NOMOGRAM OF MALAY PREGNANT WOMEN WITH HEALTH PROBLEMS IN KELANTAN

IZYANI BINTI KARUDIN

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NOMOGRAM OF MALAY PREGNANT WOMEN WITH HEALTH PROBLEMS IN KELANTAN

by

IZYANI BINTI KARUDIN

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2D	Two-dimensional
4D	Four-dimensional
AC	Abdominal circumference
AC anaemia	Mean value of AC for Malay pregnant women with anaemia
AC asthma	Mean value of AC for Malay pregnant women with asthma
AC GDM	Mean value of AC for Malay pregnant women with gestational diabetes mellitus
AC healthy	Mean value of AC for healthy Malay pregnant women
AC healthy, Hadlock et al. (1984b)	AC value of healthy pregnant women from Hadlock et al. (1984b)
AC healthy, Jeanty et al. (1984b)	AC value of healthy pregnant women from Jeanty et al. (1984b)
AC healthy, Ramzun (2009)	AC value of healthy pregnant women from Ramzun (2009)
AC hypertension	Mean value of AC for Malay pregnant women with hypertension
AC/FL	Ratio of abdominal circumference to femur length
(AC/FL) anaemia	Mean value of ratio of (AC/FL) anaemia for Malay pregnant women
(AC/FL) asthma	Mean value of ratio of (AC/FL) asthma for Malay pregnant women
(AC/FL) GDM	Mean value of ratio of (AC/FL) GDM for Malay pregnant women
(AC/FL) healthy	Mean value of ratio of (AC/FL) healthy for Malay pregnant women
(AC/FL) hypertension	Mean value of ratio of (AC/FL) hypertension for Malay pregnant women

AF	Amniotic fluid
AFI	Amniotic fluid index
AFI anaemia	Mean value of AFI for Malay pregnant women with anaemia
AFI asthma	Mean value of AFI for Malay pregnant women with asthma
AFI GDM	Mean value of AFI for Malay pregnant women with gestational diabetes mellitus
AFI healthy	Mean value of AFI for healthy Malay pregnant women
AFI healthy, Alao et al. (2007)	AFI value of healthy pregnant women from Alao et al. (2007)
AFI healthy, Hinh & Ladinsky (2005)	AFI value of healthy pregnant women from Hinh & Ladinsky (2005)
AFI healthy, Ramzun (2009)	AFI value of healthy pregnant women from Ramzun (2009)
AFI hypertension	Mean value of AFI for Malay pregnant women with hypertension
AFI/HCB	Ratio of amniotic fluid index to head circumference of newborn baby
(AFI/HCB) anaemia	Mean value of ratio of (AFI/HCB) anaemia for Malay pregnant women
(AFI/HCB) asthma	Mean value of ratio of (AFI/HCB) anaemia for Malay pregnant women
(AFI/HCB) GDM	Mean value of ratio of (AFI/HCB) anaemia for Malay pregnant women
(AFI/HCB) healthy	Mean value of ratio of (AFI/HCB) anaemia for Malay pregnant women
(AFI/HCB) hypertension	Mean value of ratio of (AFI/HCB) hypertension for Malay pregnant women
AFI/LB	Ratio of amniotic fluid index to length of newborn baby

(AFI/LB) anaemia	Mean value of ratio of (AFI/LB) anaemia for Malay pregnant women
(AFI/LB) asthma	Mean value of ratio of (AFI/LB) asthma for Malay pregnant women
(AFI/LB) GDM	Mean value of ratio of (AFI/LB) GDM for Malay pregnant women
(AFI/LB) healthy	Mean value of ratio of (AFI/LB) healthy for Malay pregnant women
(AFI/LB) hypertension	Mean value of ratio of (AFI/LB) hypertension for Malay pregnant women
AFV	Amniotic fluid volume
ANC	Antenatal check-up
ANOVA	Analysis of variance
BMI	Body mass index
BP	Blood pressure
BPD	Biparietal diameter
BPD anaemia	Mean value of BPD for Malay pregnant women with anaemia
BPD asthma	Mean value of BPD for Malay pregnant women with asthma
BPD healthy	Mean value of BPD for healthy Malay pregnant women
BPD healthy, ASUM (2001)	BPD value of healthy pregnant women from ASUM (2001)
BPD healthy, Crequat et al. (2000)	BPD value of healthy pregnant women from Crequat et al. (2000)
BPD healthy, Ramzun (2009)	BPD value of healthy pregnant women from Ramzun (2009)
BPD hypertension	Mean value of BPD for Malay pregnant women with hypertension
BPD GDM	Mean value of BPD for Malay pregnant women with gestational diabetes mellitus

BPD/AC	Ratio of biparietal diameter to abdominal circumference
(BPD/AC) anaemia	Mean value of ratio of (BPD/AC) anaemia for Malay pregnant women
(BPD/AC) asthma	Mean value of ratio of (BPD/AC) asthma for Malay pregnant women
(BPD/AC) GDM	Mean value of ratio of (BPD/AC) GDM for Malay pregnant women
(BPD/AC) healthy	Mean value of ratio of (BPD/AC) healthy for Malay pregnant women
(BPD/AC) hypertension	Mean value of ratio of (BPD/AC) hypertension for Malay pregnant women
BPD/FL	Ratio of biparietal diameter to femur length
(BPD/FL) anaemia	Mean value of ratio of (BPD/FL) anaemia for Malay pregnant women
(BPD/FL) asthma	Mean value of ratio of (BPD/FL) asthma for Malay pregnant women
(BPD/FL) GDM	Mean value of ratio of (BPD/FL) GDM for Malay pregnant women
(BPD/FL) healthy	Mean value of ratio of (BPD/FL) healthy for Malay pregnant women
(BPD/FL) hypertension	Mean value of ratio of (BPD/FL) hypertension for Malay pregnant women
BPD/HC	Ratio of biparietal diameter to head circumference
(BPD/HC) anaemia	Mean value of ratio of (BPD/HC) anaemia for Malay pregnant women
(BPD/HC) asthma	Mean value of ratio of (BPD/HC) asthma for Malay pregnant women
(BPD/HC) GDM	Mean value of ratio of (BPD/HC) GDM for Malay pregnant women
(BPD/HC) healthy	Mean value of ratio of (BPD/HC) healthy for Malay pregnant women

(BPD/HC) hypertension	Mean value of ratio of (BPD/HC) hypertension for Malay pregnant women
BW	Birth weight
BW anaemia	Mean value of BW for Malay pregnant women with anaemia
BW asthma	Mean value of BW for Malay pregnant women with asthma
BW GDM	Mean value of BW for Malay pregnant women with gestational diabetes mellitus
BW healthy	Mean value of BW for healthy Malay pregnant women
BW hypertension	Mean value of BW for Malay pregnant women with hypertension
BW/PW	Ratio of birth weight to placenta weight
(BW/PW) anaemia	Mean value of ratio of (BW/PW) anaemia for Malay pregnant women
(BW/PW) asthma	Mean value of ratio of (BW/PW) asthma for Malay pregnant women
(BW/PW) GDM	Mean value of ratio of (BW/PW) GDM for Malay pregnant women
(BW/PW) healthy	Mean value of ratio of (BW/PW) healthy for Malay pregnant women
(BW/PW) hypertension	Mean value of ratio of (BW/PW) hypertension for Malay pregnant women
CPU	Central Processing Unit
CRL	Crown-rump length
CRL anaemia	Mean value of CRL for Malay pregnant women with anaemia
CRL asthma	Mean value of CRL for Malay pregnant women with asthma
CRL GDM	Mean value of CRL for Malay pregnant women with gestational diabetes mellitus

CRL healthy	Mean value of CRL for healthy Malay pregnant women
CRL healthy, ASUM (2001)	CRL value of healthy pregnant women from ASUM (2001)
CRL healthy, Ramzun (2009)	CRL value of healthy pregnant women from Ramzun (2009)
CRL healthy, Verwoerd Dikkeboom et al. (2008)	CRL value of healthy pregnant women from Verwoerd Dikkeboom et al. (2008)
CRL hypertension	Mean value of CRL for Malay pregnant women with hypertension
Dias anaemia	Mean value of diastolic blood pressure for Malay pregnant women with anaemia
Dias anaemia (after delivery)	Mean value of diastolic blood pressure for Malay pregnant women with anaemia after delivery
Dias asthma	Mean value of diastolic blood pressure for Malay pregnant women with asthma
Dias asthma (after delivery)	Mean value of diastolic blood pressure for Malay pregnant women with asthma after delivery
Dias GDM	Mean value of diastolic blood pressure for Malay pregnant women with gestational diabetes mellitus
Dias GDM (after delivery)	Mean value of diastolic blood pressure for Malay pregnant women with gestational diabetes mellitus after delivery
Dias healthy	Mean value of diastolic blood pressure for healthy Malay pregnant women
Dias healthy (after delivery)	Mean value of diastolic blood pressure for healthy Malay pregnant women after delivery
Dias healthy, Ramzun (2009)	Diastolic blood pressure value of healthy pregnant women from Ramzun (2009)
Dias hypertension	Mean value of diastolic blood pressure for Malay pregnant women with hypertension

Dias hypertension (after delivery)	Mean value of diastolic blood pressure for Malay pregnant women with hypertension
EBL	Estimated blood loss
EBL anaemia	Mean value of EBL for Malay pregnant women with anaemia
EBL asthma	Mean value of EBL for Malay pregnant women with asthma
EBL GDM	Mean value of EBL for Malay pregnant women with gestational diabetes mellitus
EBL healthy	Mean value of EBL for healthy Malay pregnant women
EBL hypertension	Mean value of EBL for Malay pregnant women with hypertension
EDD	Expected date of delivery
EFW	Estimated foetal weight
EFW anaemia	Mean value of EFW for Malay pregnant women with anaemia
EFW asthma	Mean value of EFW for Malay pregnant women with asthma
EFW GDM	Mean value of EFW for Malay pregnant women with gestational diabetes mellitus
EFW healthy	Mean value of EFW for healthy Malay pregnant women
EFW healthy, Halaska et al. (2006)	EFW value of healthy pregnant women from Halaska et al. (2006)
EFW healthy, Landis et al. (2009)	EFW value of healthy pregnant women from Landis et al. (2009)
EFW healthy, Ramzun (2009)	EFW value of healthy pregnant women from Ramzun (2009)
EFW hypertension	Mean value of EFW for Malay pregnant women with hypertension
EFW/BW	Ratio of estimated foetal weight to birth weight

(EFW/BW) anaemia	Mean value of ratio of (EFW/BW) anaemia for Malay pregnant women
(EFW/BW) asthma	Mean value of ratio of (EFW/BW) asthma for Malay pregnant women
(EFW/BW) GDM	Mean value of ratio of (EFW/BW) GDM for Malay pregnant women
(EFW/BW) healthy	Mean value of ratio of (EFW/BW) healthy for Malay pregnant women
(EFW/BW) hypertension	Mean value of ratio of (EFW/BW) hypertension for Malay pregnant women
EFW/PW	Ratio of estimated foetal weight to placenta weight
(EFW/PW) anaemia	Mean value of ratio of (EFW/PW) anaemia for Malay pregnant women
(EFW/PW) asthma	Mean value of ratio of (EFW/PW) asthma for Malay pregnant women
(EFW/PW) GDM	Mean value of ratio of (EFW/PW) GDM for Malay pregnant women
(EFW/PW) healthy	Mean value of ratio of (EFW/PW) healthy for Malay pregnant women
(EFW/PW) hypertension	Mean value of ratio of (EFW/PW) hypertension for Malay pregnant women
FAA	Fetal abdominal area
FL	Femur length
FL anaemia	Mean value of FL for Malay pregnant women with anaemia
FL asthma	Mean value of FL for Malay pregnant women with asthma
FL GDM	Mean value of FL for Malay pregnant women with gestational diabetes mellitus
FL healthy	Mean value of FL for healthy Malay pregnant women

FL healthy, Chang et al. (2002)	FL value of healthy pregnant women from Chang et al. (2002)
FL healthy, Chitty et al. (1994)	FL value of healthy pregnant women from Chitty et al. (1994)
FL healthy, Ramzun (2009)	FL value of healthy pregnant women from Ramzun (2009)
FL hypertension	Mean value of FL for Malay pregnant women with hypertension
GA	Gestational age
GDM	Gestational diabetes mellitus
Hb	Haemoglobin
Hb anaemia	Mean value of Hb for Malay pregnant women with anaemia
Hb asthma	Mean value of Hb for Malay pregnant women with asthma
Hb GDM	Mean value of Hb for Malay pregnant women with gestational diabetes mellitus
Hb healthy	Mean value of Hb for healthy Malay pregnant women
Hb healthy, Ramzun (2009)	Hb value of healthy pregnant women from Ramzun (2009)
Hb hypertension	Mean value of Hb for Malay pregnant women with hypertension
HC	Head circumference
HC anaemia	Mean value of HC for Malay pregnant women with anaemia
HC asthma	Mean value of HC for Malay pregnant women with asthma
HC GDM	Mean value of HC for Malay pregnant women with gestational diabetes mellitus
HC healthy	Mean value of HC for healthy Malay pregnant women

HC healthy, Kurmanavicius et al. (1999)	HC value of healthy pregnant women from Kurmanavicius et al. (1999)
HC healthy, Ramzun (2009)	HC value of healthy pregnant women from Ramzun (2009)
HC healthy, Snijders & Nicolaides (1994)	HC value of healthy pregnant women from Snijders & Nicolaides (1994)
HChypertension	Mean value of HC for Malay pregnant women with hypertension
HC/AC	Ratio of head circumference to abdominal circumference
(HC/AC) anaemia	Mean value of ratio of (HC/AC) anaemia for Malay pregnant women
(HC/AC) asthma	Mean value of ratio of (HC/AC) asthma for Malay pregnant women
(HC/AC) GDM	Mean value of ratio of (HC/AC) GDM for Malay pregnant women
(HC/AC) healthy	Mean value of ratio of (HC/AC) healthy for Malay pregnant women
(HC/AC) hypertension	Mean value of ratio of (HC/AC) hypertension for Malay pregnant women
HC/FL	Ratio of head circumference to femur length
(HC/FL) anaemia	Mean value of ratio of (HC/FL) anaemia for Malay pregnant women
(HC/FL) asthma	Mean value of ratio of (HC/FL) asthma for Malay pregnant women
(HC/FL) GDM	Mean value of ratio of (HC/FL) GDM for Malay pregnant women
(HC/FL) healthy	Mean value of ratio of (HC/FL) healthy for Malay pregnant women
(HC/FL) hypertension	Mean value of ratio of (HC/FL) hypertension for Malay pregnant women
HCB	Head circumference of newborn baby

HCB anaemia	Mean value of HCB for Malay pregnant women with anaemia
HCB asthma	Mean value of HCB for Malay pregnant women with asthma
HCB GDM	Mean value of HCB for Malay pregnant women with gestational diabetes mellitus
HCB healthy	Mean value of HCB for healthy Malay pregnant women
HCB hypertension	Mean value of HCB for Malay pregnant women with hypertension
HRPZII	Hospital Raja Perempuan Zainab II
IUGR	Intrauterine growth restriction
LB	Length of birth
LB anaemia	Mean value of LB for Malay pregnant women with anaemia
LB asthma	Mean value of LB for Malay pregnant women with asthma
LB GDM	Mean value of LB for Malay pregnant women with gestational diabetes mellitus
LB healthy	Mean value of LB for healthy Malay pregnant women
LB hypertension	Mean value of LB for Malay pregnant women with hypertension
LB/HCB	Ratio of length of birth to head circumference of newborn baby
(LB/HCB) anaemia	Mean value of ratio of (LB/HCB) anaemia for Malay pregnant women
(LB/HCB) asthma	Mean value of ratio of (LB/HCB) asthma for Malay pregnant women
(LB/HCB) GDM	Mean value of ratio of (LB/HCB) GDM for Malay pregnant women
(LB/HCB) healthy	Mean value of ratio of (LB/HCB) healthy for Malay pregnant women

(LB/HCB) hypertension	Mean value of ratio of (LB/HCB) hypertension for Malay pregnant women
LGA	Large for Gestational Age
LH	Labour hour
LH anaemia	Mean value of LH for Malay pregnant women with anaemia
LH asthma	Mean value of LH for Malay pregnant women with asthma
LH GDM	Mean value of LH for Malay pregnant women with gestational diabetes mellitus
LH healthy	Mean value of LH for healthy Malay pregnant women
LH hypertension	Mean value of LH for Malay pregnant women with hypertension
LMP	Last menstrual period
PPH	Post-partum hemorrhage
Pulse anaemia	Mean value of patient's pulse for Malay pregnant women with anaemia after delivery
Pulse asthma	Mean value of patient's pulse for Malay pregnant women with asthma after delivery
Pulse GDM	Mean value of patient's pulse for Malay pregnant women with gestational diabetes mellitus after delivery
Pulse healthy	Mean value of patient's pulse for healthy Malay pregnant women after delivery
Pulse hypertension	Mean value of patient's pulse for Malay pregnant women with hypertension after delivery
PW	Placenta weight
PW anaemia	Mean value of PW for Malay pregnant women with anaemia
PW asthma	Mean value of PW for Malay pregnant women with asthma

PW GDM	Mean value of PW for Malay pregnant women with gestational diabetes mellitus
PW healthy	Mean value of PW for healthy Malay pregnant women
PW hypertension	Mean value of PW for Malay pregnant women with hypertension
ROCs	Receiver-operator curves
SD	Significant difference
SGA	Small for Gestational Age
SPSS	Statistical Package for the Social Sciences
Syst anaemia	Mean value of systolic blood pressure for Malay pregnant women with anaemia
Syst anaemia (after delivery)	Mean value of systolic blood pressure for Malay pregnant women with anaemia after delivery
Syst asthma	Mean value of systolic blood pressure for Malay pregnant women with asthma
Syst asthma (after delivery)	Mean value of systolic blood pressure for Malay pregnant women with asthma after delivery
Syst GDM	Mean value of systolic blood pressure for Malay pregnant women with gestational diabetes mellitus
Syst GDM (after delivery)	Mean value of systolic blood pressure for Malay pregnant women with gestational diabetes mellitus after delivery
Syst healthy	Mean value of systolic blood pressure for healthy Malay pregnant women
Syst healthy (after delivery)	Mean value of systolic blood pressure for healthy Malay pregnant women after delivery
Syst healthy, Ramzun (2009)	Systolic blood pressure value of healthy pregnant women from Ramzun (2009)
Syst hypertension	Mean value of systolic blood pressure for Malay pregnant women with hypertension

Syst hypertension (after delivery)	Mean value of systolic blood pressure for Malay pregnant women with hypertension after delivery
USA	United States of America
Weight anaemia	Mean value of weight for Malay pregnant women with anaemia
Weight asthma	Mean value of weight for Malay pregnant women with asthma
Weight GDM	Mean value of weight for Malay pregnant women with gestational diabetes mellitus
Weight healthy	Mean value of weight for healthy Malay pregnant women
Weight healthy, Ramzun (2009)	Weight value of healthy pregnant women from Ramzun (2009)
Weight hypertension	Mean value of weight for Malay pregnant women with hypertension

NOMOGRAM WANITA MELAYU HAMIL DENGAN MASALAH KESIHATAN DI KELANTAN

ABSTRAK

Populasi rakyat Malaysia terdiri daripada pelbagai bangsa yang berbeza. Beberapa kajian mendapati bahawa variasi etnik mempengaruhi usia kehamilan. Tujuan kajian ini ialah untuk memberikan nilai-nilai rujukan bagi menentukan usia fetus di Malaysia bagi wanita mengandung berbangsa Melayu yang mempunyai masalah kesihatan. Parameter-parameter bagi pemeriksaan antenatal (ANC), biometri bunyi lampau fetus dan rumusan kelahiran bagi wanita mengandung berbangsa Melayu dengan masalah kesihatan telah dibandingkan dengan wanita mengandung berbangsa Melayu tanpa masalah kesihatan. Analisis statistik telah dibuat menggunakan kaedah SPSS versi 19. Perbezaan-perbezaan biometri fetus telah ditentukan menggunakan ujian analisis *t*-test. Data bagi kajian ini telah dikumpul dari Jabatan Obstetrik dan Ginekologi, Hospital Raja Perempuan Zainab II (HRPZII), Kota Bharu, Kelantan. Sejumlah 1660 data bagi pemeriksaan ANC, 1844 data bagi biometri bunyi lampau fetus, 1375 data bagi rumusan kelahiran dan 5718 data bagi nisbah antara parameter-parameter telah dilaporkan. Kajian mendapati bahawa, GDM mempunyai impak yang ketara kepada tekanan darah pesakit sebelum dan selepas bersalin, berat, AC, EFW, AFI, LB, PW, denyut nadi pesakit selepas bersalin, BPD/AC, BPD/FL, HC/AC, AC/FL, BW/PW, LB/HCB, EFW/PW, EFW/BW, AFI/LB dan AFI/HCB. Tekanan darah tinggi mempunyai impak yang ketara kepada tekanan darah pesakit sebelum dan selepas bersalin, Hb, berat, BPD, EFW, AFI, LH, BPD/HC, AFI/LB dan AFI/HCB. Anemia mempunyai impak yang ketara kepada tekanan darah pesakit sebelum dan selepas bersalin, Hb, CRL, HC,

AC, EFW, AFI, LH, BW, LB, denyut nadi pesakit selepas bersalin, BPD/HC, BPD/AC, BPD/FL, AC/FL, BW/PW dan AFI/HCB manakala, asma mempunyai impak yang ketara kepada tekanan darah sistolik pesakit sebelum dan selepas bersalin, Hb, berat, HC, AC, EFW, LH, PW, denyut nadi pesakit selepas bersalin, BPD/HC, BPD/AC, HC/AC, AC/FL, BW/PW, AFI/LB dan AFI/HCB. Nisbah-nisbah bagi BPD/HC, BPD/AC, BPD/FL, HC/AC, HC/FL dan AC/FL bagi wanita mengandung yang sihat dan wanita mengandung yang menghidap penyakit GDM, tekanan darah tinggi, anemia dan asma adalah tidak seragam dari minggu ke-12 hingga minggu ke-40, maka semua nisbah tersebut adalah bergantung kepada GA dan keadaan kesihatan wanita mengandung. Manakala, nisbah-nisbah bagi BW/PW, LB/HCB, EFW/PW, EFW/BW, AFI/LB dan AFI/HCB bagi wanita mengandung yang sihat dan wanita mengandung yang menghidap penyakit GDM, tekanan darah tinggi dan asma adalah tidak seragam dari minggu ke-35 hingga minggu ke-40, maka semua nisbah tersebut adalah bergantung kepada GA dan keadaan kesihatan wanita mengandung. Manakala, nisbah BW/PW bagi wanita mengandung yang menghidap penyakit anemia adalah seragam dari minggu ke-35 hingga minggu ke-40, maka semua nisbah bagi (BW/PW) anaemia adalah tidak bergantung kepada GA dan keadaan kesihatan wanita mengandung.

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ABSTRACT

The Malaysian population is composed of a variety of race groups. Some studies suggest that ethnic variation may influence dating. The aim of this study was to establish reference values for fetal age assessment in Malaysia using Malay race groups with health problems. The parameters of antenatal check-up (ANC), fetal ultrasound biometry and summary of labour for Malay pregnant women with health problems were compared with Malay pregnant women without health problems. Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) version 19. Differences in fetal biometry were assessed by *t*-test. The data of the study were collected from Department of Obstetrics and Gynaecology, Hospital Raja Perempuan Zainab II (HRPZII), Kota Bharu, Kelantan. A total of 1660 data of ANC, 1844 data of fetal ultrasound biometry, 1375 data of summary of labour and 5718 data of ratios between parameters were reported. It was found that, GDM has significant impact on patient's blood pressure before and after delivery, weight, AC, EFW, AFI, LB, PW, patient's pulse after delivery, BPD/AC, BPD/FL, HC/AC, AC/FL, BW/PW, LB/HCB, EFW/PW, EFW/BW, AFI/LB and AFI/HCB. Hypertension has significant impact on patient's blood pressure before and after delivery, Hb, weight, BPD, EFW, AFI, LH, BPD/HC, AFI/LB and AFI/HCB. Anaemia has significant impact on patient's blood pressure before and after delivery, Hb, CRL, HC, AC, EFW, AFI, LH, BW, LB, patient's pulse after delivery, BPD/HC, BPD/AC, BPD/FL, AC/FL, BW/PW and AFI/HCB while, asthma has significant impact on systolic blood pressure before and after delivery, Hb, weight, HC, AC,

EFW, LH, PW, patient's pulse after delivery, BPD/HC, BPD/AC, HC/AC, AC/FL, BW/PW, AFI/LB and AFI/HCB. The ratios of BPD/HC, BPD/AC, BPD/FL, HC/AC, HC/FL and AC/FL of healthy and unhealthy pregnant women with GDM, hypertension, anaemia and asthma were not constant from 12 until 40 weeks and therefore dependent of both GA and health conditions of pregnant women. Meanwhile, the ratios of BW/PW, LB/HCB, EFW/PW, EFW/BW, AFI/LB and AFI/HCB of healthy and unhealthy pregnant women with GDM, hypertension and asthma were not constant from 35 until 40 weeks and therefore dependent of both GA and health conditions of pregnant women. On the contrary, the BW/PW ratio for anaemia was constant from 35-40 weeks and therefore independent of GA and health conditions of pregnant women.

CHAPTER ONE

INTRODUCTION

A fetal age study uses ultrasonography to take measurements of fetal anatomic structures, compare the results to expected values, and convert that information into an estimated gestational age (GA) of the fetus. In general, ultrasonography dating of a pregnancy is more accurate than dating using the date of the mother's last menstrual period (LMP) (Ogasawara, 2009).

1.1 RESEARCH PROBLEMS

In the absence of known date of LMP or where fundal height on abdominal examination does not agree with dates, ultrasonic biometric parameters are valuable in estimating the GA of the fetus (Loughna et al., 2009).

The common problems with published reference values and curves for fetal biometry include failure to identify the statistical method of analysis, centiles that do not change smoothly during gestation, a supernormal data set, inadequate consideration of the changes in the variability of the measurements with gestation, and lack of scatter diagrams of the data with the fitted centiles superimposed (Professional Ultrasound Services, 2006).

Moreover, prenatal measurement of fetal parameters and estimated size and weights vary among different populations, depending upon their racial, demographic characteristics and nutrition (Professional Ultrasound Services, 2006).

1.2 OBJECTIVES OF RESEARCH

The main objectives of this thesis are:

i) To determine the effect of gestational diabetes mellitus (GDM), hypertension, anaemia and asthma on antenatal check-up (ANC), fetal biometry growth and labour of neonatal outcomes whether the values have significant or insignificant differences with healthy pregnant women.

ii) To develop a nomogram for all the unhealthy conditions.

iii) To estimate the ratios of fetal biometry growth and labour of neonatal outcomes whether the values of the ratios for unhealthy and healthy pregnant women have significant or insignificant differences, and dependent or not with both GA and health conditions of pregnant women.

1.3 SCOPE OF RESEARCH

This research focused on Malay pregnant women who attended antenatal check-up (ANC) or delivered their babies at the Department of Obstetrics and Gynaecology, Hospital Raja Perempuan Zainab II (HRPZII), Kota Bharu, Kelantan. Therefore, pregnant women from other races delivered in this hospital were excluded. Twins pregnancy, abortion fetus, stillbirth and other abnormality were also excluded. Meanwhile, pregnant women with the most common medical complications in pregnancy including GDM (which is blood pressure more than 140/90 mmHg and only developed during pregnancy), hypertension (including hypertensive disorders which were chronic hypertension (blood pressure more than 140/90 mmHg), gestational hypertension (blood pressure more than 140/90 mmHg and only developed during pregnancy), preeclampsia (blood pressure more than 140/90 mmHg with proteinuria) and preeclampsia superimposed on chronic

hypertension, anaemia (including mild, moderate and severe) and asthma (including mild, moderate and severe) and without health problems to find out the differences of ANC, fetal biometry, summary of labour, and ratios of fetal biometry growth and labour of neonatal outcomes.

1.4 OUTLINE OF THESIS

The thesis is divided into six chapters. Chapter one describes the introduction of fetal biometry, problems, objectives and scope of research. Chapter two discussed on theory and literature reviews. In Chapter three methodology of research will be discussed on details about data collection and data processing. Results and discussions for antenatal check-up (ANC) record and fetal biometry will be discussed in Chapter four. Summary of labour as well as ratios between the values of the fetal biometry and labour of neonatal outcomes will be discussed in Chapter five. Chapter six gives the conclusion and further study of the research.

CHAPTER TWO

THEORY AND LITERATURE REVIEW

The standard of fetal ultrasound biometry was started after Willocks et al., (1964) published the first paper, on fetal ultrasound cephalometery. Later, in 1968, fetal cephalometery was included in routine fetal biometric scans. Many reference charts and tables have been published since then. However, a number of these were produced using old ultrasound equipment with low spatial resolution in different ultrasound velocities compared with today's modern real-time scanners which have not only opened up improved measurement technique but also provides us with multiple fetal parameters. Several of these charts, however, have methodological flaws, falling short of the ideal attributes of gestational age (GA) related reference curve design, namely: non-identification of the statistical method of analysis, a supernormal data set, and inadequate account in variability of measurements with gestation and failure to present scatter diagrams. In the publications of Altman and Chitty, methodological guidelines were created for the construction of fetal biometry charts (Chitty & Altman, 2002).

2.1 ANTENATAL CARE

The concept that the general well-being and reproductive performance of a woman might be improved by antenatal supervision is surprisingly recent was first introduced in Edinburgh in 1911. In many societies, antenatal care is not available, and for social or religious reasons is not used when it is available. The basic aims of antenatal care are to ensure optimal health of the mother throughout her pregnancy as well as to detect and treat disorders arising during pregnancy which relate to the

welfare of both mother and fetus and to ensure that the pregnancy results in a healthy mother and healthy infant (Hanretty, 2003).

2.1.1 BLOOD PRESSURE MEASUREMENT

Blood pressure (BP) is the pressure exerted by circulating blood upon the walls of blood vessels. BP refers to the arterial pressure of the systemic circulation. During each heartbeat, BP varies between a maximum (systolic: heart is beating) and a minimum (diastolic: heart is relaxed) pressure (Klabunde & Richard, 2005).

Table 2.1 shows the classification of systolic and diastolic BP adopted by the American Heart Association for adults who are 18 years and older. Various factors, such as age and gender influence a person's average BP and variations. In children, the normal ranges are lower than for adults and depend on height. As adults age, systolic pressure tends to rise and diastolic tends to fall. In the elderly, BP tends to be above the normal adult range, largely because of reduce flexibility of the arteries. There are many physical factors that influence arterial pressure. Each of these may in turn be influenced by physiological factors, such as diet, exercise, disease, drugs or alcohol, stress, obesity, emotional reactions, sleep, digestion and time of day (Health and Life, 2010).

Table 2.1: Classification of Blood Pressure for adults according to the American Heart Association (Klabunde & Richard, 2005)

Category	Systolic, mmHg	Diastolic, mmHg
Hypotension	< 90	< 60
Desirable	90 –119	60 –79
Prehypertension	120 –139	or 80 –89
Stage 1 Hypertension	140 –159	or 90 –99
Stage 2 Hypertension	160 –179	or 100 –119
Hypertensive Crisis	≥ 180	or ≥ 120

A relation of low BP during pregnancy with poor perinatal outcomes for USA population has been studied by Zhang & Klebanoff (2001). Covariance and Chi-square tests were used. It was found that low BP does not increase risk of poor perinatal outcomes.

2.1.2 HAEMOGLOBIN COCENTRATION IN BLOOD

The change in blood values such as haemoglobin (Hb) content is the result of demands of the growing pregnancy modified by the increase in plasma volume. This represents an increase in red cell mass of 18%. The plasma volume increases by 40-45%. Thus there is a reduction in the red cell count per millilitre from 4.5 million to around 3.8 million. Towards term as the plasma volume diminishes the red cell count rises slightly. Similarly the haematocrit falls during pregnancy with a slight rise at term (Hanretty, 2003).

In normal pregnancy there is a gradual and progressive fall in the Hb level up till the 32-37 week after which level shows a gradual rise up till term. This initial fall in the Hb has been attributed to the greater increase in the plasma volume compared to the increase in the red cell volume (Kwa & Ko, 1968).

Kwa & Ko (1968) investigated on Hb values in pregnancy of healthy pregnant mothers in Singapore population. Hb was estimated on capillary blood by the cyanmethaemoglobin. It was indicated that the average Hb levels of Chinese mothers were higher than that of the Malays or Indians at corresponding stages of pregnancy. Hb levels were lowest for Indians at all stages of pregnancy.

The relation of Hb to preterm birth and low birth weight (BW) in Shanghai, China has been studied by Zhou et al. (1998). Rates of birth outcomes were

compared between Hb categories based on 10 g/liter groupings, with 110-119 g/liter as the reference group. It was found that rates of low BW and preterm birth were related to early pregnancy Hb concentration.

2.1.3 WEIGHT GAIN IN PREGNANCY

The most obvious of the physical changes that occur are the enlargement of the abdomen and the increase in body weight. In normal pregnancy the average gain is 0.3 kg/week up to 18 weeks, 0.45 kg/week from 18 to 28 weeks and thereafter a slight reduction with a rate of 0.36-0.41 kg/week until term. Failure to gain weight and sometimes slight weight loss may occur in the last 2 weeks. The average weight gain for primigravidae for the whole pregnancy is 12.5 kg, and is probably about 0.9 kg less for multigravidae. Acute excessive weight gain is commonly associated with abnormal fluid retention (Hanretty, 2003).

The individual components affecting weight gain are derived from both maternal and feto-placental factors. Pregnancy is an anabolic state, and thus results in an increase in body fat, the growth of the breasts and the uterus and an expansion of blood volume and extracellular fluid. The contribution to maternal weight gain from conceptus comes from fetal weight, amniotic fluid (AF) and the placenta. Poor weight gain is associated with low BW infants, but the range of weight gain in normal pregnancy may vary from almost zero to twice the mean weight gain. An increase in fat storage occurs in normal pregnancy, with the deposition of fat occurring principally over the back, upper thighs and abdomen (Hanretty, 2003).

Relation of maternal weight gain during pregnancy and childhood overweight in Portuguese children has been studied by Moreira et al. (2007). Analysis of

variance (ANOVA), and Chi-square tests were used. It was shown that high weight gain during pregnancy was associated with higher risk of overweight.

Addo (2010) studied on the effects of pregnancy weight gain in different body mass index (BMI) groups on maternal and neonatal outcomes in Ghana. Chi square and t-tests were used. It was found that, obesity are associated with significantly increased incidence of adverse maternal and neonatal outcomes.

2.2 ASSESSMENT OF THE FETUS

Fetal ultrasound biometry is the most reliable information about the fetal growth and wellbeing. A good scanning ultrasound machine are essential for obtaining maximum advantage (Hohler, 1984). Fetal growth is defined as the time dependent changes in body dimensions that occur throughout the pregnancy. The growth rate parameters is rapid especially in the first and second trimesters. Fetal biometry can be carried out by two different kinds of studies which are cross-sectional or longitudinal. For cross-sectional study, fetuses are examined only once during gestation. This study can be performed in a small period of time and the data is easier to collect and analyse statistically. The power of statistics that can be performed on cross-sectional data is suboptimal, they are susceptible to inclusion of fetuses with abnormal growth pattern and or poorly established GA and not give the desired information. On the other hand, a longitudinal study is one in which a small number of fetuses are investigated serially, at least thrice during the course of pregnancy. In this study, fetal age is established in early pregnancy, abnormal growth curves are easily diagnosed, and the statistics provide more relevant and stronger information. These studies necessitate that the same fetuses be scanned during the whole gestation, which considerably increases the time to collect the data

and calls for a high motivation on the part of both the mother and investigator (Loughna et al., 2009).

2.2.1 CROWN-RUMP LENGTH

Pregnancy dating by transabdominal sonographic measurement of crown-rump length (CRL) was first described by Robinson showed similar growth patterns in early pregnancy. This study assumed uniform growth across the first half of pregnancy, regardless of maternal or fetal characteristics. At the time of the first scan, ultrasound measurements of fetal size, based on CRL and biparietal diameter (BPD), together with validated algorithms for deriving gestational age (GA), were considered more reliable than last menstrual period (LMP) for dating (Salomon et al., 2010).

The CRL is utilized for estimation of GA up to the eleventh week, with accuracy in 95% of cases, within 2.7-4.7 days. After that the curvature of the fetus affects the reliability of measurement, therefore, from 12^{th} week onwards, the BPD is considered to be more accurate (Bovicilli et al., 1981).

Measurements of the CRL have traditionally been considered the most precise method for estimating GA. CRL, as a single measurement, is one of the most accurate dating methods (± 4-7 days) until the 12^{th} week of gestation (Pedersen & Molsted-Pederson, 1979).

The recommended equation for calculation of GA from CRL is:

$$GA = 8.052 \times (CRL \times 1.037)^{1/2} + 23.730 \quad (2.1)$$

CRL measurements can be carried out trans-abdominally or trans-vaginally. A midline sagittal section of the whole embryo or fetus should be obtained, ideally with the embryo or fetus horizontal on the screen, so that the line between crown and rump is at 90^{o} to the ultrasound beam. Figure 2.1 shows the measurement of CRL from the top of the head (crown) to the bottom of the buttocks (rump). The dotted line is the end points of the crown and the rump. Linear calipers should be used to measure the maximum unflexed length. In very early gestations, care must be taken to avoid inclusion of the yolk sac in the measurement of CRL, as this will overestimate the GA. It must be remembered that flexion increases with increasing gestation. In measuring a flexed fetus, the GA will be underestimated and it may be more appropriate to use the head circumference (HC) if the fetus remains flexed at 13 weeks or more (Loughna et al., 2009). The measurement needs to be in the natural state with an unstretched body which is actually *C* shaped (Gary et al., 1974).

The measurement of CRL is useful in determining the GA (menstrual age starting from the first day of the LMP) and thus the expected date of delivery (EDD) (Gary et al., 1974).

Different babies do grow at different rates and thus the GA is an approximation. Recent evidence has indicated that CRL growth may be influenced by maternal factors such as age, smoking, and folic acid intake. Early in pregnancy it is accurate within +/- 4 days but later in pregnancy due to different growth rates, the accuracy is less. In that situation, other parameters can be used in addition to CRL (Gary et al., 1974).

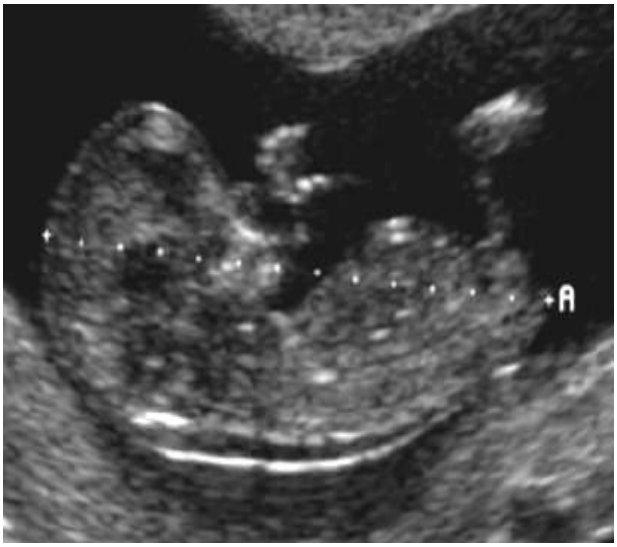

Figure 2.1: CRL measurement (Loughna et al., 2009)

Ziylan & Murshid (2003) investigated on an assessment of femur growth parameters in human fetuses and their relationship with CRL for Turkey population during second and third trimesters. Student's *t*-test and Pearson correlation coefficients were used. It was found that fetal CRL and femur growth parameters are accurate for the calculation of GA.

2.2.2 BIPARIETAL DIAMETER

In early work using ultrasound to assess fetal growth, the biparietal diameter (BPD) was measured simply because it was the only measurement that could be made reliably. For it to have any value at all, the level in the head at which the measurement had to be taken needed to be carefully defined, so that the section included the midline echo with the cavum septum pellucidum in the anterior third and the thalami on either side. With great care this is a reproducible measurement with an accuracy of about 1 mm (Campbell & Thomas, 1977).

Using this technique several researchers observed that BPD increased steadily throughout gestation, but that after about 32 weeks the rate of change decreased and the difficulty of accurate measurement increased. It became obvious that up to about 20 weeks the BPD gives an accurate guide to GA, which in itself formed the basis upon which to judge whether growth restriction was a problem (Willocks et al., 1967).

Studies report the growth of the BPD in the mid trimester is linear and rapid and biological variation at each week of gestation is small. The measurement of BPD from 14-26 weeks predicts the correct duration of gestation to the extent of ±9 days in 95% of cases (Hadlock et al., 1982). The recommended equation for calculation of BPD from GA according to ASUM (2001) is:

$$BPD = -23.533 + (3.665)GA + (0.007)GA^2 - (0.001)GA^3 \quad (2.2)$$

Fetal head measurements were obtained in a horizontal section at the level of the thalamus and the cavum septi pellucid as illustrated in Figure 2.2. In cases of symmetrical growth retardation, the fetal BPD will fall below the 10^{th} percentile (Campbell & Thomas, 1977). BPD is used in the second trimester, from 12^{th} week onwards. It measures the maximum distance between the two parietal bones taken from the leading edge of the skull to the leading edge i.e outer inner. It can also be measured from outer to outer table of the skull. This axial plane passes through the widest portion of skull where the continuous midline echo of falx cerebri is broken by cavum septum pellucidum with both the thalami enclosing the slit like opening of the 3^{rd} ventricle of brain (Hadlock et al., 1982).

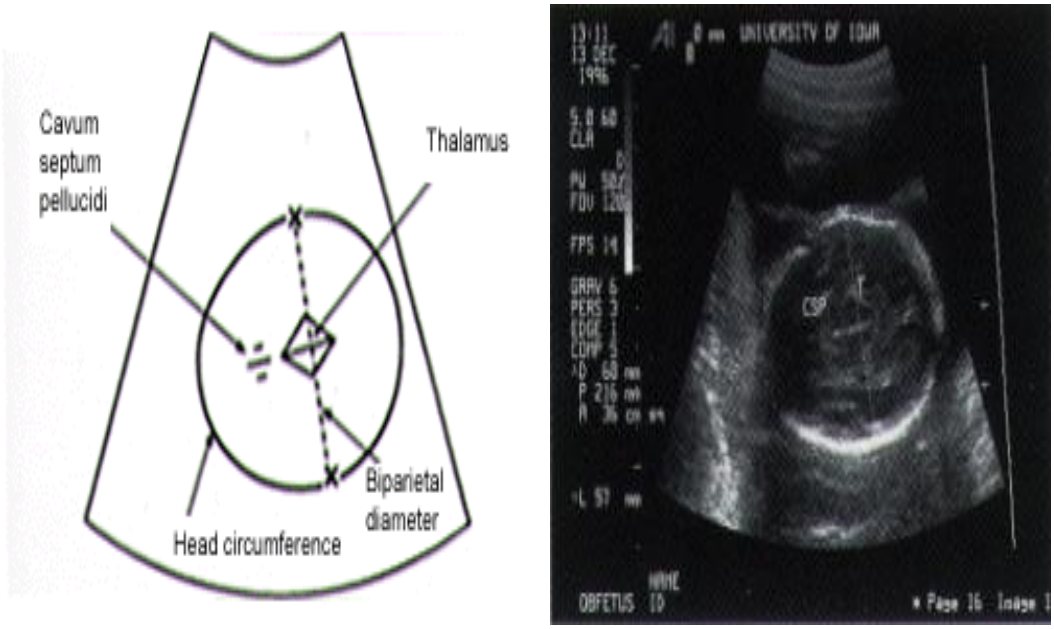

Figure 2.2: Transaxial image for BPD measurement (Campbell & Thomas, 1977)

2.2.3 HEAD CIRCUMFERENCE

Head circumference (HC) measurements are made at the same level as the BPD but involve a circumference rather than a diameter assessment (Jeanty et al., 1984a). HC used in the third trimester along with other parameters such as femur length (FL). The accuracy of this parameter is ± 2-3 weeks with 95% confidence interval (Ott, 1994).

GA should be estimated from HC using Hadlock et al. (1982) formula:

$$\text{Log}_e GA = (0.010611)HC - (0.000030321)HC^2 + (0.43498 \times 10^{-7})HC^3 + 1.848 \quad (2.3)$$

The recommended equation for HC according to Chitty et al. (1994) for estimating HC from GA is:

$$HC = -109.7 + (15.16)GA - (0.002388)GA^3 \quad (2.4)$$

HC was measured from an image that displayed the fetal head in an axial plane that included the thalamus, cavum septi pellucidi and falx. HC was measured using an ellipse trace of the outline of the fetal head as in Figure 2.3 (Stebbins & Jaffe, 1999).

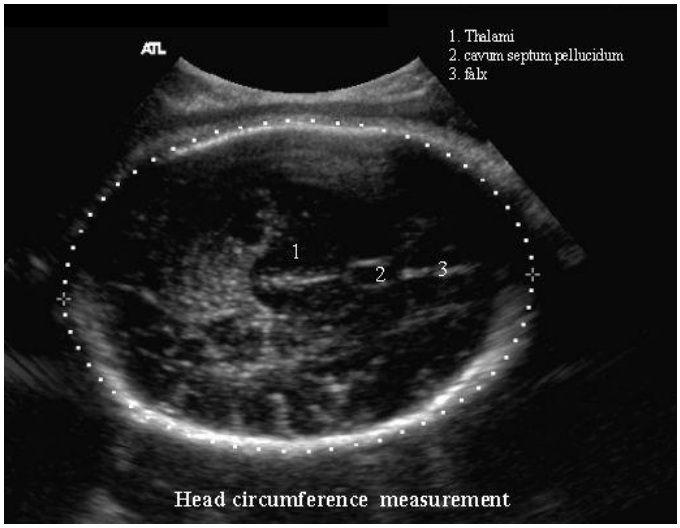

Figure 2.3: Transaxial image for HC measurement (Stebbins & Jaffe, 1999)

Hadlock et al. (1982) described on the relation between fetal HC and menstrual age in Caucasian. Mathematical modeling of the relationship of HC to menstrual age was carried out. These data indicated that the variability in predicting menstrual age from HC during this period is similar.

2.2.4 ABDOMINAL CIRCUMFERENCE

The abdominal circumference (AC) is undoubtedly the best index to assess both fetal size and growth because the measurement is taken at the level of the fetal liver, which constitutes about 4% of the total fetal weight and which steadily increases in size with GA. Measurement of the AC must be at a carefully defined level in the fetal abdomen if consistency is to be achieved (Evans et al., 1990). The fetal AC has been recognized as an essential measurement for determining abnormal

fetal growth for over two decades (Campbell & Wilkin, 1975). It has been suggested that AC measurements may be used as the primary indicator of restricted or accelerated fetal growth (Smith et al. 1997).

AC is less used for the assessment of GA. It is more used for monitoring fetal growth, especially in the third trimester and for estimation of fetal weight (Campbell & Wilkin, 1975). Until 36 weeks of pregnancy, the head circumference (HC) is larger than the AC, the HC:AC ratio is therefore more than 1, but after 36 weeks, the AC catches up with the HC, and then continues to grow at a faster rate, so that the ratio of HC to AC near term becomes less than one (Campbell & Thomas, 1977). Diabetes appears to preferentially affect the AC more than the biparietal diameter (BPD) or long bone length. Thus, this measurement is particularly useful in identifying either macrosomic or growth-restricted fetuses. The fetal liver is the organ most affected by variations in fetal nutrition and the level of the liver should, therefore, be chosen as the place for AC measurement (Ogata et al., 1980).

Genetic, environmental, nutritional and endocrinological factors, in addition to an adequately functioning placenta, are the foundation of the growth potential of the developing fetus under normal conditions. In one study, accelerated abdominal fetal growth was noted between 28 and 32 weeks' gestation (Ogata et al., 1980). Another study of Type 1 diabetic women, using serial ultrasound examinations in the third trimester, showed evidence of divergent growth acceleration of AC growth at week 32 in fetuses destined to be Large for Gestational Age (LGA) at birth (Landon et al., 1989). The recommended equation for estimating AC from Chitty et al. (1994) is:

$$AC = -85.84 + (11.92)GA - (0.0007902)GA^3 \qquad (2.5)$$

The fetal AC is measured on a transverse section through the fetal abdomen that is as close as possible to circular in shape that included the spine, portal vein, stomach and liver as illustrated in Figure 2.4. Care must be taken to identify the spine and descending aorta posteriorly, the umbilical vein in the anterior one third of the abdomen and stomach bubble in the same plane.

$$AC = \pi(d1 + d2)/2 \tag{2.6}$$

Figure 2.4: AC measurement (Stebbins & Jaffe, 1999)

Rashid (2008) highlight analyses on fetal AC growth in Bangladeshi population. A prospective, cross-sectional study was conducted on well dated, singleton pregnancies. There was a gradual increase of the AC measurements up to 37^{th} week.

Smulian et al. (2001) have studied on a comparison of outer centiles for AC with established nomograms. A nomogram for AC measurements was created by modeling the mean and standard deviation separately. Comparisons with other

published nomograms indicated that the false-negative rates for classifying United Kingdom population as < 10^{th} centile or > 90^{th} centile ranged from 11.3 % to 90.5 % and from 0 to 66.4 % respectively.

2.2.5 FEMUR LENGTH

Femur length (FL) is a very useful biometric parameter used in the second and third trimesters of pregnancy. It grows linear throughout and is best measured after 14 weeks of gestation (Deter et al., 1987).

The accuracy of gestational age (GA) calculation by FL is within 6-7 days of menstrual age at 95% confidence level (Brien et al., 1981).

Abnormal fetal biometry consisting of shorter femur and humerus length are included as Down syndrome. This is evaluated by comparing the actual long bone length measured with a calculated expected long bone measurement using published formulas (Ogasawara, 2009).

It was felt that certain ethnicities such as Asians have shorter long bones length, whereas others such as African Americans have longer long bones length compared with fetuses of white mothers (Ogasawara, 2009). The recommended equation from Chitty et al. (1994) for estimating FL is:

$$FL = -32.43 + (3.416)GA - (0.0004791)GA^3 \quad (2.7)$$

FL was measured along the horizontal long axis of the femur from outer to outer margin, including the femoral diaphysis and excluding the epiphyses as in Figure 2.5 (Stebbins & Jaffe, 1999).

The diaphysis is measured from the greater trochanter above to the lateral condyle below. The outer border of femur is straight and the inner border is curved normally (Sharlon & Filly, 1985).

The femur should be imaged lying as close as possible to the horizontal plane, such that the angle of insonation of the ultrasound beam is 90^{o}. Care should be taken to ensure that the full length of the bone is visualized and the view is not obscured by shadowing from adjacent body parts. Provided a technically good image is obtained, a single measurement is adequate (Loughna et al., 2009).

The effect in pregnant African American adolescents of maternal dairy intake at entry into prenatal care on fetal femur development between 20 and 34 week of gestation was investigated by Chang et al. (2003). Multiple linear regression models were used to address significant determinants of fetal FL. It was found that fetal FL was significantly lower in the lowest dairy-intake group than in the highest diary-intake group.

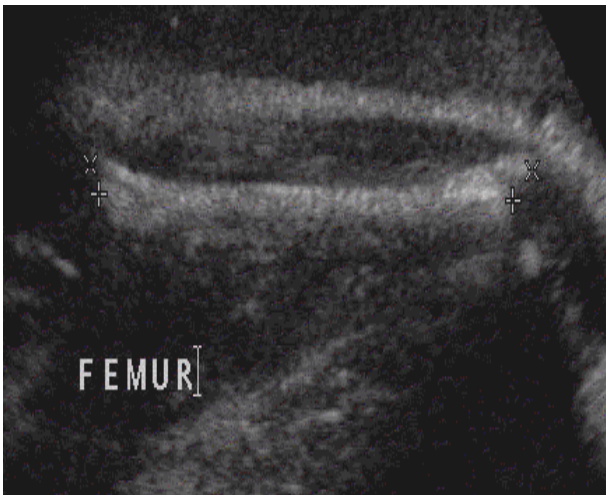

Figure 2.5: Correct imaging plane of FL measurement (Stebbins & Jaffe, 1999)

Kovac et al. (2002) determined whether current methods for detecting Down syndrome based on fetal FL calculations are influenced by ethnicity in America. Ethnic-specific formulas for expected FL were derived by simple regression. There is a significant difference in the mean expected FL by biparietal diameter (BPD) among fetuses in the second trimester with regard to ethnicity.

2.2.6 ESTIMATED FOETAL WEIGHT

Accurate estimation of foetal weight is of paramount importance in the management of labour and delivery. During the last decade, estimated foetal weight (EFW) has been incorporated into the standard routine antepartum evaluation of high-risk pregnancies and deliveries (Nzeh et al., 2000).

The two main methods for predicting birth weight (BW) in current obstetrics are clinical techniques based on abdominal palpation of foetal parts and calculations based on fundal height and, sonographic measures of skeletal foetal parts which are then inserted into regression equations to derive EFW (Nzeh et al., 2000).

Although some investigators consider sonographic estimates to be superior to clinical estimates, others, in comparing both the techniques concurrently, conclude that they confer similar levels of accuracy (Nzeh et al., 2000).

To obtain an EFW by sonography, several standard measurements of the fetus is made and these are entered into a formula that attemps to relate fetal size to weight (Holcomb et al., 2000).

The Shepherd (BPD+AC) and Hadlock (AC+FL) formulae are the most commonly used equations for measuring EFW (Shepherd et al., 1982) (Hadlock et al., 1984a).

The smallest 10% will be classed as less than the 10th percentile and therefore, Small for Gestational Age (SGA) and the largest 10% greater than the 90th percentile will be Large for Gestational Age (LGA) (Deter et al., 1981; Gallivan & Robson 1993).

Estimation of fetal weight from Hadlock et al. (1984a) was performed by using measurements of the fetal head, abdomen, and femur in the following equation:

$$\log EFW = 1.5115 + 0.0436(AC) + 0.1517(FL) - 0.00321(AC)(FL) = 0.0006923(BPD)(HC) \quad (2.8)$$

Table 2.2 shows various formulae to obtain EFW from different researchers by using the measurement of biparital diameter (BPD), fetal abdominal area (FAA), femur length (FL) or abdominal circumference (AC).

Table 2.2: Ultrasonic Fetal Weight Estimation

Study	Formulae
Aoki, 1990	$EFW = (1.25647 \times BPD^3) + (3.50665 \times FAA \times FL) + 6.3$
Campbell and Wilkin, 1975	$\log_e (EFW/1000) = -4.564 + (0.282 \times AC) - (0.00331 \times AC^2)$
Shepherd et al., 1982	$\log_{10} EFW = 1.2508 + (0.166 \times BPD) + (0.046 \times AC) - (0.002646 \times AC \times BPD)$
Hadlock et al., 1985	$\log_{10} EFW = 1.304 + (0.05281 \times AC) + (0.1938 \times FL) - (0.004 \times AC \times FL)$

EFW = estimated foetal weight (g); BPD = biparietal diameter (cm); FAA = fetal abdominal area (cm^2); FL = femur length (cm); AC = abdominal circumference (cm)

Estimation of fetal weight and comparison with actual birth-weight reference range for France population has been studied by Salomon et al. (2007). EFW was calculated based on Hadlock's formula. It was found that the EFW was larger than the actual birth-weight reference range.

Fetal size nomogram for a sub-Saharan African population has been developed by Landis et al. (2009). EFW was calculated at each ultrasound examination using the Hadlock algorithm. Reference centiles (5^{th}, 10^{th}, 50^{th}, 90^{th} and 95^{th}) were derived from this model. It was indicated that differences observed in the 10^{th} and 95^{th} centiles were inconsistent between nomograms.

Kumara & Perera (2009) compared six commonly used formulae (Shepard, Campbell, Hadlock I, II, III, and IV) for estimation of fetal weight in Sri Lanka population. Statistical analysis done using Karl Pierson correlation. It was concluded that all formulae have adequate accuracy for estimating fetal weight in the population tested, Hadlock IV has the best accuracy.

Comparison between the Clinical with Sonographic Estimation of Foetal Weight in Southwest Nigeria has been investigated by Shittu et al. (2007). Statistical analysis was done using the paired *t*-test, the Wilcoxon signed-rank test, and the chi-square test. It was showed that Clinical estimation of BW is as accurate as routine ultrasonographic estimation, except in low BW babies.

Chien et al. (2000) assessed the validity of ultrasound estimation of fetal weight at term in United Kingdom. Fetal weight was estimated by the use of four reported methods (Aoki, Campbell, Shepard, and Hadlock formulas). It was proved that the validity of ultrasonic estimation of fetal weight at term with all four formulas was high.

2.2.7 AMNIOTIC FLUID INDEX

Amniotic fluid index (AFI) is an important part of pregnancy sac and helps foetal development. It has number of important functions like development of musculoskeletal system by permitting foetal movement. Growth and development of gastrointestinal system by swallowing AFI. AFI volume rises to a plateau between 22-39 weeks of gestation reaching upto 700-800 ml, which corresponds to an AFI of 14-15 cm. Assessment of amniotic fluid volume (AFV) by ultrasonography is more reliable (Ever, 2003). Oligohydramnios was defined as when AFI < 5 cm. It is calculated as the sum of deepest vertical dimension in each quadrant of uterus (Brace & Wolf, 1989).

A reduction in AFI is an important sign that the fetal condition may be impaired, and in these circumferences perinatal mortality rises sharply. The AFI may prove to be useful, and involves the summing of amniotic fluid depth in the four quadrants of the uterus. AFI is reduced in the presence of either vascular or placenta deficiency (Campbell & Thomas, 1977).

The amniotic sac develops early in pregnancy, and has been identified in the human embryo as early as 7 days. The first signs of the development of the amniotic cavity can be seen in the inner cell mass of the blastocyst. AFI is formed by secretion of fluid from amnion and fetal skin and from the passage of fetal urine into

the amniotic sac. Circulation of AFI occurs by reabsorption of fluid through the fetal gut, skin and amnion. By 8 weeks gestation, 5-10 ml of AFI has accumulated, thereafter the volume increases rapidly in proportion to fetal growth and gestational age (GA) to a minimum volume of 1000 ml at 38 weeks gestation. Subsequently, serial diminution in the amount of fluid takes place, so that after 42 weeks the mean volume falls below 300 ml (Hanretty, 2003).

The AFI is traditionally the addition of the four pockets, with the normal range from 8 to about 18. There are fuzzy limits beyond these two extremes, but generally AFI < 5-6 cm is defined as oligohydramnios and AFI > 18-22 cm is defined as hydramnios or polyhydramnios. Most of the fluid in AFI is contributed by fetal urine. This is then reabsorbed by the membranes and umbilical cord and the turnover is pretty fast; a couple of hours. So it is possible to have differing amounts of AFI from one day to the next, even from one hour to the next. The AFI can be used to determine fetal well-being. On the other hand, a low AFI (oligohydramnios) at or near term may be an indication for delivery (Hanretty, 2003).

AFI is a rough estimate of an index for the fetal well-being. It is a part of the biophysical profile (Tom et al., 2006). Median AFI level is approximately 14 from week 20 to week 35, when the AFI begins to reduce in preparation for birth (Carr et al., 2003). The fifth percentile for GA is sometimes used as a cutoff value (Griffin et al., 2009). Meanwhile, an AFI > 20-24 cm is considered as polyhydramnios (Sylvia et al., 2003). The recommended equation for estimating AFI from GA according to Hinh & Ladinsky (2005) is:

$$AFI = 7.686 + (0.598)GA - (0.013)GA^2 \quad (2.9)$$

The AFI is measured by dividing the uterus into four imaginary quadrants as in Figure 2.6. The linea nigra is used to divide the uterus into right and left halves. The umbilicus serves as the dividing point for the upper and lower halves. The transducer is kept parallel to the patient's longitudinal axis and perpendicular to the floor. The deepest, unobstructed, vertical pocket of fluid is measured in each quadrant in centimeters. The four pocket measurements are then added to calculate the AFI (Rutherford et al., 1987).

Voxman et al. (2002) determined whether an antepartum AFI of 5 cm or less is a predictor of adverse perinatal outcome in Los Angeles, USA. Chi–square analysis, Fisher's exact test, *t*-tests and receiver-operator curves (ROCs) were used for analysis. It was proved that antepartum oligohydramnios is associated with an increased risk of fetal heart rate abnormalities.

Figure 2.6: AFI measurement (Rutherford et al., 1987)

Comparison of AFI with the single deepest pocket in the identification of actual abnormal amniotic fluid (AF) volumes has been described by Magann et al. (2000). Each woman subsequently had ultrasound-directed amniocentesis with dye-dilution and spectrophotometric calculation of actual AFV. It was showed that there