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Original Research Article

Estimation of fetal weight at term by clinical and sonographic assessment and its correlation with the birth weight – A prospective cohort study in a tertiary care hospital

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A R T I C L E I N F O

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A B S T R A C T

Background: Estimation of fetal weight is necessary to decide on the time and route of delivery. Different clinical and ultrasound methods for estimating fetal weight are followed by different institutions. Antenatal assessment of fetal weight is necessary to achieve better feto-maternal outcomes. The objectives of this study were: (a) fetal weight estimation by ultrasound (Hadlock's formula) and clinical methods (Johnson's formula and Dare's formula) and (b) to compare them with the actual weight of the baby after birth.
Materials and Methods: A prospective cohort study was conducted in a tertiary care centre at Puducherry, India including all singleton, term pregnant women with vertex presentation, normal AFI and BMI <35 kg/m^2 who delivered within the next 48 hours of assessment. The agreement between the different methods of fetal weight estimation and actual birth weight were calculated using intraclass correlation coefficient. Bland and Altman plot was done to identify the intervals of agreements.
Results: A total of 400 term antenatal women with age range of 17 to 44 years participated in the study. Intraclass correlation coefficient for Johnson's formula was 0.816, Dare's formula was 0.672 and Hadlock's formula was 0.912. All the three methods had statistically significant correlation with the actual birth weight.
Conclusion: Ultrasound estimation of fetal weight is the best out of the three methods and it correlated well with the actual birth weight. Johnson's formula also gave results close to actual birth weight. With a correlation coefficient comparable to that of ultrasound estimation, Johnson's formula can be used in low resource settings where ultrasound facilities are not available.

1. Introduction

Obstetrics begins even before conception in the form of preconceptional counselling to know the dos and don'ts in and for pregnancy. It is well said that obstetric care aims primarily at maternal well-being followed by fetal well-being. Estimating fetal weight in the antenatal period and before confinement helps to triage the pregnant women into low risk or high risk pregnancy. Risk stratification helps to decide on the level of obstetric health care system necessary during delivery. Fetal growth restriction (FGR) and macrosomia are two well-known high risk fetal growth disorders that can result in significant maternal and/or perinatal morbidity.[1]

Incidence of fetal growth restriction is around 23.8% globally and nearly 30 million babies are born with low

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birth weight each year.[2] This accounts for more than 50% of neonatal deaths. Incidence of low birth weight in India is approximately 28% and nearly 21% of which is due to fetal growth restriction.[2]

Macrosomia accounts for almost 10% of all deliveries globally.[3] A diagnosis of macrosomia is generally made only after birth. If macrosomia is suspected prior to delivery it needs further intervention. Suspicion of disordered fetal growth prior to delivery is aided by clinical and sonological fetal weight estimation. It helps the obstetrician to anticipate complications and make necessary preparation to prevent or manage such complications.

Both macrosomia and fetal growth restriction are associated with several complications. Macrosomia results in adverse neonatal outcomes like stillbirth and neonatal mortality secondary to shoulder dystocia, metabolic disorders, birth asphyxia and meconium aspiration syndrome.[4] It is reported that the occurrence of morbidity associated with macrosomia is about 6% more than that in appropriate for gestational age neonates.[4] Fetal growth restriction can also result in significant maternal and neonatal mortality and morbidity like still birth, birth asphyxia, meconium aspiration syndrome, metabolic derangement, hyperbilirubinemia, necrotising enterocolitis and hypothermia.[2] In a long run both these fetal growth disorders can lead to neurodevelopmental delay, cognitive dysfunction, metabolic and haematological disorders. A higher incidence of coronary diseases, arterial hypertension and diabetes in adult life has been reported according to Barker's hypothesis.[5]

Estimation of fetal weight is necessary to decide on the time and route of delivery. Different clinical and ultrasound methods for estimating fetal weight are followed by different institutions. In India, a birth weight of less than 2.5 kg is considered as small for gestational age and birthweight more than 4 kg are considered large for gestational age fetuses. Birth weight between 2.5 to 4 kg is considered normal birth weight.[6]

This study was aimed at knowing whether clinical estimation or ultrasonographic assessment gives a better estimate of fetal weight by comparing them with the actual birth weight (ABW). The objectives of this study were:

1. To assess the fetal weight by ultrasound (Hadlock's formula) and clinical methods (Johnson's formula and Dare's formula).
2. To compare them with the actual weight of the baby after birth.

2. Materials and Methods

This was a prospective cohort study conducted among women admitted at Pondicherry Institute of Medical Sciences, Pondicherry, India. After attaining ethical clearance from the Institute Ethical committee the study was conducted for a period of one and half year from October 2017. All singleton, term (37^{+0} to 41^{+6} weeks) with vertex presentation, normal AFI (5-25) and a body mass index (BMI)<35 kg/m^2 who delivered within the next 48 hours since examination were included in the study. Malpresentations, multifetal gestation, fetal congenital anomalies and intrauterine fetal demise were excluded. Informed written consent was obtained from the participants. A detailed history taking and clinical examination was done. Clinical fetal weight estimation was done using Johnson's and Dare's formula while ultrasound (USG) estimation was done using Hadlock's formula. Ultrasonography was done using the Sonosite Micromaxx Ultrasound machine with curvilinear trans-abdominal probe of 5 MHz to assess the biometry, amniotic fluid index (AFI) and estimated fetal weight (EFW). The measurements were taken thrice and the mean of the three was considered. The sample size was calculated by intra-class correlation method. Assuming the population reliability as 0.5, power as 80%, significance level as 5%, sample size required to have sample reliability of 0.6 was calculated as 392.

The McDonald's uterine fundal height was measured with the mother in supine position with partial flexion at hip and knee joints after emptying the bladder. Uterus is centralized and palpation is started from xiphi-sternum and proceeded downwards until the first resistance is felt. This corresponds to fundal height. The resistance of the uterine fundus was marked. Then she was asked to extend her legs. The symphysio-fundal height (SFH) was measured using a measuring tape (in cm) with the reverse side of the tape facing upwards (centimetre side facing the abdomen to avoid observer bias) from the midpoint of pubic symphysis to the marked fundal height. The abdominal girth was measured at the level of umbilicus anteriorly with patient in supine position with a measuring tape. The station of vertex was assessed by per vaginal examination under aseptic precautions by the primary observer. The same was confirmed by the senior physician in 100 (25.0%) randomly selected participants to look for inter-observer variation. The fetal weight was calculated clinically by Johnson's formula and Dare's formula.

Johnson's formula:

Estimated Fetal Weight in Grams = (SFH in cm – x) * 155

Where, x=12 - for vertex at 0 station and above, and x= 11 - for vertex below 0 station

Dare's formula:

Estimated Fetal Weight in Grams = Abdominal Girth in cm* SFH in cm

2.1. Ultrasonography (Hadlock's Formula)

With umbilicus as the midpoint the maternal abdomen is divided into four quadrants. Cord free deepest vertical pocket in each quadrant is measured and summated. This gives the amniotic fluid index. The normal range of AFI is 8 to 25. Oligohydramnios is defined as AFI less than 5 and polyhydramnios is defined as AFI more than 25. Only those with normal AFI were included in this study. The fetal weight was calculated by ultrasonography with four parameters- head circumference (HC), biparietal diameter (BPD), abdomen circumference (AC) and femur length (FL) as shown in Figures 1, 2, 3 and 4 respectively and applying them to Hadlock's formula, which is:

Estimated Fetal Weight in Grams = Log 10 EFW(g) = 1.3596 – 0.00386 (AC * FL) + 0.0064(HC) + 0.00061(BPD * AC) + 0.0425(AC) + 0.174(FL)

The birth weight of the baby was noted using the same electronic weighing machine soon after birth for all the participants in order to avoid error in measurements.

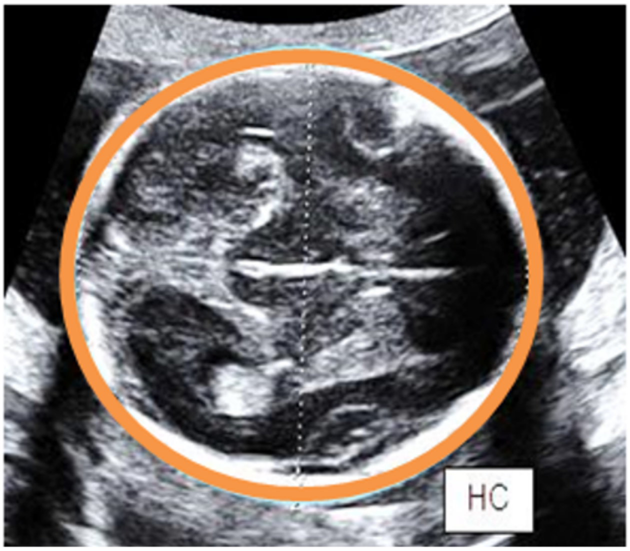

Figure 1: Head circumference - at the thalamo-cortical plane by placing the elliptical measuring around the outer edge of the fetal skull. The thalamo-cortical plane is a plane at the level of the thalami and cavum septum pellucidum (trans-thalamic view)

Also, same measuring tape was used for all patients. SFH was measured with its reverse side facing upwards. Each parameter was calculated thrice and the mean of the three was taken to avoid intra-observer bias. All the measurements like abdominal girth, symphysio-fundal height and per vaginal examination for station of vertex were confirmed with the senior physician for the 100 (25.0%) randomly selected participants to avoid inter-observer variation and to get better outcome.

All data were collected and entered in Microsoft Excel and analysed using standard statistical software Statistical Package for the Social Sciences (SPSS) version 20.0. Descriptive statistics were presented as numbers and percentages for categorical variables; mean and standard deviation (SD) for continuous variables. Inter-observer variability was estimated. Kappa statistics for agreement

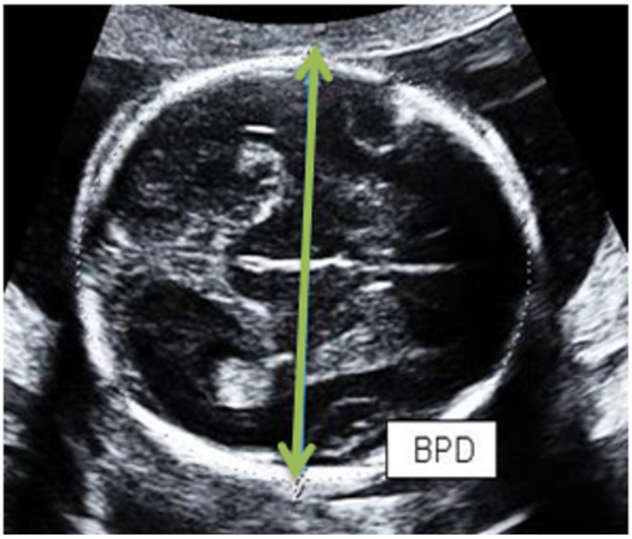

Figure 2: BPD - in trans-thalamic view from outer table of the skull in near field to inner table of the skull in far field (perpendicular to the arrow sign as seen in the thalamo-cortical plane

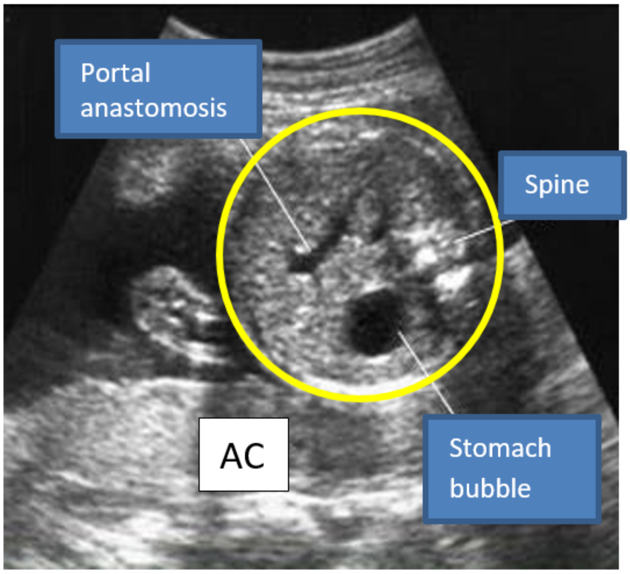

Figure 3: Abdomen circumference- in transverse plane at the level of the stomach and the confluence of umbilical vein and portal sinus. Visualization of only one vertebra and rib in the outer circumference confirms that it is a transverse image and not oblique

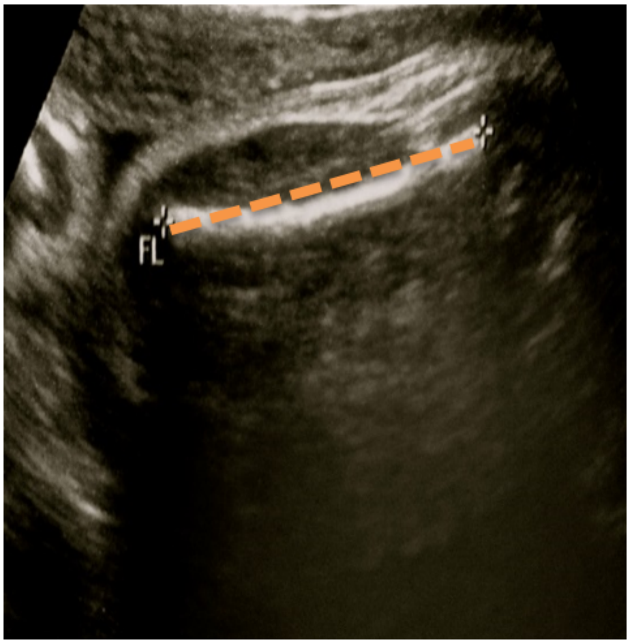

Figure 4: Femur length – USG beam perpendicular to the shaft of femur excluding the epiphyses

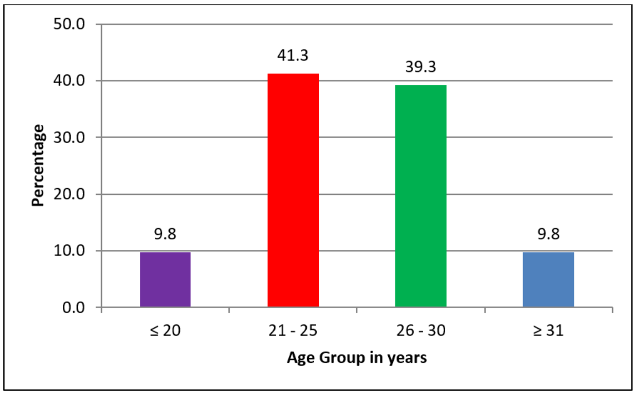

Figure 5: Age group distribution of participants

was calculated and was 0.96 indicating very minimal inter-observer variability. Intra-class correlation coefficient was used to find the agreement between the three methods and the actual birth weight. Bland and Altman plot was done to identify the intervals of agreements. A p value <0.05 was considered significant.

3. Results

Out of 400 subjects, maximum participants were between 21-25 years closely followed by 26 – 30 years. Age distribution is shown in Figure 5. The mean (±SD) age was 25.5 (± 4.1) years with a range of 17 to 44 years. 189 (47.3%) were primigravida while the rest 211 (52.7%) were multigravida (Figure 6). Maximum number of participants was in the gestational age group of 38 weeks (Figure 7) and maximum participants had a BMI between 30 to 34.9 kg/m^2(Figure 8).

The intra-class correlation coefficient for Johnson's EFW, Dare's formula and Hadlock's formula with actual weight of the baby after birth was calculated. It was found that Hadlock's formula has the highest correlation with actual birth weight followed by Johnson's and Dare's formula as shown in Table 1. All three methods had a statistically significant correlation with ABW (p<0.001). Scatter plots showing correlation between the actual birth weight and Johnson's formula (Figure 9), Dare's formula (Figure 10) and Hadlock's formula (Figure 11) depicts that all three methods utilized to estimate fetal weight had significant correlation. But the ultrasound Hadlock's method was found to have the highest correlation with actual birth weight as compared to other methods, followed by Johnson's and Dare's method. The mean estimated fetal weight in kilograms by Johnson's formula was 2.992 ± 0.379, and that of Dare's formula was 3.223 ± 0.334, and that of Hadlock's formula was 2.977 ± 0.319. The mean actual birth weight was 2.999 ± 0.394 (Table 2). Dare's formula estimated more by 0.224 kg than the actual birth weight while the other two method estimated less than the actual birth weight. However, the difference between mean actual birth weight and Johnson's formula (0.007 kg) was very low than with Hadlock's formula (0.022 kg). The Bland and Altman plot for ABW vs. Johnson's formula (Figure 12), Dare's formula (Figure 13) and Hadlock's formula (Figure 14) shows that all three methods utilized to estimate fetal weight had fair agreement between methods of measurement and the actual birth weight.

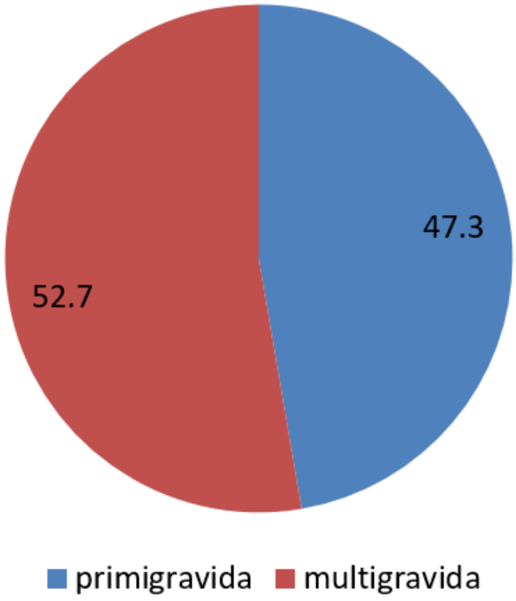

Figure 6: Distribution of participant by obstetric score

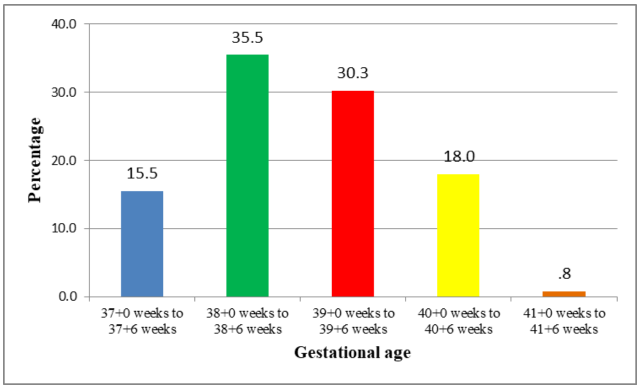

Figure 7: Gestational age distribution

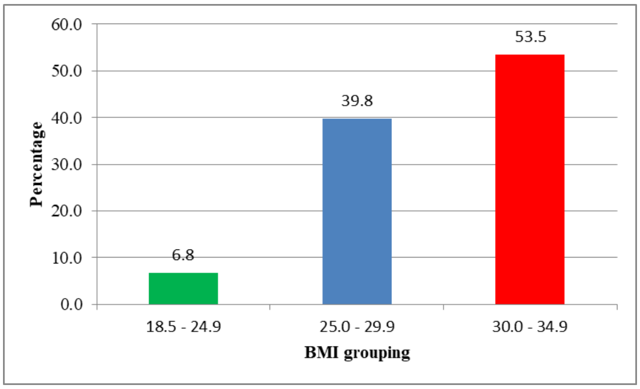

Figure 8: BMI

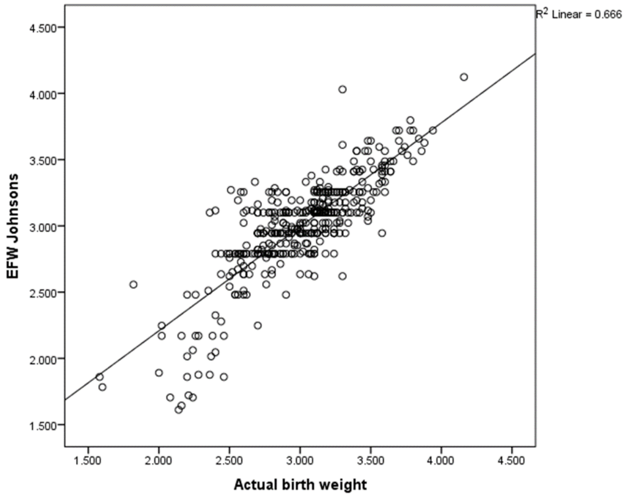

Figure 9: Scatter plot for Johnson's formula vs. Actual birth weight

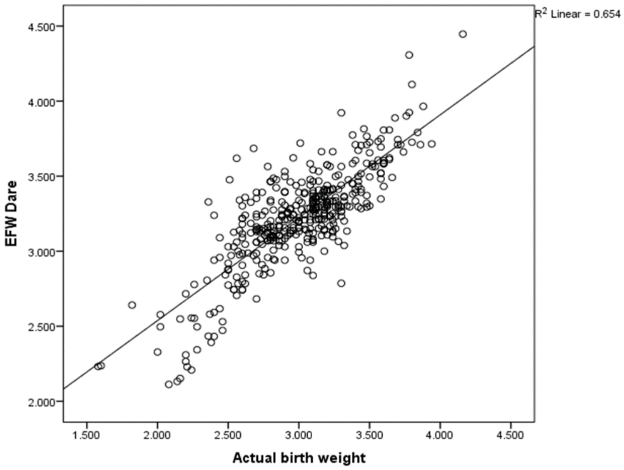

Figure 10: Scatter plot for Dare's formula vs. Actual birth weight

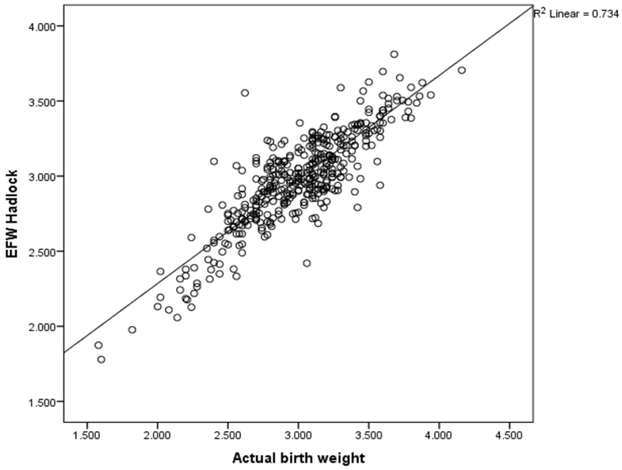

Figure 11: Scatter plot for Hadlock's formula vs. Actual birth weight

4. Discussion

A total of 400 term antenatal women satisfying the selection criteria were examined. The fetal weight estimation was done 48 hours prior to delivery by Johnson's and Dare's formulae and ultrasound Hadlock's formula and was compared with the birth weight. EFW by Hadlock's formula was the best out of the three formula used followed by Johnson's formula and Dare's formula.

Determination of gestational age by uterine fundal height and relating to the specific landmarks in abdomen was initially used as a method of assessing fetal growth. But neither fetal growth nor the abdominal landmarks were similar in pregnant women. This implication was proved wrong in early 1970s.[7] This led the clinicians to search for new methods of estimating fetal weight.

Table 1: The intra-class correlation coefficient of different methods with actual weight of the baby after birth

Method	Intraclass Correlation	95% Confidence Interval	P value
Johnson's formula	0.816	0.780 – 0.846	< 0.001
Dare's formula	0.672	0.142 – 0.848	< 0.001
Hadlock's formula	0.836	0.804 – 0.864	< 0.001

Table 2: Summary of the baby weight by different methods

Method	Mean ± Standard Deviation weight in kg	Minimum Weight	Maximum Weight
Johnson's formula	2.992 ± 0.379	1.612	4.123
Dare's formula	3.223 ± 0.334	2.112	4.447
Hadlock's formula	2.977 ± 0.319	1.779	3.811
Actual birth weight	2.999 ± 0.394	1.580	4.160

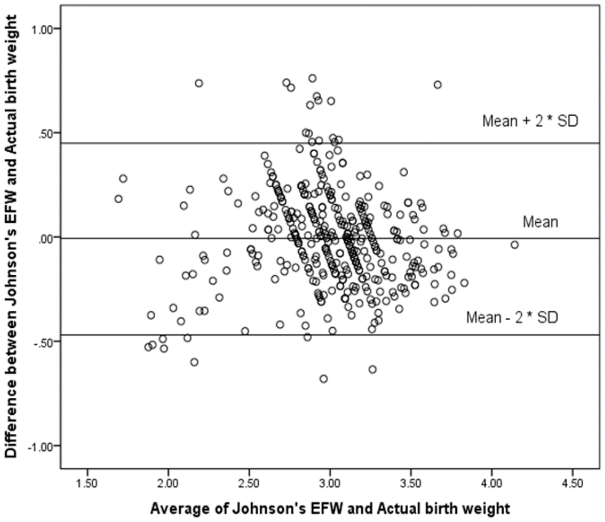

Figure 12: Bland and Altman plot for Johnson's formula EFW vs ABW

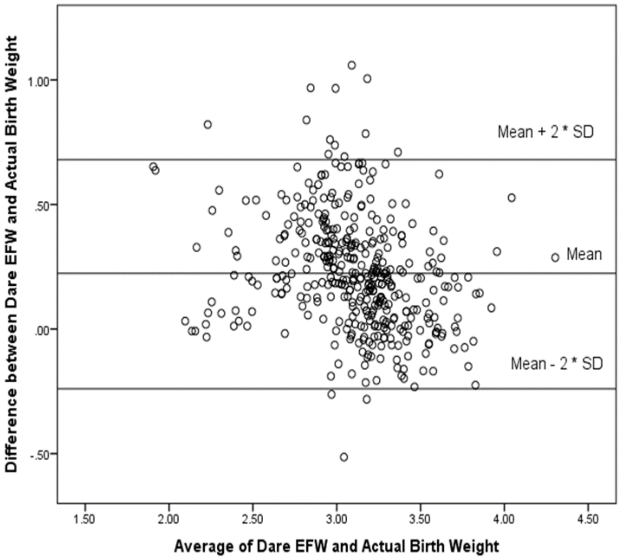

Figure 13: Bland and Altman plot for Dare's formula EFW vs ABW

Almost 30 formulae had been proposed by different researchers for fetal weight estimation. Complicated methods and calculations involved in such formulae were unacceptable by most of the obstetricians and are currently not in use. The fetal weight estimation methods that were easy and simple were used and compared by several scholars. Johnson's formula and Dare's formula were the most practical and easier to use as compared to other clinical methods. These formulae are still in use in several health facilities even after the advent of ultrasound.

The main advantage of Johnson's formula is that it requires no more than a measuring tape to derive estimated fetal weight. It is easy to use and has been widely used in many clinical institutions. Many previous studies showed that it gives estimation almost close to the actual birth weight.[8–11]

Most of the studies that compare estimated fetal weight were subjected to inter-observer bias. In most of the previous studies, more than one obstetrician and more than one sonologists were involved in estimating the fetal weight resulting in a wide range of inter-observer bias.[8,10,12,13] This has been overcome by the provision of a single primary observer in this study.

Obesity, as a single factor, influences both clinical and ultrasound measurements. Due to thick abdominal wall, clinical measurement of symphysio-fundal height and abdominal girth might be falsely increased leading to error in estimation of the fetal weight. Also in ultrasound measurements, obesity might hinder proper visualization of landmarks resulting in bias. In this study, only antenatal women who have a BMI of < 35 kg/m^2 have been included. This is a major advantage of this study as compared to other studies.[14]

Amniotic fluid index also plays a role in estimating fetal weight. Both oligohydramnios and polyhydramnios influence clinical methods of estimating fetal weight. Oligohydramnios might present as fundal height less than

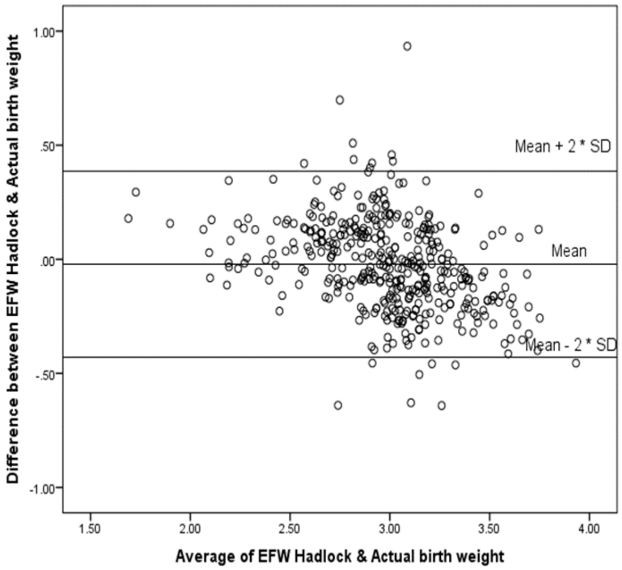

Figure 14: Bland and Altman plot for Hadlock's formula vs. ABW

that for the gestational age while polyhydramnios present as fundal height more than that for the gestational age. This would decrease or increase symphysio-fundal height respectively resulting in fetal weight estimation bias despite having an average sized baby. In this study, pregnant women with AFI less than 5 and more than 25 have been excluded to avoid this bias.

Fetuses with normal growth velocity are said to gain 200 grams per week. This means each day there is an approximate weight gain of 30 grams. Most of the previous studies did not mention this time interval or had a time interval more than acceptance.[15,16] In this study, the estimation of fetal weight to delivery interval was less than 48 hours. Thus, an increase of 30 to 60 grams of weight is expected within this interval. This marginal weight gain during this interval might not have much influence in the fetal weight estimation unlike other studies.

Malpresentations, multifetal gestation, preterm and postterm pregnancies, intrauterine fetal demise and anomalous fetuses were excluded from the study. These factors have influence on the symphysio-fundal height and so have been excluded. Ultrasound estimation may be a better alternative in these cases.

Johnson's formula provides variation in its calculation for engaged and unengaged head. Even though this variation is taken into consideration, each centimetre the head descends, there is a minor decrease in symphysio-fundal height. This may lead to bias in calculation. Dare's formula does not consider change in station of vertex. Ultrasonography becomes difficult when head becomes deeply engaged and measurements may be biased.

This is a prospective cohort study and the methods used to estimate fetal weight were based on standard formulae. As the study was conducted in a single centre by a single observer, there was no inter-observer bias. However, the first 100 samples were cross-checked by the senior physician to provide efficient results. Inter-observer variation was calculated and was minimal. The same measuring tape, ultrasound machine and electronic weighing machine were used for all the participants in order to avoid error in measurements. Each measurement was taken thrice and the mean of them was taken for evaluation. Thus, the measurements taken were more reliable and accurate.

This study was conducted in a single tertiary care centre. A larger study conducted at multiple centres may be required to know if there is any statistically significant difference amongst different ethnic and racial groups in estimation of fetal weight by different methods.

This study was conducted in a tertiary care centre in southern India. Pregnant women with BMI ≥35 kg/square metre were excluded from our study. With industrialization and life style changes, the incidence of obesity is increasing and so separate formulae may be needed for obese groups.

Ultrasound probably might be better for cases with AFI more than 25 and less than 8 as clinical methods will show either more or lesser fetal weight estimation respectively. Oligohydramnios is also in an increasing trend due to increased incidence of hypertension in pregnancy and other infections, while uncontrolled gestational diabetes mellitus, hydrops fetalis and other congenital anomalies cause polyhydramnios. Both oligohydramnios and polyhydramnios were excluded in this study despite having an increasing prevalence.

Even though the time interval between examination to delivery was less than 48 hours in our study, a weight gain of 30-60 grams is expected at the time of delivery. This weight gain was not taken into consideration for analysis in our study.

Thus, in present day obstetric practise, the obstetricians should acquire basic antenatal ultrasound skills apart from his or her clinical expertise to become a better health care provider to the antenatal women. The best obstetric practice and outcome depends on how the obstetrician correlates clinical and ultrasound examination without relying on the latter alone. The measurements taken are subjective and can vary from obstetrician to obstetrician. These subjective variations can be reduced to a great extent if the examination is done by an experienced obstetrician trained in antenatal ultrasound.

In places where there is non-availability of ultrasound equipment or trained personnel, a simple clinical method, the Johnson's formula can be used to estimate fetal weight. It provides results comparable to sonological estimation of fetal weight by Hadlock's formula. Dare's formula is less reliable.

Special circumstances like multifetal gestation, oligohydramnios, polyhydramnios, obesity and intrauterine fetal demise require further studies for application of clinical methods of estimation of fetal weight. As all these complications are increasing with advent of ART, changes in food and lifestyle and industrialization, clinical estimation of fetal weight becomes even more important in pregnant women with such complications. Ultrasound can be used as a better alternative for estimating fetal weight.

5. Conclusion

Both clinical methods i.e., Johnson's formula and Dare's formula and sonographic method i.e., Hadlock's formula are reliable methods for estimation of fetal weight. However, ultrasound estimation of fetal weight by Hadlock's formula has the best prediction with actual birth weight amongst the three methods. Thus, ultrasound estimation of fetal weight is the best method followed by Johnson's and Dare's method, all three of which have statistically significant agreement with the actual birth weight.

6. Source of Funding

No funding was involved.

7. Conflict of Interest

The authors declare that they have no conflict of interest.

8. Informed Written Consent

Informed written consent was obtained from all individual participants included in the study.

9. Ethical Approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors.

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