Clinical Estimation of Fetal Weight with Reference to Johnson's Formula: An Alternative Solution Adjacent to Sonographic Estimation of Fetal Weight

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ABSTRACT

Background

Fetal weight estimation plays a significant role in the antenatal management of high risk pregnancies. It is also an important parameter for predicting the neonatal outcome and informs decision for the mode of intra-partum management of the pregnant women. Among the various methods of prenatal fetal weight estimation, the most commonly used are clinical estimation and sonography.

Objective

The objective of this study was to compare the accuracy of clinical estimation of fetal weight using Johnson's formula and sonographic estimation with actual birth weight.

Method

This prospective study was conducted at Dhulikhel Hospital, Kathmandu University Hospital, from January 2017 to August 2018. The study included 335 pregnant women at term gestation.

Result

The estimation of fetal weight at term pregnancy using Johnson's formula is as effective as sonological method. For clinical method, the fetal weight falls between 95 gm and 183 gm at 95% confidence interval. With respect to ultrasound method, the fetal weight is found to be 45 gm and 132 gm at 95% confidence interval at p value < 0.001.

Conclusion

Clinical estimation of fetal weight can be utilized as an alternative to sonological estimation in the management of labor and delivery. Johnson's formula is a simple, easy, cost-effective, and universally applicable method to predict fetal birth weight and can be used anywhere by doctors, nurses, midwives and paramedics in centers where ultrasound is not available.

KEY WORDS

Fetal birth weight, Hadlock's method, Johnson's formula

INTRODUCTION

Prenatal estimation of fetal weight helps to predict neonatal outcome. Both fetal macrosomia and intrauterine growth restriction (IUGR) increase the risk of perinatal morbidity, mortality and long-term neurological and developmental disorders.[1] Identification of IUGR after 37 weeks of gestation is an indication for delivery to reduce the chance of fetal mortality.[2] Similarly, diagnosis of macrosomia frequently leads to delivery by means of caesarean section to reduce the risk of a failed vaginal delivery and shoulder dystocia.[3] As fetal weight cannot be measured directly, it must be estimated from fetal and maternal anatomical characteristics. Many health workers have used different methods to achieve this.

The information gained by prenatal fetal weight estimation is crucial for obstetricians to decide the time and mode of delivery. None of the diagnostic tools are however confirmatory. Interestingly clinically estimated fetal weight is considered to be more precise than sonographic estimation of fetal weight.[4] In modern obstetrics, estimated fetal weight is incorporated into the standard routine antenatal evaluation of high risk pregnancy.[5] In preterm deliveries and intrauterine growth restriction, perinatal counseling on the likelihood of survival, interventions taken for delivery to occur is completely based on gestational age and estimated fetal weight.[6,7] A large proportion of this problem is related to birth weight which remains the single most important parameter that determines neonatal survival.[8]

In fetal macrosomia, the precise fetal weight estimation would help in successful management of labor and care of the newborn. Perinatal morbidity and mortality may decrease if timely intervention is undertaken.[9-11] 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.[12,13]

The advantages of sonographic estimation fetal weight over clinical methods were suggested to be due to the fact that sonographic fetal weight estimation relies on objective intra-uterine linear and/or planar measurement of fetal parameters, thereby eliminating subjectivity associated with the clinical methods.[14] Prenatal estimation of fetal weight has become increasingly important also in regard to the prevention of prematurity and in evaluation of fetopelvic disproportion. Where a large baby is suspected, induction of labor before term, is favoured in order to prevent complications during pregnancy and importantly to rule out intrauterine growth restriction.[15]

We aimed to compare prenatal estimation of fetal weight by Johnson's formula with sonographic estimation of fetal weight and to evaluate the utility of each. The data may allow gross estimates of the fetal weight sufficient to predict complications associated with fetal birth weight. Such a prediction could indicate that the woman would require operative delivery and she could be transferred earlier to a higher center thus, reducing the likelihood of maternal and fetal morbidity or mortality.[16]

METHODS

The study was conducted at the Department of Obstetrics and Gynecology and Department of Radiology at Dhulikhel Hospital, Kathmandu University Hospital. This prospective observational study involved 335 women from January 2017 to August 2018. The sample population was women admitted in the labor and maternity ward for delivery during the study period. Those women who had a singleton pregnancy, vertex presentation and maternal body mass index (BMI) between 17-26 kg/m² were included in the study. The women with a complicated pregnancy due to chronic diseases, diagnosed with olighydramnios or polyhydramnios, an associated uterine or abdominal mass, intra uterine fetal death (IUFD) or abortion cases were excluded from the study.

The sample size for the study was determined using single population estimation formula: N= P (1-P) Z2/d2 and statistical power were calculated using G* Power 3.1. The total of 325 women were required in order to give a precision of 5% around an observed percentage of an estimated fetal weights within 10% of the birth weight at one tailed alpha of 0.05 and statistical power of 90%. However, 335 women were included in the study to increase power of the study. Purposive sampling technique was utilized for the study.

A quantitative structured questionnaire was administered to the women recruited in the study. The interview took around five minutes on average and was complemented by clinical examination and structured observation. The primary outcome variable was a measure of accuracy of Johnson's formula. Data were collected on age, ethnicity, marital status, occupation of women, educational status, annual income, gravidity, gestational age, pre-pregnancy body mass index, symphysio-fundal height (SFH), membrane status, actual birth weight and sex of the neonate. The questionnaire was developed from standardized questions following international guidelines and incorporated amendments necessary to meet the condition in the study. The questionnaire were pretested and adapted to ascertain the reliability of the questions used in the final survey instrument.

Women meeting the inclusion criteria of the study were recruited as participants in the study. Verbal and written consent from the participants was obtained. Immediately after admission, baseline data were collected using the formatted questionnaire. The gestational age was recorded from the last menstrual period (LMP) and early sonography. Pregnant mothers with unknown LMP were also involved where the gestational age could be determined

retrospectively after delivery using the Ballard score. The estimated prenatal fetal weight was recorded by applying following methods.

(a) Clinical method of fetal weight estimation using Johnson's formula

All mothers were asked to void urine before measurements were taken. Abdominal examination was done between contractions with the woman in the supine position. Measurement was made from the upper edge of the pubic symphysis following the curvature of the abdomen with a tape. The upper hand was placed against the top of the fundus of uterus with the measuring tape passing between the index and the middle fingers. Readings were taken from the perpendicular intersection of the tape with the fingers.

Fetal weight in grams = (Fundal height in cm − 11/12/13) according to the station x 155

The station was determined by the position of the presenting part, if at the level of ischial spines (zero station) 12 was subtracted from fundal height in cm, when above the level of ischial spine (minus station) 13 was subtracted and when below the level of ischial spines (plus station) 11 was subtracted from fundal height.

(b) Fetal weight estimation by Hadlock's formula using sonography

Sonographic examination was performed in all patients using a 3.5 MHz convex assay and linear assay transverse (LOGIQ model with M & B mode for simultaneous imaging and calculation of the fetal heart rate). After bi-parietal diameter (BPD) abdominal circumference (AC) and femur length (FL) were measured in centimeters (cm), the sonography machine calculated fetal weight by formula.

Log10 (EFW) = 1.4787 − 0.003343 AC x FL + 0.001837 BPD2 + 0.0458 AC + 0.158F

The predicted fetal weight estimated by each method was compared with respective neonatal actual birth weight.

After delivery, the actual birth weight was recorded. The birth weight was measured within 30 minutes after birth using baby scales. Frequent checking was performed to ensure the scales are correctly zeroed and calibrated.

Data entry was performed daily during the study period. Clinical data were double entered into an MS Excel 2010 spread sheet (Microsoft; Redmond, USA) and cross-checked. Descriptive analysis included mean and standard deviation for normally distributed data and median and inter-quartile range otherwise. Frequencies expressed as percentages with 95% confidence intervals. The absolute value of the difference between the estimated fetal weight and the birth weight was calculated for each case and from this the mean weight. Percentage error is calculated as the absolute weight difference divided by the birth weight, multiplied by 100. Percentage errors were also grouped as being within 100 gm, 200 gm or 400 gm of the birth

weight. Percentage error within 100gm of the birth weight was considered most accurate. We assessed associations between the outcome variables and hypothesized risk factors using multivariable linear regression models with random study site intercepts and controlling for potential confounders with the demographic variables of age, sex, and socioeconomic status. The associations were considered as statistically significant if p-values were < 0.05. The statistical analysis was performed with SPSS version 20.

Ethical approval was received from the Dhulikhel Hospital, Kathmandu University Hospital, and Ethical Review Board. Oral and written informed consent was obtained from each study participant before interview and the objective of the research was explained beforehand. All the information collected from the study participants were handled confidentially and anonymized by omitting their personal identification.

RESULTS

This study recruited 335 participants who were followed up through to delivery. Most of the study participants 176(52.7%) had their complete antenatal care (ANC) at Dhulikhel hospital, 144(43.1%) had visited outside the hospital and 17(4.5%) had mixed ANC both within and outside the hospital.

The majority of participans 324(96.6%) had four or more ANC visits and 11(3.3%) had ANC visits only less than four times. The study participants were mostly residents of areas near to Dhulikhel Hospital: Kavre 5(1.5%), Barabise 11(3.3%), Bhaktapur 66(19.5%), Chautara 34(10.2%), Kabhrepalanchok 10(3.0%), Ramechhap 20(6.0%), Sindhuli 30(9.0%), Sindhupalchok 39(11.7%) and Dhulikhel 120(35%). A total of 23 participants were referred to Dhulikhel Hospital from the outreach centers due to following causes: fetal bradycardia 4(17.4%), fetal tachycardia 1(4.3%), high blood pressure 5(21.7%), meconium stained liquor 7(30.4%), NPOL 3(13.0%), previous caesarian section 1(4.3%), and prolonged labor 2(8.6%).

Most of the participants were primigravida 160(47.9%), whereas 97(28.2%) were multigravida with gravida two, 57(17.1%) gravid three and 21(6.3%) grand multiparous. In majority of cases fetal weight played a major role in determining the mode of delivery. Most 240(71.9%) were normal deliveries in Dhulikhel Hospital. Other modes were 78(23.4%) LSCS, 15(3.0%) vacuum assisted vaginal delivery, and 4(4.5%) vaginal birth after caesarean section.

Johnson's formula was used to assess differences between clinical and sonographic estimation of fetal weight. The two charts presented showed the difference on fetal weight. The first one is showing variation in estimation of fetal weight by sonological method and the second about

variation in estimation of fetal weight by clinical method using Johnson's formula.

A total of 146(43.5%) had estimation of fetal weight within 200-400 gm, 61(37.2%) had within 100-200 gm, 125(18.02%) had within 100 gm and 3(0.98%) had above 400 gm. This finding suggests that the maximum variation in sonology is within 200 to 400 gm in the study population followed by within 100 gm which determines the accuracy of the method.
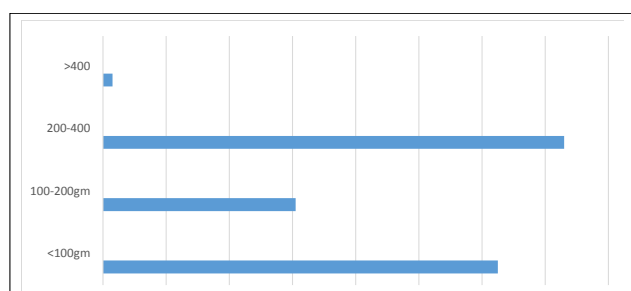

Figure 1. Graph showing variation in estimation of fetal weight by sonological method.

Figure 2 shows maximum variation of fetal weight within 200 gm to 400 gm. A total of 178(56%) within 200 to 400 gm and 83(11%) more than 400 gm of the study population had the accuracy of estimation in actual birth weight, 59(24%) within 100 to 200 gm and 15(8%) of population with accuracy within 100 gm of actual birth weight. The findings with respect to sonological and clinical estimation suggest maximum variation in sonology within 200 to 400 gm in the study population followed by within 100 gm. This accuracy determines that use of clinical estimation of fetal weight by applying Johnson's formula as clinical estimation have significant importance in estimation of birth weight at circumstances where ultrasound is not available and feasible.
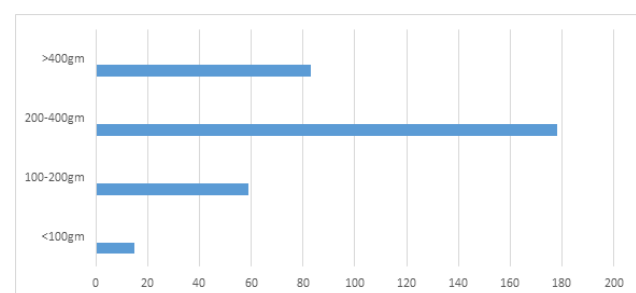

Figure 2. Graph showing variation in estimation of fetal weight by clinical method using Johnson's formula

This study showed that maximum number of study population had the actual birth weight estimated clinically using Johnson's formula for the estimation of fetal weight within the 200 to 400 gm i.e. more than 50% and around 10% had variation of more than 400 gm from the actual birth weight which was later on analyzed to be in the obese participants. Most of these participants were referred cases

and had other co-morbid conditions like pre-eclampsia and in some cases they were referred in view of non-progress of labor.

The estimation of fetal weight and comparing that with the actual birth weight participants utilized for this study were followed up till their delivery. The outcome regarding estimating fetal weight clinically and comparing with actual birth weight, the variation is shown in Table 1. In Table 1, the clinical estimation using Johnson's formula have estimation of assessment of fetal weight with respect to sonological method. Sonological method has more accuracy in estimation of fetal weight with minimal variation.

Table 1. Variation in estimation of fetal weight by different method

Details	Clinical estimation of birth weight (gm)	Sonologically estimated fetal weight (gm)	Birth weight
No	335	335	335
Mean	2988.71	2760.63	2849.58
Median	2900	2800	2680
Mode	2800	2500	2600
Std. Deviation	289.846	241.584	329.661
Minimum	2450	2200	2360
Maximum	3800	3600	4000

In order to estimate fetal weight and comparison with actual birth weight, the study participants in this study were followed up till their delivery. The outcome regarding estimating fetal weight clinically and comparing with actual birth weight, the variation is shown in Table 2. The clinical estimation using Johnson's formula having estimation of assessment of fetal weight with respect to sonological method is shown. The sonological method has more accuracy in estimation of fetal weight with minimal variation. Using Post Hoc test, multiple comparison is done and the p-value is derived which is found to be < 0.001, thus making the findings significant.

Table 2. Multiple comparison using Post Hoc test

Method (I)	Method (J)	Mean difference (I-J)	Std. Error	P value	95% confidence intervals
Clinical	USG	228.08	22.38	0.001	184.16-272.01
	Actual	139.13	22.38	0.001	95.20-183.06
USG	Clinical	-228.08	22.39	0.001	-272.01-(-184.16)
	Actual	-88.95	22.38	0.001	-132.88-(-45.02)
Actual	Clinical	-139.13	22.38	0.001	-183.06 -(-95.20)
	USG	88.95	22.38	0.001	45.02-132.88

DISCUSSION

Accurate estimation of fetal weight is of paramount importance in the management of labor and delivery. During the last decade, estimated fetal weight has been incorporated into the standard routine ante-partum evaluation of high risk pregnancies and deliveries both within Nepal and across the world.[6,17,18] A lot of work has been carried out to find accurate methods to estimate of fetal size and weight in utero. They include clinical and ultrasound estimations.[9-11,17,18]

We found the accuracy of estimation of fetal weight by Johnson's formula to be within 20% in 70% of these macrosomic babies and by ultrasound to be within 40% in 70% of these cases. In a study done by Sharma et al. showed that clinical estimation was more accurate in determining fetal weight, particularly in macrosomic babies and those diagnosed GDM cases, with the estimation of fetal weight within 20% of 60% of their study population.[19-22] Similarly, this study conducted at Dhulikhel hospital showed around 12% of the cases were macrosomic and in this group 65% were diagnosed as GDM before delivery. Despite the differences in study design, our findings are in aggreement with those reported by other studies that the accuracy of clinical estimation of birth weight is similar if not better than ultrasonic estimation. The studies by Hendrix et al. and Raman et al. showed that clinical estimation was significantly more accurate than the sonographic prediction.[11,23,24] Similar results was obtained by Sharman et al. and Titapant et al. who observed that ultrasonic estimation was more accurate only in cases of low birth weight.[12,25] Husslein et al. found clinical examination to be as a good predictor as ultrasound measurement in assessing fetal macrosomia in a diabetic population.[6]

We found that more than half 55% of the study population, had actual fetal birth weights within 200 to 400 gm of the prediction and 10% were within 100 gm of the actual birth weight which is similar to Tiwari and Sood's study.[26] In Sirohiwal et al. study, using Handlock's formula for estimation of fetal weight, 74 % of study population had birth weight within 200-400 gm of actual birth weight.[27] In contrast the accuracy was 54% within 300 gm by clinical estimation when compared to Johnson et al. and Sirohiwal et al.[1,27] The similar results were found by Bhandary et al. where 97% of babies, the percentage errors was restricted to 15% by Hadlock's method compared to 87% of cases when Johnson's formula was used.[28] Tiwari et al. found 92% cases within 15% error by ultrasound and 78% of cases by Johnson's method.[26] This can be explained as they considered only women with the vertex just sitting at the brim, whereas in the present study all the women irrespective of the station of the head were included as per Bhandary et al.[26,28]

Around 1.8% of the study population in our study had previously diagnosed polyhydramnios before delivery. In this case the accuracy of estimation by sonography was within 10% and clinical estimation using Johnson's formula was within 40%. Thus, making the sonological method superior to clinical method in patients with underlying placental pathology or amniotic fluid abnormality which has not been detected clinically due to lack of experience in the examiner. Similar studies have shown a sharp contrast to the above observation, Shamley et al. in 1994, compared clinical and ultrasonic methods, using Hadlock's formula and a non-standardized clinical method.[29] They noted that the error clinical estimaton was significantly higher than using Hadlock's formula.[29] The difference from our results may be attributed to the use of a standardized method for clinical estimation. The estimates in our study were obtained independently by two different observers (i.e. the attending resident from the obstetrics department and the on duty consultant from the Department of Radio diagnosis) in the obstetrics and radiology units respectively; precluding the possibility that one estimate may influence the other. The estimations were also done within 24 hours of delivery to increase the predictive power of each method.

In our study, we used a standardized method of clinical estimation that had been found previously to correlate well with birth weight, making it a unit protocol in various rural outreach centers in Nepal. The Hadlock formula present on the ultrasound machine in our radiology unit was used for ultrasonic estimation since authors who had compared the accuracy of conventionally-used formulae suggested that no single formula estimated birth weight more accurately to a significant degree than any other formulae, so to eliminate the potential bias our estimations only used the Hadlock formula.

Our findings have important implication for developing countries such as Nepal here there is lack of technologically-advanced ultrasound machines with sophisticated functions to estimate fetal weight but there are experienced clinicians who could perform this function equally well with clinical examination. Further studies are, necessary to improve the accuracy of fetal weight estimation and to determine if fetal weight prediction near delivery actually improves outcome; to assess how applicable these methods can be in situations that lead to altered birth weight such as premature rupture of membranes and obesity that were excluded in the present study. Despite of these strengths, our study has some limitations i.e. the subjectivity of clinical estimation; Use of only one sonographic model to derive estimates of fetal weight and no confirmation that the formula used (Hadlocks 3) is universally applicable.[12,30,31]

CONCLUSION

The overall success rate for estimation of fetal weight by Johnson's formula was high with a variation of less than

400 gm. Estimation by sonography gave a similar variation to clinical estimation. Thus, we conclude that clinical estimation of fetal weight is an effective approach for the estimation of fetal weight and can be done with reasonable accuracy by Johnson's formula similar to predictions using obstetric sonography. Therefore in rural settings where ultrasound facility is not available, an alternative clinical method using Johnson's formula can be effective for predicting fetal weight.

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