DOI -**10.21276/obgyn.2024.10.2.20** *ISSN Print – 2454-2334; ISSN Online – 2454-2342*

RESEARCH ARTICLE

A comparative study of clinical methods and ultrasound methods for prediction of fetal birth weight at term gestation

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ABSTRACT

Objectives: To compare the clinical and sonographic fetal weight estimation at term gestation. **Methods**: This prospective observational study included 500 antenatal women with singleton pregnancy with gestational age (GA) between 37-41 completed weeks delivering within 24 hours of admission and in labor or booked for elective caesarean section. Estimated fetal weight (EFW) was determined by three clinical methods (Leopold Manoeuvre, Johnson's formula, and Dare's formula) and ultrasound estimation (Hadlock's formula). The calculated weight (by all methods) was considered accurate if they were within ±10% of actual birth weight (ABW). All the measurements were tabulated in a datasheet and compared with ABW after delivery of fetus. P-value <0.05 was considered statistically significant. **Results**: Absolute mean error in prediction of actual fetal weight was significantly different among different methods with highest mean error being with Johnson's method (359.37±97.09) and lowest error being with Leopold's method (212.65±69.99), with ultrasound (233±65.86) showing the value in between both of them with p-value <0.0001. For predicting actual birth weight within the range of 10% in total study subjects, ultrasound showed the best closest estimate with 90.8% cases followed by Leopold's method with 87.80% cases, Johnson method (80.00%) and Dare's method (79.00%) (p<0.0001). **Conclusion**: Clinical methods and USG are accurate in prediction of the ABW. Among clinical methods, Leopold's maneuver was most accurate and comparable to USG. The accuracy of clinical method in comparison to sonographic method for prediction of actual birth weight may allow for its use in low resource settings.

Keywords: Actual birth weight, clinical fetal weight estimation, Dare's formula, Hadlock equation, Johnsons Formula, ultrasonography.

Estimating foetal weight is a significant component of obstetric management for high-risk patients since it aids in taking decisions during labour for avoiding complications.[1] During the first 24 hours after delivery, low 5-minute APGAR scores, severe foetal acidaemia, and seizure were reported to be more common among neonates with low birth weight children (below the third percentile).[2] Moreover, intrapartum hypoxia is found among foetuses with intrauterine growth restriction (IUGR) when exposed to the stress of labour.[3]

According to Kamanu et al[4] and Ezegwui et al,[5] vaginal delivery of macrocosmic foetuses is associated with a significant rise in perinatal as well as maternal complications. It's also been proven that birth weight is a significant predictor of infant mortality in the first year of life, and that mortality rates are more sensitive to birth weight as compared to gestational age. As a result, correct prediction of fetal birth weight may aid in the identification of foetuses at risk, which would necessitate close monitoring of labour as well as a caesarean section.[6]

The existing techniques for estimation of foetal weight can be divided into two categories: (1) clinical methods, such as Leopold's manoeuvre; clinical risk factors, such as maternal self-estimated foetal weight; and birth weight

Received: 2nd January 2022, **Peer review completed**: **9th April 2022**, **Accepted: 15th April 2023**.

Khatri R, Bhardwaj G, Rawal S, Kumar RR, Malik N. A comparative study of clinical methods and ultrasound methods for prediction of fetal birth weight at term gestation. The New Indian Journal of OBGYN. 2024; 10(2): 349 - 56.

prediction equations; and (2) imaging methods, such as ultrasonography (USG) and magnetic resonance imaging. The accuracy of USG foetal weight measurement averages 70% within 10% of actual birth weight (ABW). Unfortunately, with macrosomic and small infants, this accuracy reduces significantly.[7]

The multiplicity of many regression formulae for estimating fetal weight only represents the efforts of increasing the accuracy of USG to estimate fetal weight. Nearly 31% accuracy within 10% of the ABW is found by the use of the Woo equation, which is on the basis of the abdominal circumference (AC) and biparietal diameter (BPD). About 70% accuracy within 10% of ABW is found by the use of the Hadlock equation, which is on the basis of head circumference and femur length, AC, and BPD.[8]

The scarcity of USG in underdeveloped nations, particularly in rural areas where a larger proportion of the population lives, exacerbates the difficulties associated with using ultrasound to estimate foetal weight. This emphasises the significance of enhancing clinical skills in foetal weight estimation. Clinical foetal weight estimation has been demonstrated to be 70% accurate within 10% of ABW and compares favourably to ultrasound foetal weight estimation. This technology is widely accessible, simple to use, economical, and simple to teach, rendering it a significant tool for reproductive health, particularly in resource-constrained places, and thereby contributing to the achievement of Sustainable Development Goal 3.[9]

When assessing foetal weight in the range of 2,500–4,000 gm, clinical estimation using tactile examination of foetal size is most accurate. When the birth weight is <2,500 gm, its accuracy is 40% to 49% within 10% of actual weight; however, the sensitivity of clinical and sonographic techniques in foetal weight assessment in foetuses with actual weight >4,000 g is 50%. Although several obstetricians rely on USG to determine foetal weight.[10, 11] Clinical methods offer the benefit of being more cost-effective and accessible, particularly in resource-constrained areas.[12] The present study was conducted to compare the clinical and sonographic fetal weight estimation at term gestation, to validate the utility of clinical methods.

Methods

This prospective observational study was conducted in the department of obstetrics and gynaecology for duration of 1 year (January 2019 till December 2019), after taking the ethical clearance from the institute. The study population included 500 antenatal women with singleton pregnancy with gestational age (GA) between 37-41 completed weeks delivering within 24 hours of admission and in labor (either latent or active phase) for induction or augmentation or booked for elective caesarean section. Exclusion criteria were the women with uterine fibroid or masses, eclampsia, placenta previa, multiple pregnancy, oligohydramnios or polyhydramnios, those who delivered >24 hours after clinical or sonographic fetal estimated weight, intrauterine fetal demise, fetus with congenital anomalies, and fetus with station > +1.

The sample size was based on the findings of Weiner et al [13] (2016) who observed that the rate of accuracy to predict macrosomia (with ±10% accuracy) and SGA (with ±10% accuracy) of clinical was 76.7% and 24.1% respectively and of sonographic was 43.3% and 89.7% respectively. Taking this value as reference, the minimum required sample size with 5% margin of error and 5% level of significance was 378 patients. To reduce margin of error, total sample size taken was 500.

EFW was estimated by three clinical methods namely Leopold Manoeuvre,[14,15] Johnson's formula,[16] and Dare's formula,[17] and USG estimation was done by using Hadlock's formula;[18] the details of which are described below.

1. Leopold manoeuvre or abdominal palpation method: The palms of the examiner were used to palpate the fetal parts to estimate the fetal weight. Each palm was equivalent to 400-500 grams depending on the titrated estimate established by the resident based on experience.

2. Johnson's formula: According to this formula,

Fetal weight (grams) = [FH (cm) - n] × 155

Where, FH- fundal height,

n = 13 (if station is minus)

n = 12 (if station is zero)

n = 11 (if station is plus)

Station was defined as the location of the lowermost point of presenting part with respect to the ischial spines.

3. Dare's formula: Fetal weight (grams) = AG (cm) × SFH (cm)

Where, AG- abdominal girth

SFH - symphysiofundal height.

4. Hadlock's formula: Estimation of fetal weight was done by ultrasound using the Hadlock's formula (1985) measuring the biparietal diameter (BPD), abdominal circumference (AC), head circumference (HC) and femur length (FL), which was already set in samsung USG machine installed in labour room of BSA hospital with 3.5 MHz transducer.

Log 10 BW = 1.5662 − 0.0108 (HC) + 0.0468(AC) + 0.171 (FL) + 0.00034 (HC)10 − 0.003685 (AC × FL)

For this fetal biometry in USG was done and the individual parameters were assessed as -

1. Scanning for BPD and HC: The BPD was measured at the level of midline echo complex (the interhemispheric fissure), two lateral ventricles and the thalami showing the widest diameter in the scan. HC was measured in the same plane used for BPD measurement.

2. Scanning for AC: The transducer was placed at the right angle to the plane between the heart and the bladder; and includes the liver, the horizontal portion of portal vein along with the stomach bubble and the fetal spine. The AC was measured using the electronic callipers with maximum diameters with outer to outer technique.

3. Scanning for FL: Once the femur was located, an attempt was made to define both the ends of the calcified portion of femur. This was done most accurately when both the soft tissues of the buttock and the knee joint were able to be seen and usually avoids tangential section of the bone.

Additionally, the amniotic fluid index (AFI) was also measured and recorded using the standard four quadrant assessment technique. Third year senior residents who were approved for the study to estimate fetal weight by USG method after training for 10 days in fetal biometry by specialists in obstetric sonography performed all ultrasounds. All these senior residents performed sonographic EFW under supervision before the study period.

Written informed consent was taken from all patients as per PCPNDT act. Detailed medical and obstetric history was taken along with the examination. Clinical and sonographic estimation was done by two different third year senior residents. Each resident was blinded to the maternal characteristics (such as parity, height, diabetes). Each resident noted the findings separately and was unaware of the findings of other resident. The researcher correlated the findings by different clinical and USG methods with the actual birth weight (ABW).

The selected patients were asked to empty their bladder; and the SFH and AG in relaxed uterus with the patient supine and legs slightly flexed at knees were measured using a flexible, non-elastic standard measuring tape reverse-side up so as to forestall the bias; and the measurements were rounded to the nearest centimeters. AG was measured at the level of umbilicus without applying excessive pressure after encircling the tape on the women's abdomen. The fundal height was measured from the midpoint of upper border of pubic symphysis to the highest point of uterine fundus marked after centralizing the uterus. All these measurements were done by researcher in assistance of senior resident, so that one senior resident performed Leopold manoeuvre, other performed USG fetal weight estimation, and researcher made calculations based on Johnson's and Dare's formulae. Per-vaginal examination was performed by researcher to know the station.After delivery, the ABW was measured by staff nurse within 30 min of delivery on the same weighing machine calibrated in kilograms and grams corrected for zero error and it was recorded by researcher. If time interval between EFW and delivery was > 24 hours, the subject was excluded from the study. The calculated weight (by all methods) was considered accurate if they were within ±10% of ABW.All the measurements were tabulated in a datasheet and compared with ABW after delivery of fetus so that inference could be made for the best method of fetal weight estimation for that birth weight category.

Statistical analysis: The data was presented as "number and percentage (%)" or "means ± SD". The comparison of absolute mean error, mean percentage error and mean absolute percentage error between different methods was performed using ANOVA. The comparison estimates within ABW (±10%) between different methods in total study subjects, in normal birth weight and in low birth weight were analysed using Chi-Square test. Fisher's exact test was used for comparison of estimates within ABW (±10%) between different methods in macrosomia group. Sensitivity, specificity, positive predictive value and negative predictive value was calculated. The data entry was done in the "Microsoft EXCEL spreadsheet" and the final analysis was done with the use of "Statistical Package for Social Sciences (SPSS) software, IBM manufacturer, Chicago, USA, ver 21.0". For statistical significance, "p value of less than 0.05" was considered statistically significant.

Results

The mean age of the participants were 24.33±3.61 years. The majority belonged to lower socioeconomic status (40%) and were primigravida (55.20%). The mean weight, height, BMI, GA, SFH, AG, and AFI were 58.36±7.13 kg, 156.3±5.17 cm, 23.95±3.24 kg/m2, 39.33±1 weeks, 31.23±2.36 cm, 91.21±5.34 cm, and 7.96±1.63 cm, respectively (table 1).

Total 413 (82.60%) women had normal birth weight neonates, 83 (16.6%) women had LBW neonates, and 4 (0.8%) women had macrosomic neonates (figure 1).

Table 1: Distribution of maternal demographic characteristics

Maternal demographic	Frequency	Percentage
Age group(years)		
18-20	72	14.40%
21-25	278	55.60%
26-30	117	23.60%
31-35	30	6%
36-40	3	0.60%
Mean ± SD	24.33 ± 3.61 years	
Socioeconomic status		
Lower	200	40%
Upper lower	117	23.40%
Lower middle	101	20.20%
Upper middle	49	9.80%
Upper	33	6.60%
Parity		
Primigravida	276	55.20%
Multigravida	224	44.80%
Height (cm)		
<145	44	8.8%%
>145	456	91.20%
Mean ± SD	156.3 ± 5.17 cm	
BMI (kg/m2)		
Underweight (<18.5)	52	10.40%
Normal (18.5-24.9)	298	59.60%
Overweight (25-29.9)	129	25.80%
Obese (≥30)	21	4.20%
Mean ± SD	23.95 ± 3.24 kg/m2	
Weight (kg)	58.36 ± 7.13	
GA (weeks)	39.33 ± 1	
SFH (cm)	31.23 ± 2.36	
AG (cm)	91.21 ± 5.34	
AFI (cm)	7.96 ± 1.63	

The mean ABW was 2873.87 ± 406.04 gm and mean weight predicted by Leopold's was 2840.5±421.02 gm, by Johnson's was 2868.66±350.76 gm, by Dare's was 2857.73±338.07 gm, and by USG was 2892.12±405.2 gm (figure 2).

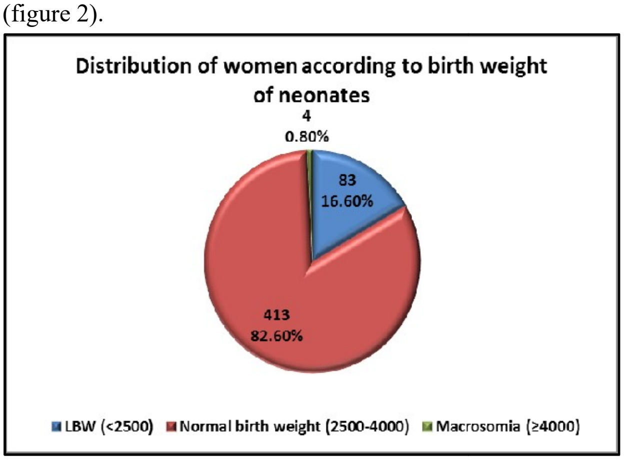

Figure 1: Distribution of women according to birth weight of neonates.

Absolute mean error in prediction of actual fetal weight was significantly different among different methods with highest mean error being with Johnson's method (359.37±97.09) and lowest error being with Leopold's method (212.65±69.99), with ultrasound (233±65.86) showing the value in between both of them with p-value <0.0001. Mean percentage error (%) in prediction of fetal weight in normal birth weight was significantly different among different methods with highest mean error being with Dare's method (-2.35 ± 5.89), and lowest error being with USG (1.52±5.06), with Johnson method (-1.82 ± 6.12) showing the value in between both of them with p-value <0.001. Mean percentage error (%) in prediction of fetal weight in low birth weight was significantly different among different methods with highest mean error being with Dare's method (8.83±5.42) and lowest error being with Leopold's method (-3.69±7.47), with USG (4.18 ± 5.55) showing the value in between both of them with p-value <0.001. Mean percentage error (%) in prediction of fetal weight in macrosomia group was significantly different among different methods with highest mean error being with Dare's method (-7.4 ± 3.18) and lowest error being with USG (-1.78 ±6.02), with Johnson's method (-4.87 ± 7.75) showing the value in between both of them with p-value =0.49 (table 2).

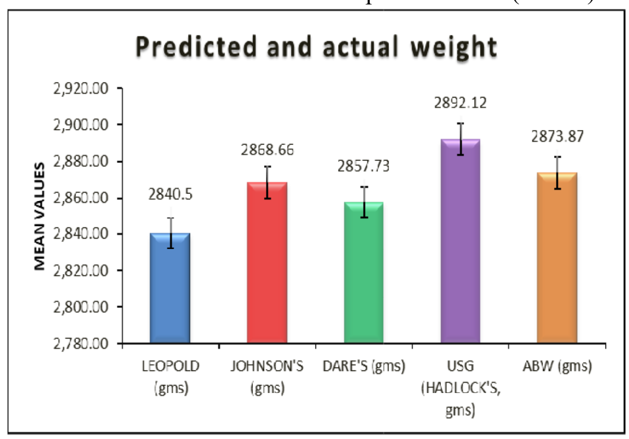

Figure 2: Graph showing mean values of ABW and predicted fetal weight by different methods.

For predicting actual birth weight within the range of 10% in total study subjects, ultrasound showed the best closest estimate with 90.8% cases followed by Leopold's method with 87.80% cases, Johnson method (80.00%) and Dares method (79.00%) (p < 0.0001). For predicting ABW (±10%) in normal birth weight, ultrasound showed the best closest estimate with 90.00% cases followed by Leopold's method with 89.52% cases, Johnson method (82.74%) and Dares method (82.25%) (p <0.001). For predicting ABW (±10%) in low birth weight, USG showed the best closest estimate with 82.77% cases followed by Leopold's method with 79.16% cases, Johnson method (67.11%), and Dare's method (63.49%) (p = 0.002). For predicting ABW (±10%) in macrosomia group, USG and Leopold's showed the best closest estimate with 100.00% cases in each followed by Johnson's and Dare's method (75.00% cases each) (p=1) (table 3).

Table 2: Comparison of absolute mean error, mean percentage error and mean absolute percentage error between different methods

Variables	Leopold's (gm)	Johnson's (gm)	Dare's (gm)	USG (gm)	P value
Absolute mean error in prediction of actual fetal weight	212.65 ± 69.99	359.37 ± 97.09	354.2 ±106.5	233 ± 65.86	<.0001*
Mean percentage error in prediction of fetal weight in total study subjects	-2.17 ± 4.47	1.29 ± 6.58	-1.04 ± 6.57	1.78 ± 5.18	<0.001*
Mean percentage error in prediction of fetal weight in normal birth weight	-2.05 ± 3.6	-1.82 ± 6.12	-2.35 ± 5.89	1.52 ± 5.06	<0.001*
Mean percentage error in prediction of fetal weight in low birth weight	-3.69 ± 7.47	8.07 ± 5.64	8.83 ± 5.42	4.18 ± 5.55	<0.001*
Mean percentage error in prediction of fetal weight in macrosomia group	-2.66 ± 3.33	-4.87 ± 7.75	-7.4 ± 3.18	-1.78 ±6.02	0.49*

* ANOVA

For normal birth weight group, ultrasound showed sensitivity, specificity, PPV and NPV of 92.20%, 74.70%, 92.40%, and 74.10%, respectively; Dare's method showed 94.50%, 60.80%, 89.00%, and 76.90%, respectively; Johnson's method showed 89.30%, 68.70%, 90.50%, and 65.83%, respectively; and Leopold's method showed 98.10%, 66.90%, 90.80%, and 91.60%, respectively (figure 3).

Table 3: Comparison of estimates within ABW (±10%) between different methods

Variables	Leopold's	Johnson's	Dare's	USG	P value
Estimates within ABW (±10%) in total study subjects	87.80%	80.00%	79.00%	90.80%	<0.0001†
Estimates within ABW (±10%) in normal birth weight	89.52%	82.74%	82.25%	90.00%	<0.001†
Estimates within ABW (±10%) in low birth weight	79.16%	67.11%	63.49%	82.77%	0.002†
Estimates within ABW (±10%)in macrosomia group	100.00%	75.00%	75.00%	100.00%	1‡

† Chi square test, ‡ Fisher's Exact test

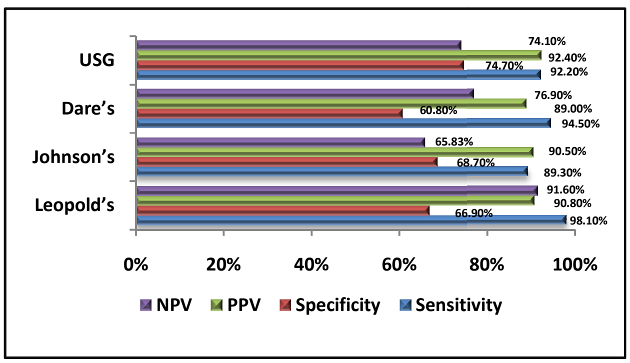

Figure 3: Accuracy of different methods to predict ABW in normal birth weight group (n=413)

For low birth weight group, ultrasound showed sensitivity, specificity, PPV and NPV of 78.30%, 94.90%, 75.50%, and 95.60%, respectively; Dare's method showed 63.80%, 97.30%, 82.80%, and 93.10%, respectively; Johnson's method showed 75.90%, 92.30%, 66.30%, and 95.00%, respectively; and Leopold's method showed 77.10%, 98.80%, 92.70%, and 95.50%, respectively (figure 4).

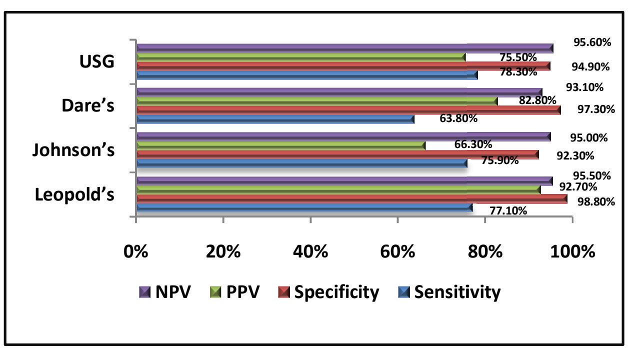

Figure 4: Accuracy of different methods to predict ABW in low birth weight group (n=83)

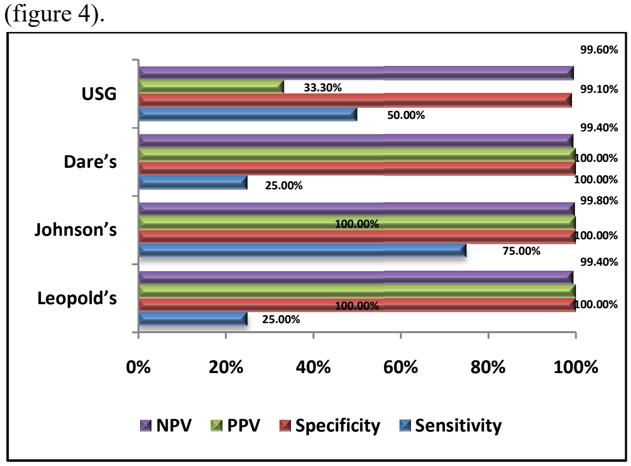

Figure 5: Accuracy of different methods to predict ABW in macrosomic group (n=4)

For macrosomia group, ultrasound showed sensitivity, specificity, PPV and NPV of 50.00%, 99.10%, 33.30%, and 99.60%, respectively; Dare's method showed 25.00%, 100%, 100%, and 99.40%, respectively; Johnson's method showed

75.00%, 100%, 100%, and 99.80%, respectively; and Leopold's method showed 25.00%, 100%, 100%, and 99.40%, respectively (figure 5).

Discussion

Estimation of fetal birth weight is critical as management of low birth weight babies can improve the outcomes of the pregnancy. A correct prediction of the estimated birth weight may help initiate treatment measures to better manage the pregnancy outcome.[19]

Though sonographic measurements of fetal body parts provides a direct way of assessing fetal size and weight through Hadlock's formula, the role of clinical methods by different formula such as Leopold's, Johnson and Dare formula may hold importance by providing a further substantial evidence.

We observed that ultrasound method and Johnson's method overestimated the actual body weight, while Leopold's method and Dare's method underestimated the actual fetal weight ($P<0.001$). Overall, Leopold's method showed the least mean absolute error of 212.65 gm, followed by ultrasound which showed a mean absolute error of 233 gm. Rest of the methods like Johnson's and Dare method showed even a higher error in prediction of actual body weight. Among other studies, Mgbafulu CC et al [1] compared the clinical methods (Johnson's and Dare's methods) with USG. It was found that the clinical methods overestimated the fetal weight. In prediction of actual body weight, Johnson's and Dare's methods showed mean percentage error of 17.12±7.59 and 15.95±7.79, respectively. The mean percentage error showed by USG was 0.77±9.38, which was least among the three methods.In the study by Yadav SS et al, [19] the fetal weight was overestimated by the clinical method, whereas fetal weight was underestimated by the ultrasonic method. Asto MR et al [20] found that Leopold's method was best as the mean absolute percentage error by Leopold's, Dare's and Johnson's methods was 3.96 ± 4.67 %, 7.44 ± 8.77% and 8.94 ± 10.16% respectively. Based on mean error, our study and many other studies found Leopold method to be the best or rather better than ultrasound method for predicting actual birth weight.

However, when the prediction was adjusted in terms of ±10% of actual body weight, it was found that ultrasound showed highest accuracy of 90.8% followed by Leopold's method with 87.8%, Johnson method with 80% and dare's method with 79%. This is consistent with the findings by Mgbafulu CC et al[1] as they also observed that the USG estimation within 10% of the ABW of 68.2% was significantly higher as compared to accuracy of Dare's formula within 10% of ABW (26.4%), Johnson's method within 10% of ABW (23.6%), and the combined clinical formulae (27.1%). Among other studies, Noumi et al [21] had reported 72% and 74% estimates within ±10% of ABW with clinical and sonographic methods respectively.

The differences in findings of the present study and other studies is because of the specific anthropometric characteristics of study population, the anterior abdominal wall thickness, size of placenta, and differences in volume of liquor in spite of being in the normal range. [1] In the present study, on comparing the methods against the birth weight of normal children, low birth weight children, and macrosomic child, it was observed that ultrasound overestimated the body weight in normal birth weight children and low birth weight children, while it underestimated the birth weight in macrosomic group. For rest of the methods, it was observed that Leopold's, Johnson's and Dare underestimated the body weight in normal birth weight, and macrosomic group, while for the low birth weight group, Leopold's method underestimated it and Johnson's and dare overestimated it. In terms of accurate prediction of the actual bodyweight, it was found that Leopold's method showed the least error for all the body weight of the children, be it normal body weight, low body weight, low birth weight or macrosomic child.

Ultrasound method held significance since it was better than Johnson's and Dare's method, but showed more error than Leopold's method. But this must be adjusted by calculating the actual body weight in ±10%, where ultrasound method showed the highest accuracy for all the body weight of the children. A similar trend was observed by Mgbafulu CC et al,[1] who found that in comparison to ABW, ultrasound overestimated the lower birth weight groups and underestimated the higher birth weight groups. The clinical methods poorly estimated the low fetal weight. The clinical estimation of fetal weight was more accurate over the 4.50–4.99 kg group. Consistent findings were reported by Suswannobol et al,[22] who observed increase in accuracy in the children with macrosomia in clinically estimated fetal weight. Nahum et al [8] and Shittu et al [12] also found that ultrasound overestimated the lower birth weight groups and underestimated the higher birth weight groups. On the contrary, Roy AG et al [13] found that Dare's and Hadlock's formulae demonstrated good correlation with ABW in all weight ranges (r- 0.77 and 0.72; $p<0.05$ for both); the best correlation was found at weight range of 2.5-3.5 Kg. Correlation was slightly lower at extremes of weight at both end. The clinical estimates were found to be as accurate as ultrasonographic for prediction of fetal weight.

Yadav SS et al [19] found that overall in study population, the clinical method overestimated fetal weight and ultrasonic method underestimated it. In the IUGR cases, clinical and USG methods overestimated birthweight; however, USG method was found to be significantly more accurate with smaller mean errors and more estimates within ±10% of actual birth weight. Comparable findings were reported by Sherman et al, [23] who reported that in LBW group, there were 48.5% and 63.4% estimates within ±10% of ABW by Leopold's and USG method, respectively ($p<0.003$). Higher values of estimates in our study could be due to smaller sample size (n=88) and we had performed estimation within 24 hours prior to delivery while Sherman et al[23] had performed fetal weight estimation within 1 week prior to delivery. Similarly, the higher estimates within ±10% and lower percentage errors were also observed in normal birth weight group in our study (n=413) as compared to the study of Sherman et al[23] (n=1389) which could be due to discrepancy in interval from fetal weight estimation to delivery in both studies. Noumi et al[21] also found similar findings as our study. They found that in macrosomic cases, the sensitivity was 50% by both clinical and sonographic methods (n=14). To improve the accuracy rate to predict macrosomia and LBW neonates by different clinical and sonographic methods, further studies are needed with more sample size.

Njoku C et al [24] found that clinical methods for estimation of fetal birth weight were accurate as they demonstrated higher sensitivity (75% vs.69.4%, P=0.3447) as well as negative predictive value (93.4% vs. 92.7%, P=0.7742) as compared to the ultrasonic estimation, whereas specificity (78.6% vs. 85.3%, P= 0.269) and positive predictive value (43.5% VS. 51.0%, p= 0.3215) ultrasonic estimation were higher compared to clinical estimation.

Limitations: The present study was limited due to subjectivity of clinical estimation. Other limitation was that only one sonographic equation (Hadlock's formula) was used to derive estimates of fetal weight. Also, fetal weight estimations were performed at various stages of labor which might have affected the accuracy of estimation. Lastly, there were relatively small number of neonates with macrosomia or SGA.

Conclusion

We found all clinical methods and USG to be accurate in prediction of the ABW. Among clinical methods, Leopold's maneuver was most accurate and comparable to USG. Clinical and sonographic estimation of fetal weight can be predicted by obstetric residents accurately. Clinical methods (Leopold's) showing comparable accuracy to sonographic method of fetal weight estimation may allow its use in low resource settings like rural India where USG facilities are not available and need more financial investment and skilled manpower.

Conflict of interest: None. **Disclaimer:** Nil.

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