 2002;47:194-8

[vi] Titapant V, Chawan PS, Mingnitpatanakul KA. Comparison of clinical and ultrasound estimation of fetal weight. J Med Assoc Thai 2001;84:1251-7.

[vii] Dudley NJ. A review of ultrasound fetal weight estimation in the early prediction of low birth weight. Ultrasound 2013;21;181-6.

[viii] Nzeh DA, Oyawoye O, Adetoro OO. Ultrasound estimation of birth weight in late pregnancy among African women. West African J ultrasound 2000;1:9-14.

[ix] Hendrix NW, Grady CS, Chauhan SP. Clinical versus sonographic estimates of birth weight in term parturients. A randomized clinical trial. J Reprod Med 2000; 45:317-22

[x] Khani S, Ahmad-Shirvani M, Mohseni-Bandpei MA, Mohammadpour- Tahmtan RA. Comparison of abdominal palpation, Johnson's technique and ultrasound in the estimation of fetal weight in Northern Iran. Midwifery 2011;27(1):99-103

[xi] Ratanasiri T, Jirapornkul S, Sombooporn W, Seejorn K, Patumnakul P. Comparison of the accuracy of ultrasonic fetal weight estimation by using the various equations. J Med Assoc Thai 2002;85:962–7

[xii] Willocks J, Donald I, Duggan TC, Day N. Foetal cephalometry by ultrasound. J Obstet Gynaecol Br Commonw 1964;71:11-20

[xiii] Hellman M, Kobayashi H, Fillissi L. Predicting fetal weight by ultrasonic B-scan cephalometry. Am J Obstet Gynecol 1967;99:662

[xiv] Woo JS, Wan MC. An evaluation of fetal weight prediction using a simple equation containing the fetal femur length. J Ultrasound Med 1986;5:453-7

[xv] Lanowski JS, Lanowski G, Schippert C, Drinkut K, Hillemanns P, Staboulidou I. Ultrasound versus clinical examination to estimate fetal weight at term. Geburtshilfe Frauenheilkd. 2017;77(3):276-283.

[xvi] Maria RT, Nelson S, Jussara LS, Ana Carolina PR, Maisa F, Paula rubia DL. Clinical formulas, mother's opinion and ultrasound in predicting birth weight: Sao Paulo Medical Journal. Vol 126:3;May 2008

[xvii] Prechapanich J, Thitadilok W. Comparison of the accuracy of fetal weight estimation using clinical and sonographic methods. J Med Assoc Thai. 2004 Oct;87 Suppl 3:S1-7

[xviii] Shittu AS, Kuti O, Orji EO, Makinde NO, Ogunniy SO, Ayoola OO, Sule SS. Clinical versus sonographic estimation of foetal weight in southwest Nigeria. J Health Popul Nutr. 2007 Mar;25(1):14-23.

[xix] Chauhan SP, Lutton TC, Bailey KJ, Morrison JC. Intrapartum prediction of birth weight: clinical versus sonographic estimation based on femur length alone. Obstet Gynecol. 1993;81(5):695–7

[xx] Chauhan SP, Lutton PM, Bailey KJ, Guerrieri JP, Morrison JC. Intrapartum clinical, sonographic and parous patients' estimates of newborn birth weight. Obstet Gynecol. 1992;79:956–8.

[xxi] Chauhan SP, Sullivan CA, Lutton TC, Magann EF, Morrison JC. Parous patients' estimate of birth weight in postterm pregnancy. J Perinatol. 1995;15(3):192–4.

[xxii] Nahum GG, Stanislaw H. Ultrasonographic prediction of term birth weight: How accurate is it? Am J Obstet Gynecol. 2003;188(2):566–74

[xxiii] Hendrix NW, Grady CS, Chauhan SP. Clinical versus sonographic estimates of birth weight in term of parturients. A randomized clinical trial. J Reprod Med. 2000;45:317-22

[xxiv] Raman S, Urquhart R, Yusof M. Clinical versus ultrasound estimation of fetal weight. Aust N Z J Obstet Gynecol. 1992;32:196-9.

[xxv] Sherman DJ, Arieli S, Tovbin J, Siegel G, Caspi E, Bukovsky IA. A comparison of clinical and ultrasound estimation of fetal weight. Obstet Gynecol. 1998;91:212-7.

[xxvi] Titapant V, Chawanpaiboon S, Mingmitpatanakul K. A comparison of clinical and ultrasound estimation of fetal weight. J Med Assoc Thai. 2001;84:1251-7

[xxvii] Watson WJ, Soisson AP, Harlass FE. Estimated weight of the term fetus. Accuracy of ultrasound vs. clinical examination. J Reprod Med. 1988;33:369-71.

[xxviii] Ramon S, Urquhart R, Yusof M. Clinical versus ultrasound estimation of fetal weight. Aust N Z J Obstet Gynaecol. 1992;32(3):196–9.

[xxix] Baum JD, Gussman D, Wirth JC. Clinical and patient estimation of fetal weight vs. ultrasound estimation. Obstet Gynecol Surv 2002;57:558–9

[xxx] Ayoola OO, Orji EO, Adetioloya VA, Nzeh DA. Accuracy of various ultrasonographic formula in predicting fetal weight in a Nigerian population. J of Chinese Clinical Med. 2008;1:3–11

[xxxi] Numprasert W. A study in Johnson's formula :Fundal height measurement for estimation of birth weight. AU JT 2004; 8(1):15-20.

[xxxii] Njoku C, Emechebe C, Odusolu P, Abeshi S, ChukwuC, Ekabua J. Determination of accuracy of fetal weight using ultrasound and clinical fetal weight estimations in Calabar South, South Nigeria. Int Sch Res Notices.2014;10:970-3

[xxxiii] Ugwu EO, Udealor PC, Dim CC, Obi SN, OzumbaBC, Okeke DO, et al. Accuracy of clinical and ultrasound estimation of fetal weight in predicting actual birth weight in Enugu, South-eastern Nigeria. Niger J Clin Pract 2014;17(3):270-5.

[xxxiv] Joshi A, Panta OB, Sharma B. Estimated Fetal Weight: Comparison of Clinical Versus Ultrasound Estimate. J Nepal Health Res Counc. 2017;15(35):51-5.

[xxxv] Bajracharya J, Shrestha NS, Karki C. Accuracy of Prediction of Birth Weight by Fetal Ultrasound. Kathmandu UnivMed J. 2012;38(2):74-6

[xxxvi] Mhaskar R, Mhaskar A, Molly SR. Symphysiofundal height (SFH) measurement for prediction of birth weight - A new formula. J Obstet Gynecol Ind.2001; 51:73-6

[xxxvii] Cunningham FG, Williams JW, editors. Williams Obstetrics. 21st ed. New York: McGraw-Hill; 2016