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SONOGRAPHIC ACCURACY OF FETAL HEAD CIRCUMFERENCE MEASUREMENT: A FACILITY BASED PROSPECTIVE CROSS SECTIONAL STUDY

A Research thesis submitted to College of Health Sciences, School of Medicine, Department of Gynecology and Obstetrics, Addis Ababa University, as Partial Fulfilment for Specialty Certificate in Gynecology and Obstetrics
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II. List of abbreviations

AC     Abdominal Circumference
BW     Birth Weight
BPD    Biparietal Diameter
CI     Cephalic Index
CPD    Cephalo-Pelvic Disproportion
CRL    Crown Ramp Length
CSD    Cesarean Section Delivery
ECS    Emergency Cesarean Section
EDA    Epidural Analgesia
FHC    Fetal Head Circumference
FL     Femur Length
GA     Gestational Age
HC     Head Circumference
LAM    Levator Ani Muscle
MDG    Millennium Development Goal
US     Ultrasound
VE     Vacuum Extraction
WHO    World Health Organization
Abstract

Background: Ultrasound examination and measurement of fetal biometry has become an integral part of modern obstetric care. These measurements can serve for dating pregnancies, assessment of fetal growth and fetal weight estimation. Knowledge of expected birth weight is attractive to clinicians as it is an important variable affecting perinatal mortality. Fetal weight estimation is thought to be helpful in predicting fetal survival and making management decisions in the very low birth weight group (<1000 g) and in managing the delivery of the large baby, where complications may occur. But sonographic fetal weight estimation is inaccurate especially in the extremes of fetal weight and skeletal part of fetus may be more predictive of birth problem than fetal weight. Accurate sonographic estimation of fetal head circumference (HC) is important for the purpose of fetal weight estimation, as well as in cases in which abnormal fetal head growth is suspected.

Objective: To assess the accuracy of sonographic estimation of fetal head circumference (HC).

Methods: The study design is facility based prospective cross sectional study comparing sonographic HC with actual HC measured immediately after delivery, involving 339 women admitted to labor and delivery wards of the study hospitals. Data was collected using structured questionnaire, developed based on study variables and available literatures and analysed using SPSS software version 21.

Result: There was a high correlation between sonographic and postnatal measurements of HC ($r = 0.557$, $P < 0.001$). Overall, sonographic HC measurements consistently underestimated actual HC measured postnatally (mean simple error, $-1.59$ cm, standard deviation of 1.73)

Conclusion and recommendation: Sonographic estimation of HC is associated with significant underestimation compared with the actual postnatal HC. This measurement error may have important clinical implications and should be taken into account in the interpretation of sonographically measured HC.

KEY WORDS: fetal head circumference, estimated fetal weight, accuracy of measurement
IV. Introduction

1. Background information

WHO estimates that Over 130 million babies are born every year, and more than 10 million infants die before their fifth birthday, almost 8 million before their first. Many countries have set under-five and maternal mortality reduction by three fourth between 1990 and 2015, as their key development goal, as suggested by international conferences such as the World Summit for Children in 1990, the United Nations Millennium Declaration and the United Nations Special Session on Children in 2002 (22).

Intrapartum deaths are one of the major contributors to perinatal mortality due to several causes. According to WHO estimates intrapartum still births are rare in developed areas of the world, where they represent approximately 10% of the estimated 84 000 stillbirths, with an average intrapartum stillbirth rate of 0.6 per 1000 births. On the other hand, intrapartum deaths in developing regions are estimated to account for between 24% and 37% of all stillbirths, which means that overall 34% of 3.2 million stillbirths, or 9 out of every 1000 births, occur during delivery. Consequently the risk of an intrapartum stillbirth is on average 14 times greater in developing than in developed countries. In the least developed countries, the risk increases to at least 17 times more than in developed countries (22, 23). A number of antepartum and intrapartum factors contribute to increased perinatal mortality. Studies show that prolonged labor due to lack of timely assisted vaginal or abdominal delivery may lead to birth asphyxia.

Prolonged labour in the developing world is commonly due to cephalopelvic disproportion (CPD), which may result in obstructed labour, maternal dehydration, exhaustion, uterine rupture and vesico-vaginal fistula. Protracted labour is more common in primigravid women than in multipara and the complications and effects of CPD differ between them. Obstructed labor; a failure of presenting part to progress due to a mismatch between fetal size and the maternal pelvis accounts for 8% of maternal deaths worldwide (5, 22, 23). Fetus size is also a well-known risk factor for obstructed labor. Heavier and larger newborns increase the likelihood of difficult deliveries (such as an ECS) or assisted deliveries resulting from shoulder dystocia, prolonged labor and signs of fetal distress (5, 13, 16).

Anticipation and early detection of abnormal progress of labor helps in reducing maternal and perinatal morbidities and mortalities.
Prolonged labor is the major cause of asphyxia in term-born neonates and can be due to inefficient uterine action, malpresentation and cephalopelvic disproportion. Active management of labor is well recognized as the primary policy to prevent and treat prolonged labor, while assisted vaginal delivery and emergency cesarean are left for the unresolved abnormal labors. High birth weight increases the risk of prolonged labor use of epidural analgesia (EDA) and instrumental or operative delivery. Better understanding of the impact of maternal and infant anthropometric measures on the course of labor may enhance the possibilities of appropriate timing of assistance to have a safe and untraumatic birth. As ultrasonographic estimation of macrosomia is not always accurate, there is a need to develop other methods to foresee this factor. A clinical study (n=423) suggests that measuring fetal head circumference (>37 cm) is as good as fetal weight estimate (>4.5 kg) to predict prolonged labor (13, 16).

This is relevant because the skeletal structure of the baby is more predictive of birth problems than birth weight. According to studies, head circumference is more important in predicting problems at delivery than birth weight (5, 13, 16).

According to a retrospective Swedish study that evaluated postnatal fetal head circumference, (FHC) nulliparous women delivering fetus with large fetal head circumference (39-41cm) are found to be at increased risk for prolonged labor, emergency cesarean section (ECS), operative vaginal delivery, signs of maternal and fetal distress compare to women delivering infant with average FHC (35cm) (13). Another retrospective study done in USA came up with the same result except for signs of fetal distress in which there was no difference between the two groups (16).

Ultrasound examination and measurement of fetal biometry has become an integral part of modern obstetric care. These measurements can serve for dating pregnancies, for assessment of fetal growth pattern and estimation of fetal size based on single or multiple fetal biometric indices. However, to ensure accurate diagnosis, selection of the appropriate cross-sectional reference charts is of great importance. Some published reference charts are methodologically flawed. Common problems include repeated measurements on the same fetuses, formation of ‘super normal’ datasets by inappropriate exclusion of complicated pregnancies, failure to identify the statistical method of analysis, and the use of statistical methods which do not consider the variability of measurements with gestational age. It is well known that ethnicity has a significant influence on fetal biometry (32).
Ultrasound has been used for accurate pregnancy dating with decreasing accuracy across gestational age being most accurate when done in the first trimester. Between the 12th and 14th weeks, crown-rump length and biparietal diameter are similar in accuracy. It is recommended that crown-rump length be used up to 84 mm, and the biparietal diameter be used for measurements > 84 mm (34).

The BPD is less reliable in determining gestational age when there are variations in skull shape, such as dolichocephalism or brachycephaly; hence some authors feel that BPD is less reliable than HC. As a single parameter, HC correlates better to gestational age than the other 3 standard parameters in the second trimester, and as with all others, it becomes less accurate with increasing gestational age. It is more challenging to measure the fetal AC than the other parameters and femur length varies somewhat with ethnicity. Short femurs are commonly a normal variant, however this finding may also indicate fetal growth restriction, aneuploidy, and—when severely shortened—skeletal dysplasias (31, 34).

Accurate sonographic estimation of fetal head circumference (HC) is important for the purpose of fetal weight estimation, as well as in cases in which abnormal fetal head growth is suspected. But, there are few data regarding the accuracy of sonographic estimation of HC compared with actual postnatal HC (25). There is considerable variation in the accuracy of different models of fetal weight estimation. For birth weights (BW) in the range of 1000 to 4500 g, models based on 3 or 4 fetal biometric indices are significantly more accurate than models that incorporated only 1 or 2 indices. The accuracy of weight estimation decreases at the extremes of BWs, leading to overestimation in low-BW categories as opposed to underestimation when the BW exceeded 4000 g (29, 30, 31, 33). According to clinical studies measuring fetal head circumference (>37 cm) is as good as fetal weight estimate (>4.5 kg) to predict prolonged labor (13, 16). This is relevant because the skeletal structure of the baby is more predictive of birth problems than birth weight. According to studies, head circumference is more important in predicting problems at delivery than birth weight due to inaccuracy in sonographic fetal weight estimation (5, 13, 16).
2. Problem statement

Most interventions during nulliparous labour use dystocia as indication and about 50% of all cesarean deliveries are related to dystocia. The reasons for the increased incidence of dystocia are only partly known. Poor head-to-cervix force may be associated with slow progress of labour, as maybe, poor engagement of fetal head at onset of labour. High fetal weight may increase the risk of dystocia, and it is debated whether epidural analgesia in itself prolongs labour (11, 21, 28). Maternal and fetal anthropometric measures play more role on the course of labor and fetal macrosomia is a risk factor for prolonged labor, operative delivery and low 5th minutes APGAR score (13, 16, 19, 28). But skeletal structures of the fetus have been shown to be more predictive of labor outcome than birth weight, which is inaccurate when measured sonographically in utero (5, 13, 16). Two retrospective studies which evaluated the effect of large fetal head circumference as independent risk factor on labor outcome have found that, nulliparous women who carry anatomically normal fetus with large FHC are at increased risk of vacuum delivery, forceps delivery, emergency cesarean section and signs of fetal distress (i.e. meconium staining of amniotic fluid, low 5-minute APGAR score) compared to average FHC fetuses (13, 16).

The potential of FHC in predicting risk of operative delivery (i.e., cesarean section, vacuum-assisted, or forceps assisted vaginal delivery), fetal distress in anatomically normal fetuses has not been previously examined in prospective studies. Understanding the association between FHC, and adverse maternal and fetal outcomes may be essential in planning intrapartum care, including neonatal resuscitation and ultrasound FHC measurements at term, as an independent and prenatal risk factor for operative delivery, may guide the timing of cesarean sections or assisted vaginal delivery.

Ethnicity is a well known factor that has significant effect on fetal biometry and current fetal biometry charts, based on western population may not be applicable to all across the globe. Femur length is the most affected by ethnicity and BPD is highly affected by the shape of skull where as AC has no bone echoes and is not always symmetrical and dependent on fetal growth factors and body position. Fetal head circumference, as a single entity is better correlated with gestational age special in the first two trimesters and may be in the third.

Accurate sonographic estimation of fetal head circumference (HC) is important for the purpose of fetal weight estimation, as well as in cases in which abnormal fetal head growth is suspected. There are few data regarding the accuracy of sonographic estimation of FHC
compared with actual postnatal HC. The purpose of this study was to determine correlation of FHC with actual HC measured within three days of delivery and its potential benefit in predicting labor outcome.

3. Literature review

WHO global survey on maternal and perinatal health, comparing cesarean delivery and perinatal outcomes revealed, CSD rates have increased from about 5% in early 1970s in developed countries to greater than 50% in some parts of the world in late 1990s. Safety of operative deliveries has improved over those times but high rates of CSD does not necessarily indicate better perinatal care and when indicated its valuable and relatively safe procedure (3, 12).

A Swedish retrospective study that evaluated indications of operative delivery between 1990 and 2010 involving 415,230 primiparous women giving birth giving birth at 37-41 weeks and 6days found most indications were due to prolonged labor, signs fetal distress and other medical complications like APH (12).

In this study total rate of induction of labor increased from 8.2% in 1999 to 11.9% in 2010, and was associated with an increased risk of both EMCS and VE. The total rate of epidural analgesia (EDA) increased from 43.7% in 1999 to 49.8% in 2010, and was associated with a double risk for VE and with an increased risk of ECS (12).

A three year retrospective study in Nigeria on labor outcome 311 macrosomic fetuses that mothers of macrosomic newborns were older, higher parity, and weighed more at term. The study group had more mothers with previous history of macrosomic babies (39.5% vs. 12.5%), diabetes (3.2% vs. 1%), significant higher cesarean section rate (27.3% vs. 11.9%), and operative vaginal delivery (3.6% vs. 1%) compared with the control. This study concludes that in utero ultrasound estimation of fetal weight is imprecise and future study should focus on other methods of accurate estimation of fetal macrosomia in utero (19).

Another two retrospective studies that evaluated influence of fetal macrosomia on duration of labor, mode of delivery and intrapartum complications showed primigravidae were at high risk of prolonged labour, operative vaginal delivery and emergency caesarean section compared to multigravidae. When delivering a macrosomic baby, primigravidae had a higher incidence of prolonged labour, operative vaginal delivery and emergency caesarean section compared to normal weight babies (20, 26).
Studies have shown that the skeletal structure of the baby is more predictive of birth problems than birth weight. For instance, head circumference is more important in predicting problems at delivery than birth weight (5).

Another cross sectional study involving 400 fetuses with GA of 15-41 weeks done to determine normal relationship between FHC and menstrual age found a FHC of 33cm-35.4cm for those between GA of 37 and 41 weeks (8).

A retrospective study that evaluated the influence of large fetal FHC on labor and neonatal outcome compared to those with average FHC (10,750 large FHC vs. 10,750 average FHC) found that, large-FHC infants were nearly twice as likely to be delivered by primary cesarean section as average-FHC infants (unadjusted relative risk 1.84, 95% confidence interval. The RR for primary cesarean section associated with large-FHC was largest for mothers aged 19 years or less, and smallest for mothers aged 35 years or greater. Large-FHC infants were at increased risk of vacuum-assisted vaginal delivery, and forceps-assisted vaginal delivery. There was no difference in risk of fetal distress for large-FHC versus average-FHC infants and these risk estimates were unaffected by adjustment for potential confounders.

Similar retrospective study done in Sweden compared with women giving birth to a neonate with average size head circumference (35 cm), women giving birth to an infant with a very large head circumference (39–41 cm) had significantly higher odds of being diagnosed with prolonged labor, signs of fetal distress and maternal distress. The odds ratios for vacuum extraction and cesarean section were thereby elevated to 3.47 and 1.22, respectively. The attributable risk proportion associated with vacuum extraction and cesarean section were 46 and 39%, respectively among the cases exposed to a head circumference of 37–41 cm (13).

Another prospective observational study which examined the rate of levator ani muscle avulsion in primiparae using 3-D transperineal ultrasound found 18.8% LAM trauma in deliveries with large FHC (>35.5cm) and duration of second stage of labor>110 minutes (9).

In a study that evaluated ultrasound efficacy comparing 26 different models using 3705 sonographic weight estimations performed less than 3 days before delivery considerable variation in the accuracy of the different models was found. For birth weights (BWs) in the range of 1000 to 4500 g, models based on 3 or 4 fetal biometric indices were significantly more accurate than models that incorporated only 1 or 2 indices. The accuracy of weight estimation decreased at the extremes of BWs, leading to overestimation in low-BW categories as opposed to underestimation when the BW exceeded 4000 g. The precision of most models was lowest in the low-BW groups (31, 33).

Another prospective study that evaluated 3 different methods of EFW—clinical,
maternal and ultrasound measurements—on 246 parous women admitted for scheduled caesarean section within 1 week of delivery in the hospital found that clinicians’ estimates of birth weight in term pregnancy were as accurate as routine ultrasound estimation in the week before delivery. Furthermore, parous women’s estimates of birth weight were more accurate than either clinical or ultrasound estimation (29).

Operator experience is important in producing accurate fetal weight estimates and studies demonstrated the learning curve in estimating fetal weight; there were significant improvements in accuracy amongst residents in training up to 24 months, where the best performance was achieved (30).

A prospective cross sectional study involving 3008 term deliveries, done to compare fetal head circumference measured up to three days before delivery with actual head circumference immediately after delivery found a high correlation between Sonographic and postnatal measurements of HC (25).
V. **Objectives**

1. **General objectives:**

The objective of the study was to determine the accuracy sonographic estimation of fetal circumference.

2. **Specific objectives:**

1. To determine US accuracy of FHC estimation.
2. To determine factors affecting accuracy of FHC estimation.
3. To determine prevalence of large FHC.

VI. **Methods**

1. **Study area and period**

The study was conducted in two teaching hospitals of AAU-medical faculty namely; Tikur Anbessa and Ghandi memorial hospitals which are found in Addis Ababa. The study was conducted from June 1-August 30, 2014.

2. **Study design**

The study design was facility based prospective cross sectional study.

3. **Population**

   a) **Source population**

   All pregnant mothers, who have had obstetric ultrasound examination done within three days of delivery and fulfilled inclusion criteria.

   b) **Study population**

   The study population was consecutively selected postpartum women who gave birth to alive and anatomically normal fetus during study period and their neonates.
4. **Inclusion and exclusion criteria**

   **a) Inclusion criteria**
   - Pregnancies reached viability
   - Anatomically normal fetus
   - Ultrasound measurement done within 3 days of delivery
   - Actual HC taken within 6 hours of delivery
   - Live birth

   **b) Exclusion criteria**
   - Mothers who have no obstetric US
   - US results done more than 3 days before delivery
   - Actual head circumference measured more than 6 hours of delivery
   - Still births

5. **Sample size and Sampling procedures**

   **a) Sample size**
   The sample size was calculated using a formula for estimating a single population mean assuming a confidence level of 95%.

   $n = \frac{Z^2 \alpha/2 \cdot SD^2}{d^2}$

   Where: $n =$ the required sample size,
   $Z =$ a standard score corresponding to 95% confidence level;
   $SD=$ is standard deviation from mean, which was 1.71 from previous studies
   $d=$ margin of error=0.14

   $n= (3.8416) \times (1.71)^2 \quad \cdot \quad N= 345$, after data cleaning 339 study participants were included

   $(0.14)^2$

   in the final analysis.
b) Sampling procedures
The sample size was allocated equally to both study hospitals. The participants were enrolled in each hospital consecutively till the required sample size is achieved.

6. Methods of data collection
Questionnaires were developed based on study objectives and available literature. Three midwives were oriented on fetal anthropometric measurements and data was collected by the midwives, interns and residents assigned to labor ward during study period and duty hours. Fetal biometry performed by all level of residents and radiologists were taken illegible. The principal investigator has supervised the data collection for the utmost quality.

7. Study variables

a) Independent variables
The independent variables will be:
   Age
   Educational level
   Religion
   Ethnicity
   Marital status
   Maternal anthropometry
   Birth weight
   Placental location
   Fetal presentation
   Amniotic fluid volume
   Fetal sex
   Level of US operator
   Time of US measurement
   Parity

b) Dependent variables
Dependent variables will be:
   US accuracy of fetal HC measurement
8. **Data quality control**
The questionnaires were designed in English language and pre-tested on 21 mothers similar to the study population (5% of the sample size) in the study hospitals which were not included in the study. The finding of the pre-test was incorporated into the final instrument for the study. The data collectors were trained on the final questionnaire and data collection techniques.

9. **Operational definition**

*Large FHC* = fetal head circumference $\geq 37$cm measured across occipitofrontal diameter.

*Average FHC* = head circumference = 34cm measured across occipitofrontal diameter.

*FHC* = measured at the level of thalami and cavum septum pellucidum around the outer perimeter of the skull.

*Assisted vaginal delivery*: is delivery attended by either forceps or vacuum extraction.

*Low birth weight*: fetal weight less than 2500grams.

*NHC*: is the measurement made along the maximal horizontal plane of fetal head, along the occipital prominence at the back, above the ears, and just above the eyebrows at the front.

*Accuracy HC of measurement*: US measurement within 10% of actual (postnatal) HC.

10. **Data processing and analysis**

Editing and sorting of the questionnaires was done manually to determine completeness. Data entry and analysis was performed using SPSS version 21. The responses in the completed questionnaires were coded and entered into a data entry template. Multivariate logistic regression was used to examine the relationship between the proposed dependent and independent variables. For each regression odds ratios (with the accompanying p-values and confidence intervals) of the relationship is reported.

VII. **Ethical consideration**
The proposal was approved by the Ethical Review Committee of department of obstetrics and gynecology research and publication of Addis Ababa University. Permission was obtained from each selected hospital to access the clients included in the study. Informed oral consent was obtained from each participant before start of data collection. Concerning the right to anonymity and confidentiality, the study participants’ names were not asked and documented on the questionnaire and were assured that their responses will not in any way be linked to them so as to assure them of confidentiality.
VIII. Dissemination of results

After accomplishing the study, the results were presented to department of obstetrics and gynecology research and publication Addis Ababa University. Subsequently, attempts will be made to present it on scientific conferences and publish it on scientific journals.
IX. Result

The mean age of the study participants is 26.69 ± 4.4 years with the minimum and maximum age being 18 and 39 years of age. The majority of the study participants are in the age range of 26-30 (42.5%) and 21-25 (31.1%) years of age. The rest comprises 31-35 (11.2%), 15-20 (10.9%) and those >35 years accounts for 4.1%.

Majority of the study participants 308 (90.9%) were from Addis Ababa, whereas about 31 (9.1) subjects were out of the city.

About 19 (5.6%) of the study subjects were illiterate but the majority have attended primary 132 (38.9%), secondary 141 (41.6%) and higher education 47 (13.9%).

About 244 (72%) were orthodox and 73 (5.6%) Muslim by religion and most are married 328 (96.8%) but 11 (3.2%) were single mothers. Except 4 (0.6%) the majority have some form of job; house wife 211 (62.2%), employed 118 (34.8%) and 6 (1.8%) are self employed.

Table 1: sociodemographic characteristics of the study participants, n=339

<table>
<thead>
<tr>
<th>characteristics</th>
<th>Value(number/percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age(years)</strong></td>
<td></td>
</tr>
<tr>
<td>15-20</td>
<td>37(10.9)</td>
</tr>
<tr>
<td>21-25</td>
<td>106(31.3)</td>
</tr>
<tr>
<td>26-30</td>
<td>144(42.5)</td>
</tr>
<tr>
<td>31-35</td>
<td>38(11.2)</td>
</tr>
<tr>
<td>&gt;35</td>
<td>14(4.1)</td>
</tr>
<tr>
<td><strong>Address</strong></td>
<td></td>
</tr>
<tr>
<td>Addis Ababa</td>
<td>308(90.9)</td>
</tr>
<tr>
<td>Out of Addis Ababa</td>
<td>31(9.1)</td>
</tr>
<tr>
<td><strong>Educational level</strong></td>
<td></td>
</tr>
<tr>
<td>primary</td>
<td>132(38.9)</td>
</tr>
<tr>
<td>Secondary</td>
<td>141(41.6)</td>
</tr>
<tr>
<td>University</td>
<td>47(13.9)</td>
</tr>
<tr>
<td>illiterate</td>
<td>19(5.6)</td>
</tr>
<tr>
<td><strong>Religion</strong></td>
<td></td>
</tr>
<tr>
<td>Orthodox Christian</td>
<td>244(72)</td>
</tr>
<tr>
<td>Muslim</td>
<td>73(5.6)</td>
</tr>
<tr>
<td>Protestant</td>
<td>20(5.6)</td>
</tr>
<tr>
<td>Catholic</td>
<td>2(0.6)</td>
</tr>
<tr>
<td><strong>Marital status</strong></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>328(96.8)</td>
</tr>
<tr>
<td>single</td>
<td>11(3.2)</td>
</tr>
<tr>
<td><strong>Occupation</strong></td>
<td></td>
</tr>
<tr>
<td>House wife</td>
<td>211(62.2)</td>
</tr>
<tr>
<td>Employed</td>
<td>124(36.6)</td>
</tr>
</tbody>
</table>
About 186(54.9%) are multiparous and 153(45.1%) primiparous with the maximum parity being five deliveries. Among study participants 213(62.8%) know their LNMP whereas 126(37.2%) do not.

Table 2: Obstetric characteristics of study participants, n=339

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Value(number/percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parity</td>
<td></td>
</tr>
<tr>
<td>Nulliparous</td>
<td>153(45.1)</td>
</tr>
<tr>
<td>Multiparous</td>
<td>186(54.9)</td>
</tr>
<tr>
<td>Last normal menstrual period</td>
<td></td>
</tr>
<tr>
<td>Known</td>
<td>213(62.8)</td>
</tr>
<tr>
<td>Unknown</td>
<td>126(37.2)</td>
</tr>
<tr>
<td>Gestational age(weeks)</td>
<td></td>
</tr>
<tr>
<td>28-33+6</td>
<td>13(3.8)</td>
</tr>
<tr>
<td>34-36+6</td>
<td>30(8.8)</td>
</tr>
<tr>
<td>37-39+6</td>
<td>107(31.6)</td>
</tr>
<tr>
<td>40-41+6</td>
<td>78(23)</td>
</tr>
<tr>
<td>≥42</td>
<td>54(15.9)</td>
</tr>
<tr>
<td>unknown</td>
<td>57(16.8)</td>
</tr>
</tbody>
</table>

More than half of the deliveries were at term (185[54.6%]) and 43 (12.6%) preterm and 57(16.8%) were post term. For about 57(16.8%) study participants GA was not known (table 2).

Table 3: Fetal characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>Number/percent</td>
</tr>
<tr>
<td>Male</td>
<td>185(54.6)</td>
</tr>
<tr>
<td>Female</td>
<td>154(45.4)</td>
</tr>
<tr>
<td>Head circumference (cm)</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>Sonographic</td>
<td>32.85 ± 1.84</td>
</tr>
<tr>
<td>Actual (postnatal)</td>
<td>34.44 ± 1.92</td>
</tr>
<tr>
<td>Actual HC ≥37cm</td>
<td>31(9.1%)</td>
</tr>
<tr>
<td>Weight (grams)</td>
<td></td>
</tr>
<tr>
<td>sonographic</td>
<td>2951±627</td>
</tr>
<tr>
<td>Birth weight</td>
<td>2978±676</td>
</tr>
</tbody>
</table>

The mean sonographic weight was 2951 grams with standard deviation of 627 grams and that of birth weight was 2978 grams with standard deviation of 676 grams (Table 3).
Accuracy of sonographic HC measurement

The prevalence of large head circumference is 31(9.1%); calculated from actual (postnatal) head circumference. The mean sonographic head circumference is 32.85cm with 1.84 SD and the actual (postnatal) head circumference is 34.44cm with 1.92 SD. Over all sonographic head circumference was lower than the actual (postnatal) head circumference with mean simple error of 1.59 cm and systematic error of 4.48 %. The sonographic HC underestimation persists throughout gestation with positive correlation between HC and increasing GA but remained statistically insignificant(r=0.31, p=0.67). The ultrasound measurement underestimates FHC in 285(84.1%) and overestimates in 54(15.9%) of study participants (table 4).

Table 4: ultrasound accuracy of fetal head circumference compared with actual HC,

<table>
<thead>
<tr>
<th>Overall</th>
<th>value(cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean FHC</td>
<td>32.85cm</td>
</tr>
<tr>
<td>Mean NHC</td>
<td>34.44cm</td>
</tr>
<tr>
<td>Mean simple error</td>
<td>-1.59cm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Accuracy of estimation n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under estimation</td>
</tr>
<tr>
<td>Over estimation</td>
</tr>
<tr>
<td>Sonographic HC within ±5% of actual HC</td>
</tr>
<tr>
<td>Sonographic HC within ±10% of actual HC</td>
</tr>
<tr>
<td>Sonographic HC within ±20% of actual HC</td>
</tr>
</tbody>
</table>

The accuracy of ultrasound estimation of HC within ±5%, ±10%, and ±20% of actual HC was 52.8%, 88.5% and 99.4% respectively. About 300 study subjects had accurate measurement wit in 10% actual (postnatal) HC, whereas about 39 measurements were not within 10% of actual HC. There was a high correlation between the sonographic and postnatal measurements of HC (r = 0.557, P < 0.001)

When the means of sonographic HC and actual HC compared using paired sample t- test, there was statistically significant difference between sonographic and actual HC [mean simple error of -1.59 and standard deviation of 1.73 ,95 % CI( -1.77,-1.40) with p<0.001).
Factors affecting sonographic accuracy

The measurement error and degree of inaccuracy of ultrasound HC within 10% of actual HC is greater in case male fetus. In order to adjust for possible confounding factor multivariate logistic regression was done and male fetus persistently associated with in accurate measurement of fetal head circumference, OR=2.32(95% CI,[1.03-5.22], p=0.043). After controlling for confounding factors fetal weight and liquor volume was not found to be associated with in accuracy of measurement within 10% of actual measurement (table 5).

Fetal presentation, placental location, experience of US performer, number of gestation and timing of ultrasound in relation to labor was not found to be associated with in accuracy of measurement.

Table 5: Factors affecting fetal HC measurement; multivariate analysis (N=339)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Accuracy of measurement within ± 10% actual HC</th>
<th>C P-value</th>
<th>C OR (95% CI)</th>
<th>Adjusted OR (95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inaccurate (n, %)</td>
<td>Accurate (n, %)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birth weight (grams)</td>
<td>1000-1499 4(36.4)</td>
<td>7(63.6)</td>
<td></td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1500-2499 11(21.2)</td>
<td>41(78.8)</td>
<td>0.007</td>
<td>.23(0.034-1.59)</td>
<td>1.49(0.35-6.44)</td>
</tr>
<tr>
<td></td>
<td>2500-3999 22(8.5)</td>
<td>237(91.5)</td>
<td>1.00</td>
<td>.49(0.098-2.51)</td>
<td>1.42(0.32-6.23)</td>
</tr>
<tr>
<td></td>
<td>≥4000 2(11.8)</td>
<td>15(88.2)</td>
<td>1.00</td>
<td>1.44(0.308-6.69)</td>
<td>.32(0.03-3.41)</td>
</tr>
<tr>
<td>Amniotic fluid volume</td>
<td>adequate 31(10.3)</td>
<td>271(89.7)</td>
<td>0.046</td>
<td>.42(0.17-0.98)</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>oligohydramnios 8(21.6)</td>
<td>29(78.4)</td>
<td></td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Fetal sex</td>
<td>Male 28(15.1)</td>
<td>157(84.9)</td>
<td>0.025</td>
<td>.43(0.2-0.89)</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Female 11(7.1)</td>
<td>143(92.9)</td>
<td></td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>
X. Discussion
In this study we looked for accuracy of sonographic estimation of fetal HC compared to actual HC measured within 6 hours of delivery and factors that affect accuracy of estimation. Sonographic measurement of fetal head circumference consistently underestimates the actual head circumference on average by simple mean error of 1.59 cm and 4.6 percent. Despite the wide use of US for fetal weight estimation or when abnormal fetal growth is suspected there are few data that available on the accuracy of fetal HC measurement and factors affecting the accuracy of measurement. Melamed et al, in study of 3008 subjects found that sonographic estimation of fetal HC underestimate the actual HC on average by -1.36cm or 4% with standard deviation of 1.71. In contrast to our study Hadlock et al, in a study of 400 fetuses, found that the sonographic HC estimations were comparable to postnatal standards published previously by others (mean difference, −0.94 ± 0.47 mm), but after 35 weeks of gestation the sonographic measurements were consistently smaller (by 4–8 mm) than the postnatal measurements. Similar to our study, Fescina and Ucieda found that sonographic measurements of HC (n = 14) significantly underestimated postnatal HC (mean difference, −11 mm).

In this study we also found that the prevalence of large fetal head circumference is 9.1 percent. Educational level of the US scanner which was not examined in previous studies is not found to be associated with sonographic underestimation of fetal HC.

The reason for consistent sonographic underestimation of postnatal head circumference is unclear but one possible cause, previously suggested by Hadlock et al., is that at term it can be difficult to distinguish fetal scalp from contiguous soft tissue of the uterus, so that sonographic measurements include only the bony calvaria of the fetal skull. In our study the sonographic underestimation of actual HC is only relate to the male fetus which may be due to difference in the shape of the head. Another possible explanation is may be due to the technical difficulty in obtaining the appropriate sonographic plane for HC measurement when the head is engaged. Another source of error could be the reliability of the postnatal HC measurement, which may also affect the correlation between sonographic and postnatal HC measurements but several studies have reported high correlation coefficients for both intraobserver (0.999) and interobserver (0.979) measurements.
XI. Conclusion
The prevalence of large fetal head circumference is 9.1 percent. We found that the sonographic estimation of HC is associated with significant underestimation of the actual HC, measured immediately postnatal and the difference constantly occur with advancing gestational age. The difference is more pronounced with male fetus compared to the female counterpart. But we didn’t found association between accuracy of measurement and fetal presentation, amniotic fluid volume, parity, level of education, number of gestation or placenta location. This measurement error may have important implications and should be taken into account in the interpretation of sonographically measured HC in cases of borderline fetal weight estimation or in sequentially measured fetal HC and compared to postnatal reference charts.

XII. Limitation
The limitation of the study is small sample size and it is a facility based study, and may not be generalized to the population.

XIII. Recommendation
Further study is recommended with large sample size. Further studies are also needed to determine whether other modalities, such as three-dimensional ultrasound or magnetic resonance imaging, can provide more accurate estimation of fetal HC.
XIV. References


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XV. ANNEX

Questionnaire

I. SOCIO-DEMOGRAPHIC CHARACTERISTICS

MRN-----------------------------------------------

1. Age ---------
2. Address
   A. Addis Ababa       C. Rural
   B. Out of Addis Ababa D. Urban
3. Educational level
   A. Primary          C. University
   B. Secondary school D. Able to read and write
   E. Cannot read and write
4. Religion
   A. Orthodox Christian C. Protestant
   B. Muslim           D. Catholic     E. Others
5. Ethnicity
   A. Oromo            C. Tigre
   B. Amhara          D. Gurage     E. Others
6. Marital status
   A. Married         C. Widowed
   B. Single          D. Divorced   E. Cohabit
7. Occupation
   A. House wife      C. Self employed
   B. Government employee D. Unemployed

II. Maternal characteristics

1. Maternal height-------, weight-------, BMI---------
2. Gravidity------, Abortion----------------------
3. LMP-------------, Gestational age----------weeks
4. Do you have ANC follow up?
   A. Yes       B. No

III. Fetal biometry (US measurement)

1. FHC----------cm  4. BPD---------cm  7. EFW--------g
2. AC---------- cm  5. OFD---------cm
3. FL---------------- cm  6. CI---------------- cm

IV. Factors affecting sonographic measurement
1. Level of operator
   A. Level of residency--------yr  C. Radiology resident---------
   B. Radiologist-----------------  D. OBGYN Consultant---------
2. Time of operation
   a) Working hours  b) Duty hours
3. Days of operation
   a) Week days  b) Weekends
4. Fetal presentation
5. Sex of the fetus
   A). Male  B). Female
6. Liquor volume
7. Placental location
8. Timing of operation
   A). Antepartum  B). Intrapartum
V. Labor outcome

1. Mode of delivery
   A. SVD-----------------  B. Operative delivery (specify)----------
   B. Indication-----------------

2. Fetal outcome
   A). Weight------------grams.  B). APGAR score--------1st----------5th minutes
   C). Neonatal HC----------cm.

3. Labor patterns
   A). Normal pattern
   B). Abnormal patterns of labor (specify)-------------------

4. Any maternal and fetal complications (specify)----------------