INTRODUCTION

Ultrasonographic assessment of fetal growth to estimate fetal weight is widely used in obstetrics because birth weight represents the most important risk indicator for neonatal and infant mortality and morbidity.

An accurate estimation of fetal weight is valuable information for planning the mode of delivery and management of labor. Several formulas that have been proposed over the past 30 years use different combinations of standardized fetal biometric parameters, such as biparietal diameter (BPD), head circumference, abdominal circumference, and femur length ***(Dudley, 2005).*** A few attempts to improve accuracy have been published that combine the above mentioned parameters and nonstandard ultrasonographic measurements (subcutaneous tissue, cheek-to-cheek diameter) ***(Chauhan et al., 2000),*** maternal or fetal data such as parental characteristics, fetal gender, gestational age, or fundal height, but these have yielded few improvements ***(Kurmanavicius et al., 2004)***.

The introduction of three-dimensional (3D) ultrasonography has led some authors to propose new formulas that incorporated volumetric data of fetal limbs. The application of these techniques was generally limited by the excessive time required for making volume measurements (scan and data processing) and by the need for access to a 3D machine with specific software. Therefore, such complex formulas (integrated formulas and volumetric assessment) seem poorly suited for everyday clinical practice ***(Rosati et al., 2009; Scioscia et al., 2008)***.

The two main methods for predicting BW in obstetric practice are clinical estimation and sonographic fetal measurements. Direct comparison of clinical and sonographic estimates of BW has found ultrasound techniques to be superior for preterm infants; clinical assessment to be superior for infants between 2,500 and 4,000 g and both techniques to have similar accuracy (or inaccuracy) over 4,000g ***(Chauhan et al., 1998; Sritippanyawan et al., 2007)***.

Mongelli and Gardosi (1996) proposed the gestation-adjusted projection (GAP) method of predicting fetal weight from sonographic measurements of fetal ultrasound parameters remote from term. The clinical value of this model is suggested in many primary health care centers, where the equipment or expertise is unavailable. This extrapolation technique is based on the assumption that normal fetuses do not cross percentiles on growth curves. This implies that in the third trimester of pregnancy, the ratio between the EFW at the time of the ultrasound examination and the median fetal weight at that gestational age will be the same as the ratio between estimated BW and the median BW for gestational age at delivery ***(Zelig et al., 2009; Mongelli & Gardosi, 1996).***

As fetuses remained on their predicted growth curves, and the GAP method was fairly accurate, with a mean absolute percent error that was statistically lower than that of the ultrasonographic examinations performed after 37 weeks gestation .With regard to prediction of macrosomia, the results were more modest as fetuses can cross the growth curves), Applying correction factor to the GAP method improved its accuracy for heavier fetuses in (those above the mean EFWUS) with statistically significant improvement in specificity for macrosomia without a statistically significant change in sensitivity ***(Zelig et al., 2009)***.

AIM OF THE WORK

The aim of the present study was to assess the accuracy of applying a correction factor to gestation-adjusted projection (GAP) method for prediction of birth weight (BW) by ultrasound done at 34 – 36^{+6} weeks gestation for feti with normal and extremes of birth weight.

Chapter I

THE USE OF ULTRASOUND IN OBSTETRICS

Introduction:

Diagnostic ultrasound has been described as an extension Of the human hand, such is our dependence on it in obstetrics. From its official introduction into the medical world in 1942 by Karl Dussick ***(Levi, 1998)*** its metamorphosis into today's high-tech equipment has led to a general trend towards increased power output and the potential for associated risks**.** ***(Barnett and Kossoff, 1998; Kloster-Banz, 1996).***

Physics and types:

The picture displayed on the screen is produced by sound waves reflected back from the imaged structure. Alternating current is applied to a transducer containing piezoelectric crystal that convert electric energy to high frequency sound waves. Sound waves pass through layers of tissue, encounter an interface between tissues of different densities, and reflected back to the transducer to be converted back to electrical energy displayed on the screen. Dense tissue as bone produces high velocity waves that appear white on the screen. Fluid produces low velocity waves appearing as black. Images are generated so quickly that produces a real-time scan and the picture appear to move.

Procedures for signal processing include:

1- ***A-mode (amplitude modulation):*** echo displayed as blip or deflection, size related to strength of echo.

2- ***B-mode (brightness modulation):*** movements of the transducer yield a series of dots which build 2D Image.

3- ***M-mode (time-position mode):*** demonstrates movements.

4- ***Real-time scan:*** transducer moves automatically to generate successive B-scan (15-60 frames/second).

5- ***Grey-scale:*** selective amplification of low level echoes from soft tissues

Bioeffects:

Thermal effects

An increase in tissue temperature is the most worrying bioeffect associated with diagnostic ultrasound. Some ultrasound energy is absorbed into the target tissue and some scatters into surrounding tissues Absorbed ultrasound energy is converted to thermal energy, with a subsequent local temperature elevation ***(Jolly et al., 2007).*** B-mode, M-mode and three-dimensional imaging are less likely to give rise to thermal injury in routine practice, Doppler ultrasound devices can cause significant temperature rises. A temperature rise of <1.5c is tolerated with no harm even if kept indefinitely ***(Kloster-Banz, 1996).***

Mechanical effects

1- Cavitation refers to the development of gas bubbles in an acoustic field at high negative pressures. These bubbles may be transient (inertial) or of the stable (non-inertial) type.

2- Acoustic streaming and torque: Radiation forces produced by the disseminating ultrasound wave tend to push target tissue away from the transducer, leading to acoustic streaming in fluids, cell distortion and lysis ***(Barnett et al., 1994)***.These have been unlikely to be significant with diagnostic ultrasound in soft tissues in vivo, where the in situ adhesiveness is high **.**

Safety:

The principle of using the lowest acoustic power output, for the shortest duration, with the least exposure to sensitive target tissues, while achieving the optimum diagnostic information, can reduce biohazards. The ALARA (As Low As Reasonably Achievable principle applies to diagnostic ultrasound. Safety guidelines laid out by the British Medical Ultrasound Society (BMUS), the European Federation of Societies for Ultrasound in Medicine and Biology (EFSUMB) and the World Federation for Ultrasound in Medicine and Biology (WFUMB) specifically emphasize the need for competence in the safe application of ultrasound ***(Marinac et al., 2002; Barr, 2001; Barnett and Maulik, 2001).***

Ultrasound is a type of mechanical energy that penetrates tissue as an oscillating wave of alternating pressure (measured in megapascals [MPa]). In B-mode, M-mode and three dimensional imaging, this energy is transmitted in pulses, with interim pauses for image reception and display. Doppler ultrasound devices, especially pulsed spectral Doppler, produce a fixed ultrasound beam which, when directed to a fixed target tissue, cause a significant rise in temperature within a relatively short time ***(Kloster-Banz,1996)***. The hazard potential of ultrasound depends mainly on four diverse yet mutually dependent factors***(tog 2007)***

- Ultrasound exposure The ultrasound energy or total acoustic output power (w) emitted by the equipment.
- Target tissue This determines the acoustic composition absorption coefficients. In general, more proteinaceous tissue is more susceptible tothermal injury while higher fluid and gas content makes tissue susceptible to cavitational activity.

- Tissue susceptibility Rapidly proliferating fetal or embryonic tissues are more susceptible to ultrasound effects. Most adult tissues have a static cell population and safety features such as the hyperaemic reflex (an increase in blood flow through the tissue that carries the heat away).
- Clinical settings The type of transducer used, the depth of penetration and overlying layers of tissue alter the acoustic output to the particular target.

Safety indices

Thermal index

The thermal index is an indicator of the temperature elevation possible at a particular equipment setting. It is defined as ‘the ratio of the acoustic power emitted by the transducer to the acoustic power required to produce a 1-C rise in temperature at a particular equipmentsetting. The thermal index has three subdivisions :soft tissues (TIS); bone (TIB); and adult cranial exposure or bone at a surface (TIC*).(Figure 1)*

In obstetric scanning the TIS should be used for the first eight weeks after conception and the TIB should be monitored thereafter**.** Maximum recommended exposure times for an embryo or fetus ***(Reproduced from the British Medical Ultrasound Society).***

Thermal index (TI)	**Maximum exposure time (minutes)**
0.7	60
1.0	30
1.5	15
2	4

Mechanical index

The mechanical index is an indicator of the likelihood of cavitation events. It is defined as the 'maximum estimated in situ rarefaction pressure: maximum negative pressure (in MPa) divided by the square root of the frequency (in MHz)'. Thus,the mechanical index is inversely proportional to the frequency ***(Barnett, 2000).*** Mechanical bioeffects have not been reported in humans from exposure to the acoustic power outputs currently used in diagnostic ultrasound. In general use, the mechanical index should be < 1.9 *(figure2,3,4)*

The current FDA (Food and Drug Administration, Center for Devices and Radiological Health, USA) regulations allow manufacturers to increase power outputs by up to 8–10 times that used in the past, provided there is a display of safety indices on the screen.

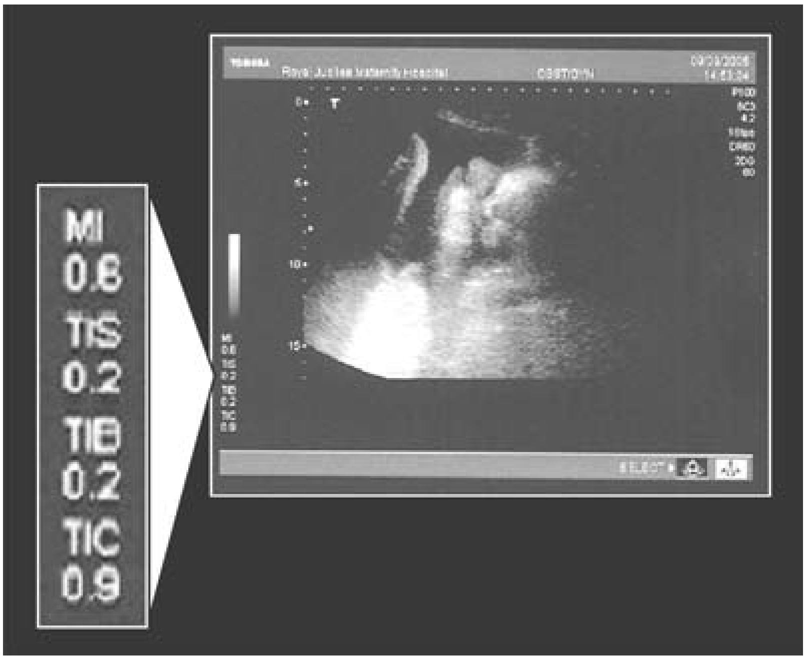

Figure (1): Safety indices (blocked arrow): mechanical index (MI); thermal index soft tissues (TIS); bone (TIB); adult cranial exposure or bone (TIC)

Figure (2): B-mode ultrasound (TIB and MI are displayed in the top right hand corner). TIB = 0.2, MI = 1.1

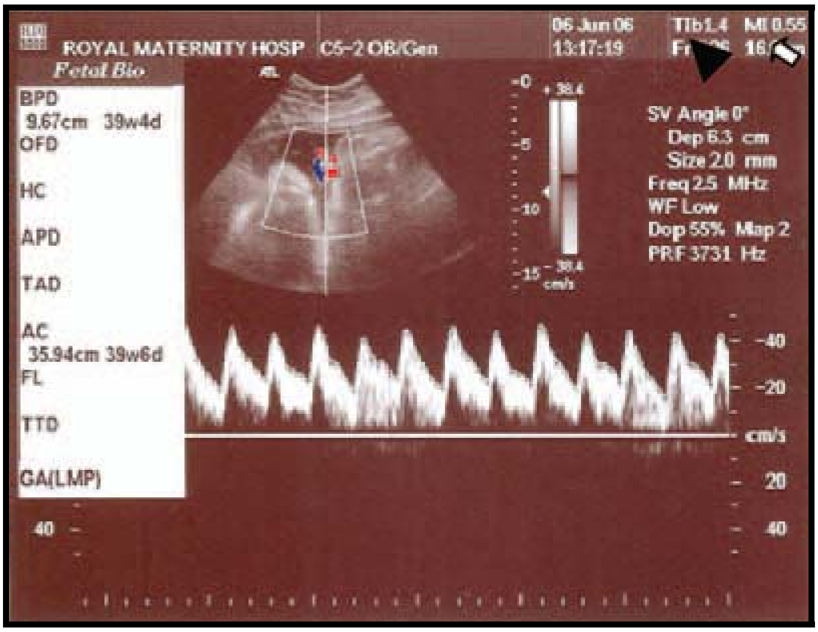

Figure (3): Doppler mode. Note the change in TIB and MI when the settings are changed from Bmode to Doppler mode TIB = 1.4, MI = 0.55

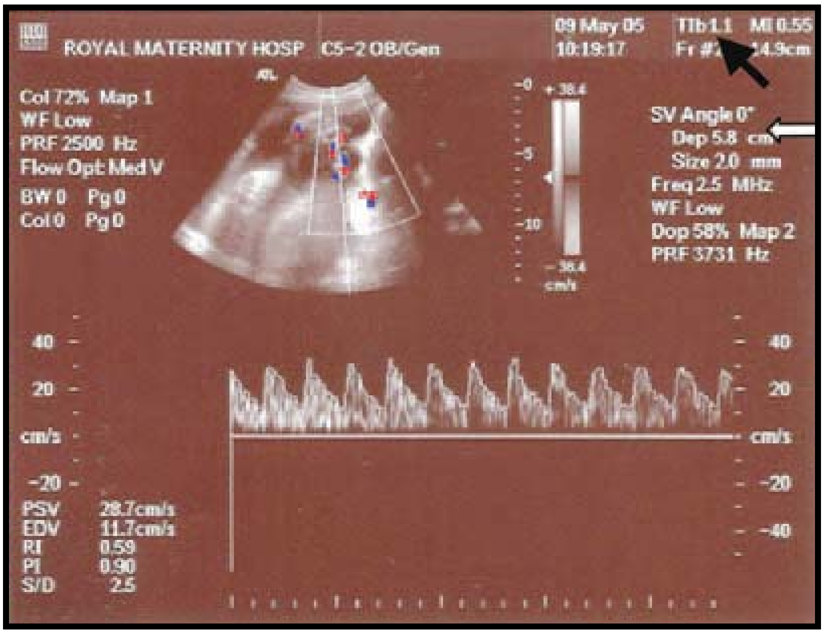

Figure (4): Umbilical artery Doppler. TIB (solid arrow) is displayed in the top right hand corner TIB = 1.1, MI = 0.55.

Long-term effects

Newnham et al. (2004) in a randomized controlled trial to assess the effect of multiple (five) ultrasound exposures in singleton pregnancies concluded that there was an unexplained, significantly increased incidence of growth restricted newborns. However, follow-up to eight years of age showed no differences in childhood growth and development of speech, language, behaviour and neurological development compared with children who had only a single prenatal ultrasound scan ***(Newnham et al., 2004)*** In contrast, others report an increased incidence of dyslexia and speech delay ***(Campbell et al., 1993)***. On follow-up, some studies have reported a significant increase of non right-handedness in boys exposed to ultrasound *in utero* ***(Salvesen, 2002)***. There is an ongoing scientific debate as to whether this is due to an increased susceptibility of male fetal brains to ultrasound induced disturbances in neuronal migration and development of synapses ***(Salvesen and Eik-Nes, 1999).***

There is no evidence to date that ultrasound exposure increases the congenital malformation rate or that any specific anomaly can be attributed to ultrasound exposure . In a meta-analysis of epidemiological studies on ultrasound exposure, Salvesan and Eik-Nes concluded that there was no association between diagnostic ultrasound exposure during pregnancy and reduced birthweight, childhood malignancies or neurological development ***(Salvesen and Eik-Nes, 1999; Salvesen, 2002)***. While these findings are reassuring and, at present, the general consensus is that diagnostic ultrasound is safe in pregnancy, with no substantiated long term effects, caution should, nonetheless, be exercised as machines become ever more powerful.

Chapter II

ESTIMATION OF FETAL WEIGHT

Introduction:

Accurate estimation of fetal weight has an important role in routine antenatal care and for detection of fetal growth abnormalities ***(Melamed et al., 2009).*** It is well known that both low birth weight (BW) and excessive fetal weight are associated with an increased risk of newborn complications during labor and the first post-natal period ***(Heiskanen et al., 2006).*** The two main methods for predicting BW in obstetric practice are clinical estimation and sonographic fetal measurements ***(Chauhan, 1998; Prechapanich et al., 2004).***

Direct comparison of clinical and sonographic estimates of BW have found ultrasound techniques to be superior for preterm infants, clinical assessment to be superior for infants between 2,500 and 4,000 g and both techniques to have similar accuracy (or inaccuracy) over 4,000 g. ***(Sherman et al., 1998; Chauhan et al., 1998).*** American College of Obstetricians and Gynaecologists (ACOG) has referred to a third method of obtaining an estimate of fetal size, namely the mothers own estimate of fetal size. There is some evidence that serial sonographic measurements may improve the predictive accuracy of abnormal fetal weight ***(O'Reilly-Green et al., 2000).***