

2016

Accuracy of ultrasound in estimation of Fetal Weight at Term

Protocol for Thesis

Submitted for the partial fulfillment of the master degree

In Obstetrics and Gynecology

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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

"يُؤْتِي الْحِكْمَةَ مَنْ يَشَاءُ
وَمَنْ يُؤْتَ الْحِكْمَةَ فَقَدْ
أُوتِيَ خَيْرًا كَثِيرًا وَمَا
يَذْكُرُ إِلَّا أُولُو الْأَلْبَابِ"

صدق الله العظيم

سوره البقره: الايه ٢٦٩

Abstract

Aim of the study, the aim of this study is to compare the accuracy of different sonographic formulae for fetal weight estimation.

Methodology, we evaluated 8 different formulae using 120 sonographic weight estimations performed within 24 hours before delivery. Using correlation coefficient, regression analysis and Bland &Altman method to compare between the studied formulae with each other and knowing the effect the different fetal biometric indices on accuracy of estimates by ultrasound.

Results, A considerable variation in the accuracy of the different formulae was found. For birth weights (BW) in the range of 2500 to 3500 g, formulae based on 3 or 4 fetal biometric indices were significantly more accurate than formulae that incorporated only 1 or 2 indices. The accuracy of formulae decreased at the extreme of birth weight ≥ 4000 gs, leading to underestimation of ABW (actual birth weight).

Conclusion, we conclude that to improve the accuracy of fetal weight estimation, sonographic formulae that are based on 3 or 4 fetal biometric indices should be preferred. Recognizing the accuracy and the tendency for underestimation or overestimation of each formula is important for the judicious interpretation of fetal weight estimations, especially at the extremes of fetal weight.

Key words.

Ultrasound, term pregnancy, formulae, fetal parameters.

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List of abbreviation	
AC	Abdominal circumference
ABW	Actual birth weight
AFW	Actual fetal weight
AFI	Amniotic fluid index
AFV	Amniotic fluid volume
ANOVA	Analysis of variance
AP	Antero - posterior
AGA	appropriate for GA
BD	Binocular diameter
BI	Biometric indices
BMI	Body mass index
BP	Biometric parameter
BPD	Biparietal diameter
BR	Biometric Ratio
BW	birth weight
CI	Cephalic Index
CRI	Compound Resolution Imaging
CRL	Crown rump length
2D/US	Two dimension Ultrasound
3D/US	Three dimension Ultrasound
4D/US	Four dimension Ultrasound
EDD	Expected Day of Delivery
EFW	estimated fetal weight
EUS	endoscopic ultrasound
FL	Femur length
FPS	frames per second
GA	Gestational Age
Gs	Grams
HC	Head circumference
HELLP	Hemolytic anemia, elevated liver enzymes and low platelet count
HL	Humeral length
IUFD	Intra-Uterine Fetal Death
IUGR	Intrauterine growth retardation
LMP	Last Menstrual Period
LS	Longitudinal section
LGA	Large for GA
Ms	Meters
M	Mean
MA	Maternal age

MAD	Middle abdominal diameter
MCA	Middle cerebral artery
MRI	Magnetic resonance imaging
MM	Millimeter
MW	Maternal weight
OFD	Occipitofrontal diameter
Radar	Radio Detection And Ranging
S	Second
SD	Standard deviation
SG	Specific gravity
SGA	Small for GA
Sonar	Sound Navigation And Ranging system
TCD	Transverse cerebellar diameter
TC	Thoracic circumference
TS	Transverse section
US	Ultrasound
Wt	Weight
WK	Week

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Introduction and Aim of work

The ultrasound estimation of fetal weight in term pregnancies is used to determine fetal growth, and this may affect the timing and route of delivery, [Bamberg C, Kalache KD 2004, Conway DL 2002](#).

Although antenatal care has focused more on the diagnosis of fetal growth restriction and fetal macrosomia, the delivery of macrosomic infants is associated with higher rates of adverse outcomes for both mother and infant in comparison to the delivery of normal weight infants. Increased risks to the large infant include shoulder dystocia, brachial plexus injury, perinatal asphyxia, and neonatal death. [Stotland NE et al 2004](#) Adverse maternal outcomes include prolonged labour, genital tract trauma, postpartum haemorrhage, and a higher rate of caesarean delivery. [Jolly MC et al 2003](#)

Macrosomia has variously been defined as birth weight >4000 g, >4500 g or >90th centile for weight by gestation. [Coomarasamy A et al 2005](#) one of the main causes of fetal macrosomia is maternal diabetes. [Stotland NE et al 2004, Abramowicz JS, Ahn JT 2006](#) so ultrasound of fetal weight estimations is undertaken as part of the routine antenatal care of pregnant women, accurate estimation of fetal weight now has an important role in routine antenatal care and for detection of fetal growth abnormalities, for this reason, researchers have invested much effort in creating formulae that would accurately predict fetal weight. These formulae are mainly based on different combinations of sonographically measured fetal biometric indices, mainly abdominal circumference (AC),

femur length (FL), biparietal diameter (BPD), and head circumference (HC).

Although some formulae include only 1 or 2 fetal indices, other models, in an effort to improve accuracy, incorporated either 3 or all 4 fetal indices.

But other formulae may use other methods, such as the physically based volumetric method that uses routine 2-dimensional biometric measurements [Combs CA et al 1993](#) or measurement of the volume of fetal body parts using 3-dimensional Sonography. [Schild RL et al 2000](#) or specific gravity as in [Shinozuka N et al 1987](#), or maternal weight as in [Hart N et al 2010](#) or gestational age as in [Sabbagha et al 1989](#) this refers to greater effort that created to establish the accuracy of fetal weight measurement by ultrasound but it remains unclear which of the many models available is the most accurate. [Dudley NJ 2005](#).

(Table -1); 8 Regression formulae for fetal weight estimation that evaluated

Regression formula	Year of publication	Regression Equation
<u>Woo</u> AC, BPD, FL	1985	$\text{Log}_{10} \text{ EFW} = 1.54 + 0.15(\text{BPD}) + 0.00111(\text{AC})^2 - 0.0000764 (\text{BPD})(\text{AC})^2 + 0.05(\text{FL}) - 0.000992(\text{FL})(\text{AC})$
<u>Warsof</u> AC	1977	$\text{Log}_{10} \text{ EFW} = -1.8367 + 0.092(\text{AC}) - 0.000019(\text{AC})^3 (\text{g, cm})$
<u>Merz I</u> AC ,BPD	1988	$-3,200.40479 + 157.07186 (\text{AC}) + 15.90391 (\text{BPD}) (\text{BPD}), (\text{g, cm})$
<u>Hadlock II</u> AC, HC,FL	1985	$\text{Log}_{10} \text{ EFW} = 1.326 - 0.00326(\text{AC}) (\text{FL}) + 0.0107(\text{HC}) + 0.0438(\text{AC}) + 0.158(\text{FL})$
<u>Hadlock IV</u> AC,BPD, HC,FL	1985	$\text{Log}_{10} \text{ EFW} = 1.3596 + 0.0064(\text{HC}) + 0.0424(\text{AC}) + 0.174(\text{FL}) + 0.00061(\text{BPD}) (\text{AC}) - 0.00386(\text{AC})(\text{FL})$
<u>Hadlock I</u> AC,FL	1985	$\text{Log}_{10} \text{ EFW} = 1.304 + 0.05281(\text{AC}) + 0.1938(\text{FL}) - 0.004(\text{AC}) (\text{FL})$
<u>Shepard</u> AC,BPD	1982	$\text{Log}_{10} \text{ EFW} = -1.7492 + 0.166(\text{BPD}) + 0.046(\text{AC}) - 0.002546(\text{AC})(\text{BPD})$
<u>Hadlock III</u> AC,BPD,FL	1985	$\text{Log}_{10} \text{ EFW} = 1.335 - 0.0034(\text{AC})(\text{FL}) + 0.0316(\text{BPD}) + 0.0457(\text{AC}) + 0.1623(\text{FL})$

Aim of work

This study compares the accuracy of different sonographic formulae in estimation of fetal weight at term to show the most accurate formula by ultrasound in estimation of fetal weight at term.

Also, to obtain the most effective fetal parameter that affect in estimation of fetal weight at term by ultrasound.

Also examine the validity of each formula in different fetal birth weight categories at term

Chapter 1

History and Note about the ultrasound

Introduction:

Ultrasound is an important tool in diagnosis and assessment of treatment in obstetrics and gynecology.

Sound is mechanical vibrations travelling in a physical medium such as air, water, metal or even human tissue. Whether the airborne vibrations come directly from the source or are reflected, they produce impressions on the eardrums of our vestibular organs.

Sound may be categorized according to various frequency levels:

- **Infrasound** (0–20 Hz)
- **Audible sound** (20–20 kHz)
- **Ultrasound** (>20 kHz)
- **Diagnostic ultrasound** (1–20 MHz)

Humans do not hear the infrasound but other species such as whales, dolphins, elephants, hippopotamuses and rhinoceros do. The upper frequency limit for humans is 20 kHz. Frequencies above 20 kHz are called ultrasound. Some species may hear sound frequencies which for humans are categorized as ultrasound, for example mice (10–70 kHz), dogs (40–60 kHz) and bats (20–200 kHz) (**Watts, Geof 2009**).

History of the Development of Ultrasound in Medicine:

After the passenger ship *Titanic* hit an iceberg on its maiden trip in 1912, the Physicists took an interest in using sound to detect large objects submerged in water, initially their researches actually failed.

During World War I, the French physicist Paul Langevin was responsible for developing the hydrophones needed to detect submarines; this underwater sonar technology resulted in the first sinking of a German submarine in 1916. In 1917, Langevin invented the quartz sandwich transducer which served as the basis for the modern ultrasonic era. Between World War I and World War II, the development of sonar (Sound Navigation and Ranging System) and radar (Radio Detection and Ranging) took place. The latter technique used electromagnetic waves rather than ultrasound. The next important step was the use of ultrasound to detect flaws in metal using high frequency ultrasound. The metal flaw detectors became increasingly important as World War II was approaching, but were reported after the war, (**Desch CH et al 1946, Firestone FA 1946**).

After World War II, Howry and Bliss, in Denver, started to experiment with sonar equipment and amplifiers from the navy (**Howry and Bliss 1952**)

They developed a pulse-echo technique in 1948–49, and later produced cross-sectional images of a human partly submerged in water. At the same time, **Wild JJ 1951** in Minneapolis developed abreast scanner and actually made a diagnosis of breast lesions with his device. The Swedish physician Inge Edler and physicist Helmut Hertz, at the University of Lund, borrowed a metal flaw detector from Kockum's Shipyard in Malmö, Sweden. In 1953, they managed to trace the

movements of the human cardiac valves by means of the sound waves emitted and received by their modified instrument (**Elder H, Hertz CH 1954**). This was the start of a new era in cardiology relying on sound technology (**Elder I 1952**).

The next breakthrough was by the Scottish physician Ian Donald, in Glasgow (**Donald I et al 1958**) who conducted the basic research for the development of a machine for clinical use employing ultrasound to make two-dimensional images of human tissue. Donald had served in the Air Force during World War II and his past experience influenced his prototype machine, which consisted of two metal flaw detectors. His Lancet paper of 1958, 'Investigation of abdominal masses by pulsed ultrasound', is considered to be one of the most important for the development of clinical ultrasound, (**Donald I et al 1958**).

Since the late 1950s, the development of ultrasound in medicine in general and in the field of obstetrics and gynecology in particular has continued in an exponential way. Breakthrough advances have been repeatedly made in spite of claims that the development of ultrasound in medicine has reached its physical limits.

History of development medical ultrasound machine:

In order to make a simple ultrasound machine, we need to be able to produce high-frequency sound. In the 1880s the Curie brothers discovered the **Piezoelectric effect**, by using a piezoelectric material (quartz crystal) it is possible to produce high frequency sound waves that emerge from the crystal into human tissue. The same crystal can pick up