COMPARATIVE STUDY ON JOHNSON'S FORMULA, INSLER'S FORMULA AND HADLOCK'S FORMULA FOR ESTIMATING FOETAL WEIGHT AT TERM

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ABSTRACT

BACKGROUND

Foetal weight is one of the greatest factor determining the survival of the foetus. Estimation of foetal weight predelivery helps to decide the mode of delivery and anticipate problems during labour.

Aim of the study is to assess the foetal weight in term pregnancies by various methods, i.e. abdominal girth x symphysiofundal height (Insler's Formula), Johnson's formula and Hadlock's formula using USG to study the accuracy of these methods and to correlate these methods of estimation of foetal weight with actual birth weight of the baby after delivery.

MATERIALS AND METHODS

200 cases having term pregnancies were selected from antenatal clinics and maternity wards in whom delivery was anticipated within one week of foetal weight estimation. Foetal weight estimation was done clinically by two methods, i.e. AG x SFH, Johnson's formula and by ultrasound using Hadlock's formula. Results were compared to the actual weight of the babies after delivery with respect to mean birth weight±SD and average error in estimating foetal weight and prediction of birth weight within 10% of actual birth weight. Statistical analysis was done using Student's t-test, Pearson's correlation.

RESULTS

The mean birth weight by symphysiofundal height * abdominal girth±SD was 2967.79±348.52 whereas mean of actual birth weight±SD was 2903±460.02. The p value calculated to be 0.118, which is statistically not significant. Average error in estimating foetal weight was 189.2 g by Hadlock's formula and 304.2 g by AG x SFH method. The difference is not statistically significant. Prediction of birth weight within 10% of actual birth weight was in 63.5% of cases by AG x SFH formula, 81% by Hadlock's formula and 49% by Johnson's formula.

CONCLUSION

AG x SFH (Insler's formula) has better predictable results is foetal weight estimation as difference between it and actual birth weight is not statistically significant making SFH * AG method more accurate for estimation of foetal weight if compared to actual birth weight. So, it can be of great value in a developing country like ours where ultrasound is not available at many healthcare delivery systems.

KEYWORDS

Abdominal Girth, Symphysiofundal Height, Estimated Foetal Weight, Ultrasonography.

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BACKGROUND

The aim of a good obstetrician is to give a healthy baby to a healthy mother. The perinatal and maternal outcome grossly depends upon foetal weight at term gestation. Accurate estimation of foetal weight is of paramount importance in management of labour and delivery. Foetal weight in conjunction with gestational age is an important indicator of pregnancy outcome.[1] Knowledge of the weight of the foetus in utero is important for the obstetrician to decide whether to deliver or not to deliver the foetus and also to decide the mode of delivery. Extremes of birth weight are associated with an increased risk of newborn complications during labour and puerperium.

It is very important for the prevention of prematurity, evaluation of pelvic disproportion, before induction of labour and detection of intrauterine growth restriction.[2] Management of diabetic pregnancies, vaginal birth after previous caesarean section and intrapartum management of foetuses presenting by breech will be greatly influenced by estimated foetal weight.[3] Accurate estimates of foetal weight can help the obstetrician in knowing the salvageability of the baby outside the uterus as birth weight is principal variable affecting the survival of the neonate. When dealing with the anticipated preterm delivery perinatal counselling on likelihood of survival, the intervention undertaken to postpone the preterm delivery, optimal route of delivery or the level of hospital where the delivery should occur maybe based entirely or in part on the estimation of expected birth weight of the foetus. For excessively large foetuses, the potential complications associated with delivery include shoulder dystocia, brachial plexus injuries and intrapartum asphyxia. Therefore, categorisation of foetal weight into either small or large for gestational age may lead to timed obstetric interventions that collectively represent significant departure from routine antenatal care.[4] A quick, easy, clinical method for estimation of foetal weight in utero would be of obvious benefit not only to the obstetrician, but also for the birth attendants and paramedical staff working in rural areas to decide regarding referral to higher centre.[5]

AIMS AND OBJECTIVES

Aims of this study is to assess the foetal weight in term pregnancies by various methods, i.e. abdominal girth x symphysiofundal height (Insler's formula), Johnson's formula and Hadlock's formula using USG. To study the accuracy of these methods and to correlate these methods of estimation of foetal weight with actual birth weight of the baby after delivery.

MATERIALS AND METHODS

It is hospital-based cross-sectional observation study conducted in the Department of Obstetrics and Gynaecology, VSSIMSAR, Burla, for the duration of two years, i.e. November 2014 to November 2016. In Department of Obstetrics and Gynaecology, VSSIMSAR, approximately there occurs 200 deliveries (normal and caesarean section) per month, which is 4800 deliveries in two years (which is this study period) out of which after excluding the patients coming under exclusion criteria and patients not giving consent for the study, approximately 200 cases were included in this research study. A total of 200 women at term who were fulfilling the inclusion criteria were randomly included in this study. These patients were selected from antenatal clinics and maternity wards who had their last USG done within one week prior to delivery. The foetal weight was estimated clinically by two formulas within a week prior to the delivery. If the delivery did not occur within a week of the estimation, they were excluded from the study.

The present study was undertaken to make a comparative evaluation of foetal weight estimation in term pregnancy using abdominal girth x symphysiofundal height (Insler's formula), Johnson's formula and Hadlock's formula using ultrasonography. All measurements taken and results were compared to the actual birth weight.

Inclusion Criteria

Patients with singleton term pregnancy (37 to 42 weeks) with cephalic presentation and intact membranes with USG estimated foetal weight within a week prior to delivery, admitted for planned delivery/booked/unbooked/referred cases. All pregnancies irrespective of parity/height/head descent/routes of delivery/socioeconomic status/maternal age were included in this study.

Exclusion Criteria

Patients with multifetal gestation, non-cephalic presentation, antepartum haemorrhage, diabetes mellitus, eclampsia, preeclampsia, gestational hypertension, poly or oligohydramnios, fibroids or adnexal masses, known foetal malformations/uterine malformations, obesity, preterm and post-term pregnancies, ruptured membrane at presentation, pregnancy with intrauterine foetal demise, patients not sure of their last menstrual period were excluded from this study.

Procedure of the Study

Foetal weight by Insler's formula was estimated by- EFW (weight in grams) = abdominal girth (cm) x symphysiofundal height (cm). After emptying the bladder, patient should lie supine with legs flat on the bed, i.e. extended both at hip and knee. SFH and AG were measured using a flexible, non-elastic standard sewing tape in between contractions. After correction of dextrorotation, McDonald's measurement of height of the fundus from the midpoint of the upper edge of symphysis pubis following the curvature of abdomen were taken in centimetre tape. The upper hand was placed firmly against the top of the fundus with the measuring tape pressing between the index and middle fingers readings were taken from perpendicular intersection of the tape with the fingers. For abdominal girth measurement the tape was repositioned to encircle the women's waist at the level of umbilicus without applying excessive pressure to tighten the tape around the abdomen.

To estimate foetal weight by Johnson's formula as mentioned in previous method, McDonald's measurement of symphysiofundal height is done. Station of presenting part was assessed by abdominal examination and by vaginal examination, the cervical dilation and degree of descent of the foetal head into the pelvis was noted down. Foetal head was considered to be at minus/zero/plus stations if the lowermost portion of the foetal head was above/at/below the level of ischial spine, respectively.

Foetal weight was estimated as follows-

Foetal weight (g) = (symphysiofundal height - 13) x 155 when the presenting part was at 'minus' station.

Foetal weight (g) = (symphysiofundal height - 12) x 155 when presenting part was at 'zero' station.

Foetal weight (g) = (symphysiofundal height - 11) x 155 when presenting part was at plus station.

Haddock's sonographic examination of foetal weight was done in all patients using 3.5 MHz convex assay and linear assay transverse (transverse Siemen's Sonoline SL grey scale model with M and B mode for simultaneous imaging and calculating foetal heart rate). After Biparietal Diameter (BPD), Abdominal Circumference (AC) and Femur Length (FL) were measured in centimetres, the sonography machine calculated foetal weight by formula.

Log10 (EFW) = 1.4787 - 0.003343 AC x FL + 0.001837 BPD2 + 0.0458 AC + 0.158FL BPD diameter is measured using real-time scanner.

RESULTS

Statistical Analysis

Data was collected by taking 200 cases and was put in Microsoft XL sheet. Analysis was done using Statistical Package for Social Sciences (SPSS) software version no. 11. Student's t-test, Pearson's correlation and one way ANOVA tests were applied. Statistical analysis of the difference between calculated estimated foetal weight and actual birth weight was done in all methods using one way ANOVA for comparison of multiple groups where $P<0.05$ is significant. Pearson's correlation coefficient to know if there is a significant relationship between estimated and actual birth weight for all the methods.

Age Groups	Number of Respondents	% of Respondents
<= 20 yrs.	43	21.5
21-30 yrs.	148	74.00
31-36 yrs.	9	4.5
Total	**200**	**100.00**
Mean Age	**24.07**	
SD Age	**3.77**	

Table 1. Distribution of Respondents by Age Groups

Parity	Number of Cases	Percentage
Primigravida	81	40.5
Multigravida	119	59.5
Total	**200**	**100**

Table 2. Parity Wise Distribution

Method	Mean Birth Weight±SD	Range (g)
Actual birth weight	2903±460.02	1890-3900
SFH * AG (Insler's)	2967.79±348.52	2146-4000
Johnson's formula	3293.97±422.48	2430-4185
Hadlock's formula	3026.05±391.33	2022-4174

Table 3. Mean Birth Weight by Different Methods

Procedure	Mean	Std. Dv.	Mean Diff. (g)	Paired t	p-value
Symphysiofundal height * AG	2967.79	348.52			
Actual birth weight	2903.80	460.02	63.99	1.568	0.118

Table 4. Comparison of Symphysiofundal Height * AG (Insler's Formula) and Actual Birth Weight by Paired T-Test

*p<0.05.

Procedure	Mean	Std. Dv.	Mean Diff. (g)	Paired t	p-value
Johnson's formula	3293.97	422.48			
Actual birth weight	2903.80	460.02	390.17	8.834	0.00001*

Table 5. Comparison of Johnson's Formula and Actual Birth Weight by Paired T-Test

*p<0.05.

Procedure	Mean	Std. Dv.	Mean Diff. (g)	Paired t	p-value
Hadlock's formula	3026.05	391.33			
Actual birth weight	2903.80	460.02	122.25	7.077	0.00001*

Table 6. Comparison of Hadlock's Formula and Actual Birth Weight by Paired T-Test

*p<0.05.

Method	Mean Difference	P value	Significance
Act. Bwt - Insler's	63.99 g	0.54	NS
Act. Bwt - Johnson's	390.17 g	0.0001	S
Act. Bwt - Hadlock's	122.25 g	>0.14	NS

Table 7. Mean Difference of Different Methods

NS- Not Significant; S- Significant.

Variable	Correlation between Actual Birth Weight with		
	r-value	t-value	p-value
SFH * AG (Insler's)	0.34	5.7642	0.00001*
Johnson's formula	0.32	5.5355	0.00001*
Hadlock's formula	0.62	17.0812	0.00001*

Table 8. Correlation between Actual Birth Weights with Others by Karl Pearson's Correlation Coefficient Method

	SFH * AG	Johnson's	Hadlock's
Average error (g)	304.2	424.9	189.2
% error	10.3%	14.4%	6.44%

Table 9. Average Error and Percentage Error in Each Method

Method	<2000	2000-2500	2501-3000	3001-3500	>3500
Average error (g)					
SFH*AG	550	386.82	294.70	268.1	456.71
Johnson's	867.5	662.95	446.98	328.48	171.14
Hadlock's	107	200.26	179.32	203.2	176.57

Table 10. Average Error in Various Foetal Weight Groups by Various Methods

The average error in various foetal groups was least with Hadlock's formula closely followed by Insler's formula. The average error in various foetal groups was maximum with Johnson's formula except in the >3500 g group where the average error was least compared to Insler's and Hadlock's formula. Insler's formula found to have maximum average error in >3500 gm group compared to other two formulas.

Method	<2000	2000-2500	2501-3000	3001-3500	>3500
Maximum Error(g)					
SFH*AG	700	1285	1250	763	848
Johnson's	945	1645	1400	790	500
Hadlock's	192	839	800	709	374

Table 11. Maximum Error in Various Foetal Weight Groups

The maximum error in various foetal weight groups was most marked with Johnson's formula (except in >3500 g) and least with Hadlock's formula. Maximum error by various methods was seen more in birth weight of range 2000-2500 g.

Percentage Error	SFH * AG	Johnson's	Hadlock's
Up to 5%	45 (22.5)	46 (23)	101 (50.5)
5-10%	82 (41)	52 (26)	61 (30.5)
>10%	73 (36.5)	102 (51)	38 (19)

Table 12. Percentage Error by Various Methods

Method	Correlation Coefficient*	Prediction Equation (Estimating Act. B. Wt)	Standard Deviation (g)
SFH*AG	0.34	B. wt = 1705.4 + 0.41 (AG* SFH)	348.52
Johnson's	0.32	B. wt= 1801.4 + 0.05 (Johnson's)	422.48
Hadlock's	0.62	B. wt= 695.11 + 0.74 (Hadlock's)	391.33

Table 13. Prediction of Birth Weight by Various Methods and Standard Deviation of Prediction Error

*Pearson's correlation coefficient P <0.0001, significant.

The standard deviation indicates how much variation can be expected in the predicted birth weight by each method. Least variation was found in AG x SFH (±348.52 g) followed by Hadlock's method (±391.33 g) and highest variation in Johnson's method (±422.48 g).

DISCUSSION

It is generally accepted that a simple, accurate and universally applicable method of assessing in utero foetal weight leads to improved prospective management of high-risk pregnancies and a possible reduction in perinatal mortality and morbidity. This study was conducted in labour room under Department of Obstetrics and Gynaecology in VSSIMSAR, Burla, Sambalpur. 200-term pregnant women were selected who fulfilled the inclusion criteria.

The mean age of pregnant women in this study is 24.07 years±3.77 (range 19-36 years). 81 were primigravida and 119 were multigravida. Maximum cases, i.e. 69 (34.5%) cases were between 37 wks. - 37 wks. 6 days. 121 respondents out of 200 underwent full-term vaginal delivery, which was 60.5%. 79 respondents out of 200 underwent lower segment caesarean section, which was 39.5%. The majority of infants (48.5%) were in 2500 to 2999 g. The range of actual birth weight was 1890 to 3900 g. Mean actual birth weight range was 2903±460.02.

All studies included various clinical and ultrasonographic methods of foetal weight estimation except study by Dawn et al (1983) had included the clinical estimation by Dawn's formula[6] and Dare et al[7] (1990) had included clinical estimation by Insler's formula for estimation of foetal weight. In present study, both clinical and ultrasonographic methods of foetal weight estimation were included.

In present study, mean of actual birth weight is 2903±460.02. Mean birth weight by symphysiofundal height * AG (Insler's) is 2967.79±348.52. Mean birth weight by Johnson's formula is 3293.97±422.48. Mean birth weight by Hadlock's formula is 3026.05±391.33.

In the present study, the mean of estimated foetal weight by SFH*AG and Hadlock's method is almost closer to mean of actual birth weight. This shows that foetal weight estimation by clinical method of SFH*AG (2967.79±348.52) is almost closer to actual birth weight (2903±460.02). Dare FO et al studied that product of SFH*AG in cm fairly correlates with the actual birth weight. This signifies that there is not much statistically significant difference in SFH * AG and Hadlock's formula for estimation of foetal weight, SFH * AG being more accurate followed by Hadlock's formula.

Bhandary Amritha et al[8] found the average error in various foetal weight groups by AG x SFH was 224.37 g, which was least when compared to Johnson's and Hadlock's method. Tiwari and Sood[9] in their study showed an average error of 364.96 g, 327.28 g and 198.6 g by SFH * AG, Johnson's and Hadlock's ultrasound method, respectively. In present study, the average error in g was least by Hadlock's formula, which was 189.2 g and by AG x SFH method was 304.2 g then followed by Johnson's formula, which was 424.9 g similar to above studies.

Sherman et al[10] (1998) reported that rates of estimates within 10% of birth weight was not statistically significant in clinical and USG method (72% and 69%, respectively). Bhandary Amritha et al[8] reported that rates of estimates within 10% of birth weights was not statistically significant in AG x SFH method and USG method (67% and 62%, respectively). In present study as well clinical estimation by AG x SFH (Insler's formula) and USG method are equally good for estimation of birth weight within 10% (63.5% and 81%, respectively).

Present study showed that the maximum error in various foetal weight groups was least by Hadlock's method, which is similar to the results obtained by the study conducted by Dr. Syeda Ayesha Siddiqua[11] in October 2014. In present study, it was noted that average error in estimating foetal weight by Johnson's formula was least in >3500 g group, which is very similar to the results obtained by the study conducted by Bhandary Amritha et al (2004), Sowmya et al in 2014 and Jili Basumatary[12] et al in October 2015 suggesting that Johnson's method is more accurate in the higher weight category.[13]

The standard deviation (of prediction error) indicates how much variation can be expected in the predicted birth weight by each methods. Least variation was found in AG x SFH (±348.52 g) followed by Hadlock's method (391.33 g) and highest variation in Johnson's method (±422.48 g), which is similar to the results of the study conducted by Tiwari and Sood.[9] Also, the present study results are similar to the results obtained by the study conducted by Dr. Syeda Ayesha Sidduique in October 2014 where least variation was found in AG x SFH (±379.65 g) followed by Hadlock's method (389.33 g) and highest variation in Johnson's method (±430.04 g).[11]

Despite the differences in study design, our findings are in consonance with those reported by others that the accuracy of clinical estimation of birth weight is similar if not better than that of ultrasonic estimation. The studies by Hendrix et al[14] and Raman et al showed that clinical estimation was significantly more accurate than sonographic prediction. Similar results as obtained by Sharma N et al[15] and Titapant et al[16] who observed that ultrasonic estimation was more accurate only when there is low birth weight similar to present study.

Thus, based on this study, Insler's formula has better predictable results in foetal weight estimation than Hadlock's and Johnson's formula and can be used for foetal weight estimation in term pregnancy especially when ultrasound facility is not available for better management of labour and delivery. The role of ultrasound estimation appears that when clinically estimated weight suggests weight <2000 g. This study also proves that clinical estimation, i.e. Johnson's formula is better than ultrasound and Insler's when actual birth weight is >3500 g. Based on this finding, combining the different methods of foetal weight prediction to improve their overall efficacy maybe possible. Further studies are however necessary to improve the accuracy of foetal weight

prediction near delivery actually improves outcome and how applicable these methods can be to situations that alter birth weight such as premature rupture of membranes and obesity that were excluded in the present study.

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

Of the three clinical formulae studied, AG x SFH (Insler's formula) has better predictable results in foetal weight estimation compared to Johnson's and Hadlock's formula. Diagnostic ultrasound is painless, noninvasive and has potential to screen all the patients. However, costly sonographic equipment, specially trained personnel and subjective variations in estimating results of ultrasound are limitations of usage of ultrasound and can be of great value in developed countries. Thus, based on this study, AG x SFH (Insler's) clinical formula can be of great value in a developing country like ours where ultrasound is not available at many healthcare delivery systems. It is easy, cost effective, simple and can be used even by midwives. Therefore, the finding in our study showing clinical methods to be better than ultrasound will be useful in our setup.

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