Accuracy of Ultrasound Estimation of Fetal Weight at Three Teaching Hospitals in Addis Ababa

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Abstract

Background

Ultrasound examination and measurement of fetal weight have become an integral part of modern obstetric care. Knowing the accuracy of the ultrasound estimation of fetal weight (EFW) and what factors affect it helps make a more informed decision. Fetal weight estimation is thought to help predict fetal survival and make management decisions in the low birth weight group and in managing the delivery of the large baby, where complications may occur.

Objective

To assess the accuracy of ultrasound estimation of fetal weight.

Methods

The study design was a facility-based prospective cross-sectional study comparing sonographic EFW with actual birth weight, involving 384 women admitted to the study hospitals. And assessed 12 factors that might affect accuracy (place of delivery/scan, level of the operator, time of scan (working vs. non-working hours), fetal presentation, liquor volume, placental location, days passed between scan and delivery, time of the scan to labor (antepartum vs. intrapartum), fetal sex, maternal BMI, gestational age, and fetal weight. Data were collected using structured questionnaires, developed based on study variables and available literature, and analyzed using SPSS software.

Result

The EFW that is within 10% of the actual birth weight is 62.4%. The overall mean error of EFW was 9.1%, with an SD of ± 7.1%. Of the 12 factors assessed, it was found that the place of delivery/scan ($p = 0.017$) and the level of resident experience ($p = 0.47$) significantly affected the accuracy. When R4 was compared to R1's OR = 4.656(95%CI, [1.111–19.506], $p = 0.035$) and R2's OR = 2.112(95%CI,[1.062–4.201],$p = 0.033$) but not significant when compared to R3's OR = 1.227(95%CI,[0.563–1.191],$p = 0.607$). A paired sample t-test was applied ($P = 0.14$).

Conclusion and recommendation

The EFW of R4's was significantly different from that of R1's and R2's, but not R3's we recommend that all ultrasound scans whose weight estimation can affect the management plan of the patient to be done by the senior residents rather than the junior residents i.e. the R3's and R4's.

Background

Obstetrics took a great leap forward with the advent of ultrasound in the second half of the 20th century with the ability to image the pregnant uterus and its contents. EFW in late pregnancy or before delivery is

often an important variable in clinical decision-making in obstetrics. Fetal weight estimation is of key importance in the decision-making process for obstetric planning and management (1).

Ultrasonographically, EFW is obtained from measurements of fetal parts and the use of these measurements in a regression formula to derive birth weight. Obstetric ultrasound has turned from a luxuries instrument that is used seldom into an almost basic and integral part of the obstetric examination.

When scans are done by well-trained sonographers, most studies show a mean absolute error in birth weight prediction of approximately 8–10% of the birth weight (2). Perhaps a more telling statistic is that in about 30% of cases, the absolute error in estimated weight is greater than 10% of the birth weight. In most of the remaining cases, the error is less than 20% of the birth weight. (2) The rate of clinically significant errors is greater if an inexperienced person performs the ultrasound examination (3).

Antenatal care has focused on the diagnosis of fetal growth restriction, which may be associated with iatrogenic premature delivery, intrauterine fetal compromise, or intrauterine demise, which will all result in decreased fetal weight for the gestational age. On the other hand, the delivery of macrosomic infants is equally important and is associated with higher rates of adverse outcomes for both mothers and infants in comparison to the delivery of normal-weight infants. Risks to the large infant include shoulder dystocia, brachial plexus injury, perinatal asphyxia, and neonatal death. Adverse maternal outcomes include prolonged labor, genital tract trauma, postpartum hemorrhage, and a higher risk of cesarean section (4, 5). Accurate prediction of both small and large infants plays an important role in obstetric clinical practice.

The accuracy of EFW is documented as the percentage of correctly estimated fetal weights (usually stated as < 10% difference from the actual birth weight), and the studies put the results indicate how number of the scans were within 10% of the actual birth weight, and some also assessed that many scans was within 5%, 10%, or 20% of the actual birth weight after delivery. Some just put the mean absolute errors ± standard deviation of ultrasound fetal weight estimations.

There have been A large number of studies in which the accuracy of ultrasound for predicting birth weight has been evaluated (6, 7).

Ultrasound results in the ± 10% of actual birth weight were 62.9% in a study done in Italy in 2008 involving 589 pregnant women using 35 different formulas. Only patients delivered within 48 hours were included and concluded that most formulas are relatively accurate at predicting birth weight up to 3,500 g, and all algorithms tended to underestimate large fetuses (8).

When we see studies done on our continent with residents doing the scan, one study in Tunisia in 2015 involving 500 pregnancies was scanned on day of delivery by Ob-Gyn residents showed a result in the range of ± 10% in 75.2% of the cases. Linear regression analysis revealed a good correlation between EFW and birth weight ($r = 0.79$, $p < 0.0001$). In conclusion, the EFWs calculated by residents were as

accurate as those calculated by experienced sonographers. Nevertheless, predictive performance remains limited, with low sensitivity in the diagnosis of macrosomia (9).

There are also different studies done to assess the factors affecting the accuracy of the EFW. One of the studies concluded that advancing training among residents significantly decreased the percent error and reached acceptable levels of more than 70% of estimates within 10% of birth weight after 24 months of ultrasonographic experience (10), while a study comparing Ob-Gyn residents to maternal-fetal medicine subspecialists showed more experienced maternal-fetal medicine subspecialists to be more accurate(11), while there was one study in our university that assessed only sonographic accuracy of fetal head circumference measurement and concluded that the experience of US performers was not found to be associated with the accuracy of the measurement (12).

In another study, a systemic literature review was done on factors influencing EFW. The review was done in Switzerland in 2014 and involved 29 studies and investigated 14 variables and found that GA, maternal BMI, AFI, and ruptured membranes, presentation of the fetus, location of the placenta, and the presence of multiple fetuses do not seem to have an impact on EFW accuracy. The influence of the examiner's grade of experience and that of fetal gender were discussed controversially. Fetal weight, the time interval between estimation and delivery, and the use of different formulas seem to have an evident effect on EFW accuracy. No results were obtained on the impact of active labor (13).

Knowing the EFW accurately will help in the decision process. Data on how the experience of the sonographer affects the accuracy of ultrasound EFWs are sparse. There are even fewer studies that assess the accuracy of ultrasound EFWs made by obstetrics and gynecology (Ob-Gyn) residents alone (10, 11, 14, 15). When we come to our setup, there are no studies that access the accuracy of EFW done by any level of professionals. There is only one study done that assessed the accuracy of Johnson's formula and the palpation method of EFW done in 2004 (16), and another study was done in 2014 assessing "Sonographic accuracy of Fetal Head Circumference Measurements" (12).

Methods

This is a facility-based prospective cross-sectional study that was conducted on all pregnant women who came to deliver in the hospitals and had US estimation of fetal weight in Addis Ababa, who is in the catchment area of the three hospitals, two teaching hospitals of Addis Ababa University-medical faculty hospitals Tikur Anbessa Specialized Hospital *(*TASH*)* and Zewditu Memorial Hospital (ZMH) and St. Paul's Hospital Millennium Medical Collage's Hospital (SPHMMC), which are found in Addis Ababa. The study was conducted from April 1-June 30, 2016.

This study aimed to determine the accuracy of ultrasound estimated fetal weight performed by residents at the three teaching hospitals and identify factors affecting the accuracy of ultrasound EFW. All pregnant women who had had the US scans done in the above-mentioned hospitals and had delivered in the same hospital within seven days of the scan and fulfilled the inclusion criteria.

Questionnaires were developed based on the study objectives and available literature. Data were collected by the residents assigned to the labor ward during the study period and duty hours. Fetal biometry was performed at all levels of residents was taken. The principal investigator supervised the data collection for the utmost quality.

All scans were performed using a *Curved Array Transducer C362 (6-2Mhz)* abdominal probe from the *SonoScope SSI-8000™* platform. This US is available in all three hospitals. The weight of the fetus was calculated using the Hadlock III formula using three parameters. BPD, AC, and FL log10 EFW = 1.335–0.0034(AC)(FL) + 0.0316(BPD) + 0.0457(AC) + 0.1623(FL).

Data entry and analysis were performed using SPSS version 20. The responses in the completed questionnaires were coded and entered into a data entry template. Descriptive statistics were computed for sociodemographic characteristics and maternal and fetal characteristics. A paired sample t-test was applied between the two means i.e actual birth weight and EFW. Both bivariate and multiple logistic regressions were computed to assess the presence and strength of the association between the dependent and independent variables. P-values less than 0.05 were taken as significant in multivariate regression. For each regression, odds ratios (with the accompanying p-values and confidence intervals) of the relationship were reported. Summary tables were used to describe the data.

Results

The total number of respondents was 397. The mean age of the study participants was 27.92 ± 4.9 years, with the minimum and maximum ages being 18 and 45 years of age respectively. The majority of the study participants 300(, 81.7%) were from Addis Ababa, whereas the rest were out of the city. ***Table 1*** shows the maternal characteristics of the study participants.

Table 1: Maternal and fetal characteristics of the study participants, n=367

Maternal Characteristics	Value(number/percent)
Parity	
Nulliparous	155(42.2)
Primiparous	116(31.6)
Multiparous	90(24.5)
BMI	
Underweight	6(3.5)
Normal BMI	127(74.3)
Overweight	38(22.2)
Gestational age(weeks)	
$28\text{-}33^{+6}$	25(6.8)
$34\text{-}36^{+6}$	44(12.0)
$37\text{-}41^{+6}$	230(62.7)
≥42	37(10.1)
Unknown	31(8.4)
Fetal Variable	*Value*
Sex	Number/percent
Male	178(48.5)
Female	188(51.2)
Ambiguous	1(0.3)
Weight	
Low birth weight	81(22.1)
Normal birth weight	266(72.5)
Macrosomia	20(5.4)
EFW Vs Actual Weight	
Sonographic	2854± 740
Birth weight	2880 ± 721

The mean birth weight of the deliveries was 2880gm with a standard deviation of 721gm, and the mean EFW was 2854gm with a standard deviation of 740gm.

The participants were equally distributed among the three hospitals 123(33.5%), 123(33.5%), and 121(33.0%) in ZMH, TASH, and SPHMMC, respectively. 13(3.5%) of the ultrasound scan was done by R1, 203(55.3%) by R2, 81(22.1%) by R3, and 70(19.1%) by R4.

The EFW that was within 5% of the actual birth weight was 36%, while within 10% of actual birth weight was 62.4% and within 20% of actual birth weight was 91.3%. See table 2.

Table 2: Level of accuracy of EFW

Accuracy	*Count*	*Percent*	*Cumulative Percent*
EFW ≤5%	123	36%	36%
5%<EFW ≤10%	97	26.4%	62.4%
10%<EFW≤20%	106	28.9%	91.3%
20%<EFW	32	8.7%	100%

The overall mean error of EFW was 9.1%, with an SD of ±7.1%. In other words, 229 of the 367 scans were within 10% of the actual birth weight and 138 of the scans were outside 10% of the actual birth weight.

The least-underestimated EFW was 30.17% of the actual weight. It was a 1800gm fetus estimated as 1257gm by a 2nd-year resident, while the most overestimated EFW was 31.82% from the actual weight. It was a 2200gm fetus estimated as 2900gm by a 1st-year resident.

A paired sample t-test was applied (P= 0.14). The standard error of the difference between the two means was also calculated, which was 17.34. This difference in standard error was not even equal to the actual difference between the two means (i.e., 25.6). So the difference in EFW and actual fetal weight was statistically insignificant.

The measurement error and degree of inaccuracy of ultrasound EFW within 10% of actual birth weight were found to be the least in ultrasound scans done at SPHMMC. To adjust for possible confounding factors, multivariate logistic regression was done and SPHMMC scans were consistently associated with a more accurate measurement of EFW's OR=2.703(95% CI,[1.322-5.532],p=0.006) when compared with ZMH and OR=2.486(95%CI,[1.166-5.302], p=0.018) when compared to TASH.

The measurement inaccuracy of the ultrasound EFW within 10% of the actual birth weight was found to be the lowest in ultrasound scans done by R4's and was statistically significant when compared to R1's and R2's but not to R3's. OR=4.656(95%CI,[1.111-19.506],p=0.035) when compared to R1's, OR=2.112(95%CI,[1.062-4.201],p=0.033) when compared to R2's and OR=1.227(95%CI,[0.563-1.191],p=0.607) when compared to R3's.

The other factors analyzed and found not to be associated with the accuracy being within 10% were maternal BMI, gestational age, fetal weight (being macrocosmic, normal rage or low birth weight), time of scan (working hours vs. duty hours), fetal presentation, amniotic fluid volume, placental location, how many days elapsed between scan and delivery, whether the scan was done during antepartum or intrapartum, and fetal sex. See table 3.

Table 3: Factors that might affect the scan.

Variable	*No*	*Mean Percentage Error with SD*	% Within 10%	Significant Difference (p<0.05)
Place of Delivery				
TASH	123	9.0±7.2	61.8%	Yes: p=0.017
ZMH	123	9.7±7.6	56.9%	
SPHMMC	121	8.6±6.3	68.6%	
Level of Operator				
R1	13	12.9±11.1	53.8%	Yes: p=0.047
R2	203	9.3±6.6	59.1%	
R3	81	8.3±6.5	65.4%	
R4	70	8.7±7.1	70.0%	
Time of Operation				
Working hours	201	9.0±7.0	63.2%	NO: p=0.203
Duty hours	166	9.2±7.1	61.4%	
Fetal Presentation				
Cephalic	307	9.0±7.0	62.5%	NO: p=0.722
Breech	55	9.6±7.1	61.8%	
Transverse	5	10.2±11.9	60.0%	
Liquor Volume				
Adequate	256	8.8±6.7	64.5%	NO: p=0.684
Oligohydramnios	63	9.0±7.9	60.3%	
Placental Location				
Anterior	152	8.5±7.0	66.4%	NO: p=0.248
Posterior	96	8.9±6.9	63.5%	
Days Passed Between Scan & Delivery				
Same day	117	8.0±6.6	71.8%	NO: p=0.053
1 day	100	9.6±6.8	55.0%	
2 days	73	8.6±6.7	65.8%	
3days	27	8.9±8.8	63.0%	
4 days	17	9.3±6.9	64.7%	
5 days	11	13.2±7.9	45.5%	
6 days	9	15.0±8.1	22.2%	
7 days	13	10.5±8.1	53.8%	
Timing of Scan in Relation to Labour				
Antepartum	309	9.2±7.3	61.2%	NO: p=0.514
Intrapartum	58	8.6±5.3	69.0%	
Fetal Sex				
Male	178	9.9±6.9	56.2%	NO: p=0.136
Female	188	8.3±7.1	68.6%	
Ambiguous	1	12.5	0%	
BMI				
Underweight	6	7.0±4.5	66.7%	NO: p=0.725
Normal weight	127	8.9±7.4	63.0%	
Overweight	38	9.0±7.9	60.5%	
Gestational Age				
Pre-Term	69	10.3±9.3	68.1%	NO: p=0.250
Term	230	8.7±6.4	61.7%	
Post-Term	37	8.1±5.6	62.2%	
Fetal Weight				
Low birth weight	81	10.5±8.2	58%	NO: p=0.092
Normal weight	266	8.6±6.5	63.9%	

Macrocosmic	20	10.4±8.2	60.0%

Discussion

The first intention of this study was to see the accuracy of our EFW scan. When we compare our results with other studies, the EFW that was within 10% of the actual birth weight is comparable with other studies. Our result was 62.4% within 10%, and among the other results maximum number was 91.6% and the minimum result was 60.6% among 10% and 49.4% within 10% for a subgroup in one of the studies.

The second intention of the study was to assess the factors affecting our scan. We assessed 12 factors that might affect our accuracy, they are the place of delivery (scan), level of the operator, time of scan (working hours vs. duty hours), fetal presentation, liquor volume, placental location, days passed between scan and delivery, time of the scan to labor (antepartum vs. intrapartum), fetal sex, maternal BMI, gestational age, and fetal weight.

When we see the other studies mentioned previously in the literature review, the only factor that persistently affected EFW accuracy was the time interval between estimation and delivery i.e. 0–7 days vs. 8–14 days (13, 17). But our study only included scans done within 7 days of delivery and the EFW was not affected among the scans done in this interval.

One factor not assessed by any of the studies and one systemic literature review involving 29 studies stated “No results were obtained on the impact of active labor” (13). In our study, active labor was not found to affect the accuracy of EFW.

The only two factors that had an impact on the EFW accuracy were the place of delivery/scan SPHMMC measurement OR = 2.703(95% CI,[1.322–5.532],p = 0.006) when compared with ZMH and OR = 2.486(95%CI,[1.166–5.302], p = 0.018) when compared to TASH i.e. scans done at SPHMMC were more likely to be within 10% of the actual weight compared to the scans done elsewhere. At SPHMMC, most of the scans were done by R2’s (71.1%) compared to 51.2% at ZMH and 43.9% at TASH, while only 1.7% of the scans at SPHMMC were done by R4’s, while 23.6% of the scans at ZMH and 31.7% at TASH were done by R4’s. This is because, at SPHMMC, R2’s have Radiology attachment for one month was the R2’s do obstetric ultrasound the whole day guided by the fetomaternal subspecialty candidates compared to Addis Ababa University-medical faculty hospitals (TASH and ZMH), which do not have this dedicated month for Radiology attachment. Some of the scans at SPH are done by the fetomaternal subspecialty fellows, but the result is signed off by the R2’s and we have no way of distinguishing which ones are done by the fellows, but their numbers are few. This might have been the reason why the place of delivery i.e. the residents at SPH, were more accurate.

The second factor that had a significant association was the level of residency experience when R4’s were compared to another level of residents, OR = 4.656(95%CI,[1.111–19.506],p = 0.035) when compared to R1’s, OR = 2.112(95%CI,[1.062–4.201],p = 0.033) when compared to R2’s and OR = 1.227(95%CI,[0.563–1.191],p = 0.607) when compared to R3’s. Similar findings were found in a study done by Predanic M. et

al. (10) in the USA and concluded that there is a learning curve for ultrasonographic estimates of fetal weight, with a significant decrease in the percent error seen with advancing training among residents, reaching acceptable levels of more than 70% of estimates within 10% of birth weight after 24 months of ultrasonographic experience. Similarly, a study was done by Pks Yau et al. (11) in Hong Kong showed that more experienced Fetomaternal subspecialists were more accurate than the less experienced Ob-Gyn residents. But in a systemic review of 29 studies done by Juozas et al. (18) in Switzerland stated that experience was found to be controversial among the 29 studies 6 assessed skill/ experience of the examiner and it was discussed controversially. Meanwhile, in a study done by Ivo Markus et al. (17) in Germany, the experience did not affect the accuracy of EFW.

Conclusion

The difference between the mean birth weight of the deliveries and the mean EFW was statistically insignificant. Showing that on average, the EFW was accurate enough measurement to be used for decision making. The EFW that was within 10% was 62.4%. The overall mean error of EFW was 9.1%, with an SD of ± 7.1%.

Of the 12 factors assessed that might affect the accuracy of EFW, it was found that the only place of delivery/scan and the level of resident experience significantly affected the accuracy. In place of delivery, the scans done at SPHMMC were found to be more accurate than scans done either at TASH or ZMH. When we see the level of residency, we found that the accuracy of EFW goes up when the level of residency increased from R1 to R4. The most accurate being the R4's but the accuracy is not significantly different from R3's while the difference is significant when compared to R1's and R2's.

Limitation

The limitation of the study was that the study was facility-based and may not be generalized to the population. Besides, the use of only one sonographic model i.e. Hadlock's formula, only to derive estimates of fetal weights, while there was no study that this formula is the best for our population.

Recommendation

Because the EFW of R4's was significantly different from R1's and R2's but not R3's we can recommend that all ultrasound scans whose weight estimation can affect the management plan of the patient to be done by the senior residents rather than the junior residents i.e. R3's and R4's.

Abbreviations

AC: Abdominal circumference; AC: Abdominal circumference; AFI: Amniotic fluid index; BMI: Body mass index; BPD: Biparietal diameter; BW: Birth weight; CI: Confidence intervals; CTG: Cardiotocography; EFW: Estimated fetal weight; FL: Femur length; g: grams; GA: Gestational age; HC: Head circumference; R:

Resident; SPHMMC: St. Paul's Hospital Millennium Medical Collage's Hospital; SD: Standard deviation; TASH: Tikur Anbessa Specialized Hospital; ZMH: Zewditu Memorial Hospital.

Declarations

Ethics approval and consent to participate

Ethical clearance was obtained from the Research and Publication Committee (RPC) of the Department of Gynecology and Obstetrics of the College of Health Sciences, Addis Ababa University. Permission was also obtained from the study facilities to collect data. Participation in the study was completely voluntary, and informed written consent was acquired from every participant before participation. The study did not involve vulnerable populations.

Consent for publication

Not applicable since data were anonymized and no data on a specific participant are presented.

Availability of data and materials

All data generated or analyzed during this study are included in this published article (Results section and tables within the manuscript).

Competing interests

The study has no financial associations. The authors declare that they have no competing interests.

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Authors' contributions

Conception: AM. Planning: EK. Execution: AM, EK. Analysis: AM. Writing up the manuscript: AM, EK. Critical revision of the manuscript: EK, AM. All authors have read and approved the final manuscript.

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References

1. Oliver Preyer HH, Concin N, Ridder A, Musielak M, Pfeifer C. Willi Oberaigner & Peter Husslein Fetal weight estimation at term – ultrasound versus clinical examination with Leopold's manoeuvres: a prospective blinded observational study. BMC Pregnancy Childbirth. 2019;19:122.

2. Steven G. Gabbe MJRN, Joe Leigh Simpson MD, Mark MD, Landon B, Henry MD, Galan L, MD Eric RM, Jauniaux MD, PhD Deborah A, Driscoll. MD Edward J. Quilligan Frederick P. Zuspan. OBSTETRICS NORMAL AND PROBLEM PREGNANCIES. 6th Edition ed2012.
3. Baum JDGD, Wirth JC 3rd. Clinical and patient estimation of fetal weight vs. ultrasound estimation. J Reprod Med. 2002;47:194.
4. Boulet SLAG, Salihu HM, et al. Macrosomic births in the United States: determinants, outcomes, and proposed grades of risk. Am J Obstet Gynecol. 2003;188:1372–8.
5. Stotland NECA, Breed EM, et al. Risk factors and obstetric complications associated with macrosomia. Int J Gynaecol Obstet. 2004;87:220–6.
6. Sherman DJAS, Tovbin J, et al. A comparison of clinical and ultrasound estimation of fetal weight. A comparison of clinical and ultrasound estimation of fetal weight. Obstet Gynecol. 1998;91:212.
7. Nyberg DAAA, Ville Y. Ultrasound assessment of abnormal fetal growth. Semin Perinatol. 2004;23:3.
8. AU Scioscia M VA CO, Vicino M, Selvaggi LE. SO Estimation of birth weight by two-dimensional ultrasonography: a critical appraisal of its accuracy. Obstet Gynecol. 2008;111(1):57.
9. Dimassi KDF, Ajroudi M, Triki A, Gara MF. Ultrasound Fetal Weight Estimation: How Accurate Are We Now Under Emergency Conditions? Ultrasound Med Biol. 2015 05.020.
10. Predanic MCA, Ingrid F, et al. Ultrasonographic estimation of fetal weight: acquiring accuracy in residency. Ultrasound Med. 2002;21:495–500.
11. Pks Yau WS, Lee H. Kc Au Yeung. Accuracy of Ultrasound Estimation of Fetal Weight by Obstetrics and Gynaecology Residents and Maternal-fetal Medicine Subspecialists. HKJGOM. 2013;13(1).
12. Sonographic accuracy of fetal head circumference measurement: A faculty based prospective cross-sectional study [Internet]. 2014. Available from: http://localhost:80/xmlui/handle/123456789/1071.
13. Chantal Huber JAZ, Mueller M, Daniel Surbek. Department of Obstetrics and Gynaecology, Bern University Hospital, Bern, Switzerland. Factors Influencing the Accuracy of Fetal Weight Estimation with a Focus on Preterm Birth at the Limit of Viability: A Systematic Literature Review. Fetal Diagn Ther. 2014;36:1–8.
14. Noumi GC-KF, Bombard A, et al. Clinical and sonographic estimation of fetal weight performed during labor by residents. Am J Obstet Gynecol. 2005;192:1407–9.
15. Ben-Aroya ZSD, Hadar A, et al. Effect of Ob/GYN residents' fatigue and training level on the accuracy of weight estimation. Fetal Diagn Ther. 2002;17:177–81.
16. Belete: W. Clinical estimation of fetal weight in low resource settings: comparison of Johnson's formula and the palpation method. Ethiopian medical journal January. 2008;46(1):37–46.
17. Ivo Markus Heer CK, Nadin, Vögtle. Susanne Müller-Egloff, Martin Dugas, Alexander Strauss Analysis of Factors Influencing the Ultrasonic Fetal Weight Estimation. Fetal Diagn Ther. 2008;23:204–10.
18. Juozas Kurmanavicius* TB. Josef Wisser, and Renate Huch. Perinatal Research Unit, Department of Obstetrics, Zurich University Hospital, Zurich, Switzerland. Ultrasonographic fetal weight estimation:

accuracy of formulas and accuracy of examiners by birth weight from 500 to 5000 g. J Perinat Med. 2004;32:155–61.

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