"ULTRASONOGRAPHIC MEASUREMENT OF PLACENTAL THICKNESS AND ITS CORRELATION WITH GESTATIONAL AGE IN NORMAL PREGNANCY"

By

DR. SURESH K K M.B.B.S

Dissertation submitted to the

B.L.D.E. UNIVERSITY VIJAYAPUR, KARNATAKA

In partial fulfilment of the requirements for the degree of

DOCTOR OF MEDICINE

IN

RADIO-DIAGNOSIS

Under the guidance of

Dr. BHUSHAN. N. LAKHKAR M.D.

PROFESSOR AND HEAD

DEPARTMENT OF RADIO-DIAGNOSIS

B.L.D.E.U'S SHRI B. M.PATIL MEDICAL COLLEGE HOSPITAL & RESEARCH CENTRE, VIJAYAPUR KARNATAKA

2016

B.L.D.E. UNIVERSITY'S

SHRI B. M. PATIL MEDICAL COLLEGE, HOSPITAL &

RESEARCH CENTRE, VIJAYAPUR

DECLARATION BY THE CANDIDATE

I, **Dr. SURESH K K,** hereby declare that this dissertation entitled **"ULTRASONOGRAPHIC MEASUREMENT OF PLACENTAL THICKNESS AND ITS CORRELATION WITH GESTATIONAL AGE IN NORMAL PREGNANCY"** is a bonafide and genuine research work carried out by me under the guidance of **Dr. BHUSHAN. N. LAKHKAR** Professor and Head, Department of Radiodiagnosis, B.L.D.E.U's Shri B. M. Patil Medical College Hospital and Research Centre, Vijayapur.

Date:

Place: Vijayapur

Dr. SURESH K K
Post Graduate Student,
Department of Radiodiagnosis,
B.L.D.E.U's Shri B. M. Patil
Medical College, Hospital &
Research Centre, Vijayapur.

B.L.D.E. UNIVERSITY'S

SHRI B. M. PATIL MEDICAL COLLEGE, HOSPITAL &

RESEARCH CENTRE, VIJAYAPUR

CERTIFICATE BY THE GUIDE

This to certify that the dissertation entitled **"ULTRASONOGRAPHIC MEASUREMENT OF PLACENTAL THICKNESS AND ITS CORRELATION WITH GESTATIONAL AGE IN NORMAL PREGNANCY"** is a bonafide research work done by **Dr. SURESH K K**, under my overall supervision and guidance, in partial fulfilment of the requirements for the degree of M. D. in Radiodiagnosis.

Date:

Place: Vijayapur

Dr. BHUSHAN. N. LAKHKAR M.D.
Professor and Head
Department of Radiodiagnosis,
B.L.D.E.U's Shri B. M. Patil Medical
College, Hospital & Research Centre,
Vijayapur.

B.L.D.E. UNIVERSITY'S

SHRI B. M. PATIL MEDICAL COLLEGE, HOSPITAL &

RESEARCH CENTRE, VIJAYAPUR

ENDORSEMENT BY THE HEAD OF DEPARTMENT

This to certify that the dissertation entitled **"ULTRASONOGRAPHIC MEASUREMENT OF PLACENTAL THICKNESS AND ITS CORRELATION WITH GESTATIONAL AGE IN NORMAL PREGNANCY"** is a bonafide research work done by **Dr. SURESH K K** under the guidance of **Dr. BHUSHAN. N. LAKHKAR** Professor and Head, Department of Radiodiagnosis at B.L.D.E.U's Shri B. M. Patil Medical College Hospital and Research Centre, Vijayapur.

Date:

Place: Vijayapur

Dr. BHUSHAN. N. LAKHKAR M.D.
Professor and Head
Department of Radiodiagnosis,
B.L.D.E.U's Shri B. M. Patil Medical
College, Hospital & Research Centre,
Vijayapur.

B.L.D.E. UNIVERSITY'S

SHRI B. M. PATIL MEDICAL COLLEGE, HOSPITAL &

RESEARCH CENTRE, VIJAYAPUR

ENDORSEMENT BY THE PRINCIPAL

This to certify that the dissertation entitled **"ULTRASONOGRAPHIC MEASUREMENT OF PLACENTAL THICKNESS AND ITS CORRELATION WITH GESTATIONAL AGE IN NORMAL PREGNANCY"** is a bonafide research work done by **Dr. SURESH K K** under the guidance of **Dr. BHUSHAN. N LAKHKAR** Professor and Head, Department of Radiodiagnosis at B.L.D.E.U's Shri B. M. Patil Medical College Hospital and Research Centre, Vijayapur.

Date**:**

Place: Vijayapur.

Dr. S.P. GUGGARIGOUDAR **M.S.(ENT)**
Principal, B.L.D.E.U's
Shri B. M. Patil Medical College,
Hospital & Research Centre,
Vijayapur.

B.L.D.E. UNIVERSITY'S

SHRI B. M. PATIL MEDICAL COLLEGE, HOSPITAL &

RESEARCH CENTRE, VIJAYAPUR

COPYRIGHT

DECLARATION BY THE CANDIDATE

I hereby declare that the B.L.D.E. UNIVERSITY, VIJAYAPUR, Karnataka shall have the rights to preserve, use and disseminate this dissertation/thesis in print or electronic format for academic/research purposes.

Date:

Place: Vijayapur

Dr. SURESH K K
Post Graduate Student,
Department of Radiodiagnosis,
B.L.D.E.U's Shri B. M. Patil Medical
College, Hospital & Research Centre,
Vijayapur.

ACKNOWLEDGEMENT

This piece of work has been accomplished with the grace of almighty God. It gives me immense pleasure to express my heartfelt gratitude to all. I dedicate this page to each and everyone who have helped me to explore the expanses of knowledge.

I express my profound gratitude and sincere thanks to my guide, ***Dr. Bhushan N. Lakhkar*** ***M.D.,*** *Professor & Head, Department of Radio-diagnosis, B.L.D.E.U's Shri B. M. Patil Medical College, Vijayapur, for his constant and unfailing support, professional insight, valuable suggestions, motivation and exemplary guidance to carry out and complete this dissertation. I am deeply grateful to him for providing me necessary facilities and excellent supervision to complete this work.*

I offer my sincere thanks to ***Dr. S.P. Guggarigoudar*** ***M.S.(ENT)*** *,Principal, B.L.D.E.U's Shri B. M. Patil Medical College, Vijayapur, for his support and inspiration.*

My sincere thanks to our Medical Superintendent ***Dr. Vijaykumar T K*** ***M.D.,*** *for his support and inspiration.*

I am deeply indebted and grateful to my professors ***Dr. R.C Pattanshetti*** ***M.D.,*** ***Dr. B R Dhamangoankar*** ***M.D.,*** *and* ***Dr. M. M Patil*** ***DMRD,*** *Senior Resident, Department of Radio-diagnosis, B.L.D.E.U's Shri B. M. Patil Medical College, Vijayapur, who with their valuable suggestions and constant guidance supported me throughout the preparation of this dissertation work.*

My thanks to ***Dr. Ajey Bhagwat*** ***M.D.,*** *Associate professor,* ***Dr. Veeresh Hanchnal*** ***M.D.,*** ***Dr. Praveen M M*** ***M.D.,*** ***Dr. Satish Patil*** ***M.D.,*** ***Dr S. V Patil*** ***M.D..,*** ***Dr. Bhushita Lakhkar*** ***M.D.,*** *Assistant professors and* ***Dr. Vishal N.S*** ***DNB.,*** *Senior Resident, Department of Radio-diagnosis, B.L.D.E.U's Shri B. M. Patil Medical College,*

Vijayapur, for their valuable suggestions and encouragement which have definitely helped me improve my research work.

I acknowledge my gratitude to ***Dr. Nandish, Dr. Naveen, and Dr. Rathi,*** *Postgraduate colleagues, Department of Radio-diagnosis, B.L.D.E.U's Shri B. M. Patil Medical College, Vijayapur, for his support, advice and help in data collection.*

I also thank all my seniors ***Dr. Vinod, Dr. Sheetal****,* ***Dr. Shivendra and Dr.Uday****, my juniors* ***Dr. Iranna, Dr. Rohini, Dr. Parth, Dr. Karthik, Dr. Holebasu, Dr. Avinash, Dr. Namith and Dr. Shivu*** *for their co-operation during the preparation of this dissertation.*

I thank Mr. Shah Nawaz*, Statistician for his masterly guidance and statistical analysis. I sincerely acknowledge the support and kindness shown towards me by all the staff of Central Library, Shri B. M. Patil Medical College, Vijayapur, at all times.*

I am thankful to all the Technical and non-teaching Staff of the Department of Radiology, Shri B. M. Patil Medical College, Vijayapur for their co-operation.

My heartly thanks to my beloved grandparents ***(Late) Mr. Ramshet & Mrs. Devakamma,*** *parents* ***Mr. Krishnamurthy KR, Mrs. Chanchala S Raykar,*** *my brother* ***Er. Suraj K K*** *and my wife* ***Dr. Shruti G Raikar*** *for their encouragement, support and sacrifices.*

It is with great pleasure I express my sincere gratitude to ***Dr. Padma, Dr. Monica, Dr. Vidya, Mr. Satyanarayana, Mr. Ganapati R*** *and* ***Mrs. Geeta R*** *for their constant encouragement, inspiration and sacrifices.*

I would also like to thank ***Preeti Net Zone****, Vijayapur for their printing work.*

Last but not the least, my sincere thanks to all the patients of this study for their cooperation without which this study would not have been possible.

Date-
Place: ***Dr. SURESH K K***

LIST OF ABBREVIATIONS

AC	ABDOMEN CIRCUMFERENCE
AFI	AMNIOTIC FLUID INDEX
APH	ANTE-PARTUM HAEMORRHAGE
BPD	BIPARIETAL DIAMETER
EGA	ESTIMATED GESTATIONAL AGE
EFW	EXPECTED FETAL WEIGHT
GMS	GRAMS
GP	GROUP
HC	HEAD CIRCUMFERENCE
HT	HYPERTENSION
IUGR	INTRAUTERINE GROWTH RESTRICTION
LMP	LAST MENSTRUAL PERIOD
LBW	LOW BIRTH WEIGHT
MM	MILLIE METERS
MS	MICROSOFT
OBG	OBSTETRICS AND GYNAECOLOGY
PIH	PREGNANCY INDUCED HYPERTENSION
PT	PLACENTAL THICKNESS
SD	STANDARD DEVIATION
USG	ULTRASOUND
WKS	WEEKS
W.R.T	WITH RESPECT TO
YRS	YEARS

ABSTRACT

BACKGROUND & OBJECTIVES:

Ultrasonography is the most effective method to estimate the gestational age. Placenta is a materno-foetal organ which is a reflection of health and size of the foetus. PT can be used as a new parameter to estimate the gestational age of the foetus. In our present study we measured the placental thickness at the level of umbilical cord insertion to determine its relationship with GA of foetus, BPD & FL in normal singleton pregnancy between 12 – 24 weeks.

METHOD OF COLLECTION OF DATA:

This was a cross sectional study consisting of 201 normal antenatal women who were referred to the Department of Radio diagnosis from antenatal clinic, Department of OBG, Shri B.M. Patil Medical College Hospital and Research Center, Bijapur from December 2014 – June 2016. All the subjects were enrolled with detailed oral and written consents. Normal singleton pregnancies of gestational ages from 12 to 24 wks were included in the study. PT, in mm, was calculated by averaging the three best measurements for each case at the level of umbilical cord insertion.

Correlation of mean PT with GA, BPD & FL was calculated. Data was compiled in MS excel sheet and analysed using SPSS software, chi square test and Pearson's correlation coefficient were applied considering value of $P < 0.05$ as statistically significant.

RESULT:

In the total study group of 201 normal singleton pregnancies from 12 to 24 wks of gestation, age ranged between 18 yrs to 37 yrs with majority in age group

between 21-25 yrs. Anterior placenta was noted to be the most common location amongst the study sample. Lateral location of the placenta was found to be more accurate in measuring the placental thickness, however anterior, posterior & fundal locations also showed significant correlation. PT taken at individual weeks of gestation almost matched with GA, BPD & FL with few negative correlation in some weeks in which PT was less than 1mm w.r.t, gestation in wks.

To prove that there was a correlation between PT with GA, BPD & FL the Pearson correlation coefficient was found to be $r = 0.98$ and the p value was <0.001, thereby establishing a positive correlation between the variables.

CONCLUSION: It was observed that PT (in mm) correlated well with GA, BPD & FL (in weeks) from 12 to 24 wks of gestation. And also the thickness of the placenta and growth pattern did not vary relative to the placental locations.

KEY WORDS: Placental thickness; Gestational Age; BPD; FL; Umbilical Cord; Ultrasonography

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The criteria of a normal pregnancy is delivery of a single baby in good condition at term (between 38 and 42 weeks), with fetal weight of 2.5 kg or more and with no maternal complication. As such, a normal pregnancy is a retrospective term.[1]

The best possible antepartum care and the successful deliveries of babies always revolve around the accurate knowledge of the Gestational Age (GA). The gestational age is of utmost importance in the interpretation of biochemical tests such as the screening for the expanded maternal serum biomarkers (Human Chorionic Gonadotrophin, Alfa fetoprotein, oestrogen & progesterone levels) for the risk assessment of various fetal anomalies, in evaluating the fetal growth by distinguishing the normal from the pathological foetal development.

This allows obstetrician to institute measures that will optimize the foetal outcome.[2]

When an anomaly is detected, the interventional modality which is used is influenced by the gestational age. Virtually, all the important clinical decisions, which include caesarean section, elective labour induction, etc., depend on the knowledge of the gestational age. The gestational age is approximately 280 days, which is calculated from the first day of the last menstrual period and so, the dating of the pregnancy starts even before the fertilization. The determination of the gestational age is a common clinical problem.

Ultrasonography has provided a safe and non-invasive means to evaluate the placenta whose normal and abnormal size, appearance and growth pattern can have significant antenatal implications.

Role of USG in the evaluation of morphology and detection of placental abnormalities in clinical conditions such as non-immune hydrops, gestational diabetes and intra-uterine growth restriction has been well established.

The placenta is a fetal organ which provides the physiologic link between a pregnant woman and the fetus with important metabolic, endocrine and immunologic functions besides being responsible for nutrition, respiration and excretion for the fetus, acting as a barrier; it has a role in protecting the fetus from noxious agents. [3] Placental size is a reflection of health and size of the fetus.

The placenta develops from the chorionic villi at the implantation site at about the fifth week of gestation and by the ninth or tenth week, it is clearly apparent at sonography as diffuse granular echo texture. It reaches its maximum growth at term.[4,5]

It is usually 2 - 4 cm thick and weighs about 600 grams. It is technically defined as the apposition or fusion of fetal organs to maternal tissue for the purpose of physiologic exchange.[6]

With the new advances in grey scale and Doppler sonography, we are able to study the placental sonographic appearance and its relationship to uteroplacental blood flow measurement and intrauterine growth.

Ultrasonography (US) enables the evaluation of the placenta and the detection of placental abnormalities using different parameters such as placental thickness and volume or especial techniques like three-dimensional (3D) power Doppler.[7–11] Recent studies focused on 3D measurement of placenta to predict the adverse pregnancy outcome; however, this technique is relatively new, needs complex clinical setting and gives conflicting results regarding its reproducibility in evaluating placenta.[12]

Ultrasound measurement of placental thickness is a relative simple, reproducible and clinical useful way, which had been used for more than two decades.[7,8,10]

Ultrasonography (USG) is commonly used to estimate the gestational age by measuring the foetal dimensions like the Biparietal Diameter (BPD), the Abdominal Circumference (AC), the Head Circumference (HC) and the Femur Length (FL).

An Ultrasonograph is prone to observer bias, as it depends on the observer's technical skills. Also, the foetal parameters, the different techniques of measurement and the positional problems may diminish the accuracy of the gestational age estimation.[13]

Wolfson *et al,,* showed that the biparietal diameter was not reliable in the fetuses which had a premature rupture of the membranes.[14] There are some drawbacks in those above said parameters in estimating the gestational age.

So, there is a need of another parameter for supplementing the gestational age estimation with minimal error. Nyberg and Finberg reported that the placental thickness parallels the gestational age.[15]

Placental thickness appears to be a promising parameter for estimation of gestational age of the fetus because of increase in placental thickness with gestational age.

It seems reasonable that serial evaluation of placental thickness in second trimester could help to determine normal development and functional placenta and deserve as a good predictor of fetal growth and birth weight.

Diseases and abnormalities affecting fetus can be indicated by an abnormal size of the placenta during the second trimester.

Studies by Mital *et al,,*[16] and Jain *et al,,*[17] have reported the use of placental thickness as an indicator of gestational age.

Placental thickness measured at the level of the umbilical cord insertion can be used as a new parameter to estimate gestational age of the fetus.

The present study was undertaken to evaluate the relationship between placental thickness and gestational age of the fetus.

AIMS AND OBJECTIVES

1. Placental thickness (mm) and its correlation with gestational age (wks) in normal pregnancy from 12 to 24 weeks of gestation.
2. Placental thickness (mm) and its correlation with biparietal diameter (wks) in normal pregnancy from 12 to 24 weeks of gestation.
3. Placental thickness (mm) and its correlation with femur length (wks) in normal pregnancy from 12 to 24 weeks of gestation.

REVIEW OF LITERATURE

HISTORICAL BACKGROUND

Existence of ultrasound was first demonstrated by Spellanizine back in 1974 on bats. Langevia of France was, however the first to use it for detection and destruction of submarines during first world war (1915) when it was named SONAR (SO-sound; N-navigation; A-and; R-ranging) and after the war it was used to locate schools of fish and to map the ocean floor.

After World War II, ultrasound was used to detect flaws in various materials including metals and metallic structures like beams, bridges etc.

The first medical use of ultrasound was done by Austrian Physician Karl Dussik in 1942 who described using ultrasound to map the adult human brain which he termed as “hyperphonogram”. He claimed to have identified abnormalities based on changes in attenuation, but this technique was very crude and he used very high energy ultrasound, which was positively harmful for the tissues.

Physiatrists in the USA were the first to use ultrasound in regular clinical practice, although they used it as a treatment modality for muscle disorders rather than a diagnostic tool. In 1953, Cecil Bircher, a manufacturer of ultrasound equipment, supplied the physiatrist members of the original American Institute of ultrasound (AIUM) with ultrasound equipment for therapeutic use.

In year 1958 Prof. Ian Donald of Glasgow University is credited with being the first to successfully use diagnostic Ultrasonography to investigate the gravid uterus and is considered as the father of modern ultrasound.[18] The first equipment in his laboratory was developed in research department of the Hillington factory in Glasgow.

Donald reported the identification of twins, hydramnios and the fetal skull as well as gynaecological pathology. He further advanced Ultrasonography in OBG by discovering that a urine filled bladder provided a means of displacing the gas filled intestine thus enabling the sound beam to reach the pelvic viscera. Donald also found a way to eliminate the need for water tanks, in which a patient had to sit or water containers, which were applied against the area being scanned by smearing the skin with olive oil.

Before the advent of Ultrasonography, the only part of fetus that could be measured without the use of X-ray was the fetal head, which could be palpated. Recognizing that the BPD measurements might be means of measuring the growth of a fetus, Donald along with Brown and Willocks developed a technique using 'A scope' to obtain the measurement.

In year 1969 Campbell further refined the method by incorporating B mode scanning into cephalometry and Donald published the first BPD normogram based on Campbell's measurements of 400 fetuses that were delivered within 3 days of the expected dates of confinement.

With the advent of gray scale imaging in 1972, organ parenchyma could be visualized and detailed; this made thorough investigation of every fetal organ possible especially fetal brain. All organs and structures visible today by the ultrasound with the exception of vasculature demonstrated with color Doppler were visible once gray scale was introduced.

Further impact on the field of ultrasound was made by the advent of real time scanning. It made scanning faster and easier to the effect that it was possible to chase a floating embryo and to observe and study patterns of movements including fetal cardiac anatomy and physiology.

Real time made it safer to perform invasive procedures such as chorionic villus sampling, intrauterine transfusions and fetal surgery.

Intrauterine surgery such as repair of diaphragmatic hernia, decompression of renal obstruction and the placement of shunts for hydrocephalus has become a reality with usage of ultrasound.

EMBRYOLOGY OF PLACENTA

Ovulation occurs approximately 14 days following the last menstrual cycle and fertilization occurs 1-2 days later. During the early stages of development of placenta, the placenta completely surrounds the embryo as a shell of tropohoblast that begins to invade the uterine stroma.[19] The yolk sac placenta is located in the coelomic cavity. This is connected to the developing embryo via the vitelline stalk and its vessels. It is a transient structure, subsequently replaced by the definitive chorio-allantoic placenta. It is formed by growth of allantoic stroma and blood vessels from the embryo (the forerunner of the umbilical cord) into the chorionic plate.[20] Fetal blood vessels form inside the developing villi to elaborate the chorionic villous trees. The chorio-allantoic placenta surrounds the developing embryo, but by 9 to 12 weeks gestation two thirds of it regresses, resulting in the smooth chorion (chorion leave), whereas the remaining third, to which the umbilical cord is attached, continues to develop as the definitive placenta (chorion frondosum).[20] By 12 weeks the definitive placenta can be seen easily on ultrasound and it has a granular, gray appearance. It comprises around 50 developing villous trees, each known as a placentoma. These trees function independently, although they are fused as the placental organ. [21] A central, maternal spiral artery perfuses each placentoma. From 12 weeks to term, these structures grow at a variable rate and specialize to accommodate the exponential growth in fetal size.

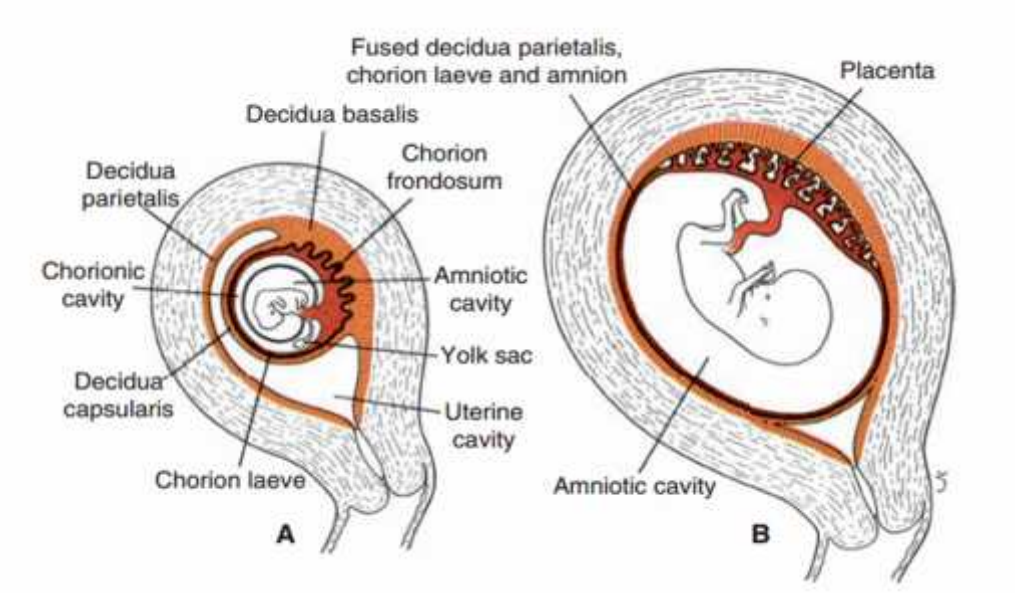


Figure 1: Relation of fetal membranes to wall of the uterus. **A**. End of the second month. Note the yolk sac in the chorionic cavity between the amnion and chorion. At the abembryonic pole, villi have disappeared (chorion laeve). **B**. End of the third month. The amnion and chorion have fused, and the uterine cavity is obliterated by fusion of the chorion laeve and the decidua parietalis.[22]

ANATOMY[23]

Fetal Portion — the fetal portion of the placenta consists of the villi of the chorion frondosum, which branch repeatedly, and increase enormously in size. These greatly ramified villi are suspended in the intervillous space and are bathed in maternal blood, which is conveyed to the space by the uterine arteries and carried away by the uterine veins.

Maternal Portion — the maternal portion of the placenta is formed by the decidua basalis containing the intervillous space. Four layers separate maternal and fetal blood. Fetal capillary endothelium is surrounded by a thin layer of connective tissue, which is covered by two strata of ectodermal cells derived from the trophoblast.

Cytotrophoblast represents the deeper stratum and syncytiotrophoblast represents the superficial stratum, which is in contact with the maternal blood.

The fetal and maternal blood traverses the placenta, the former passing through the blood vessels of the placental villi and the latter through the intervillous space. The two circulations do not intermingle, being separated from each other by the delicate walls of the villi.

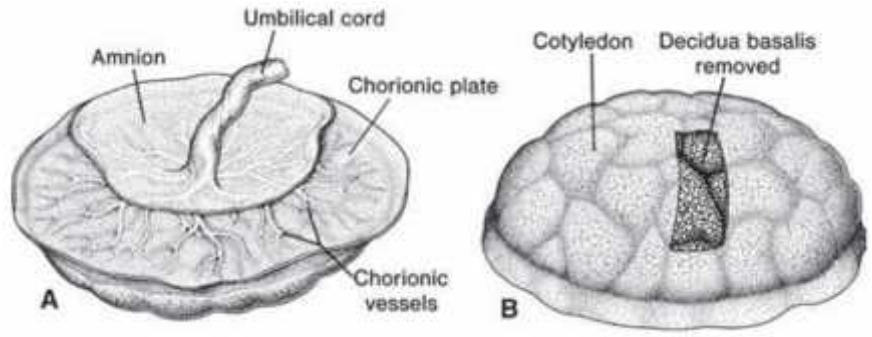


Figure 2: A full-term placenta. **A**. Fetal side. The chorionic plate and umbilical cord are covered by amnion. **B**. Maternal side showing the cotyledons. In one area, the decidua has been removed. The maternal side of the placenta is always carefully inspected at birth, and frequently one or more cotyledons with a whitish appearance are present because of excessive fibrinoid formation and infarction of a group of intervillous lakes.[22]

FETAL-PLACENTAL-UTERINE CIRCULATION[23]

The fetal-umbilical circulation originates with deoxygenated blood pumped by the fetal heart through the ductus arteriosus and into the descending aorta. Fetal blood continues through the hypogastric arteries to the umbilical arteries and into the umbilical cord. Within placenta, the umbilical arteries freely divide into multiple capillary branches that course through the tertiary villi. As a result of changes in the trophoblast, only a thin layer normally separates fetal blood from maternal blood.[15]

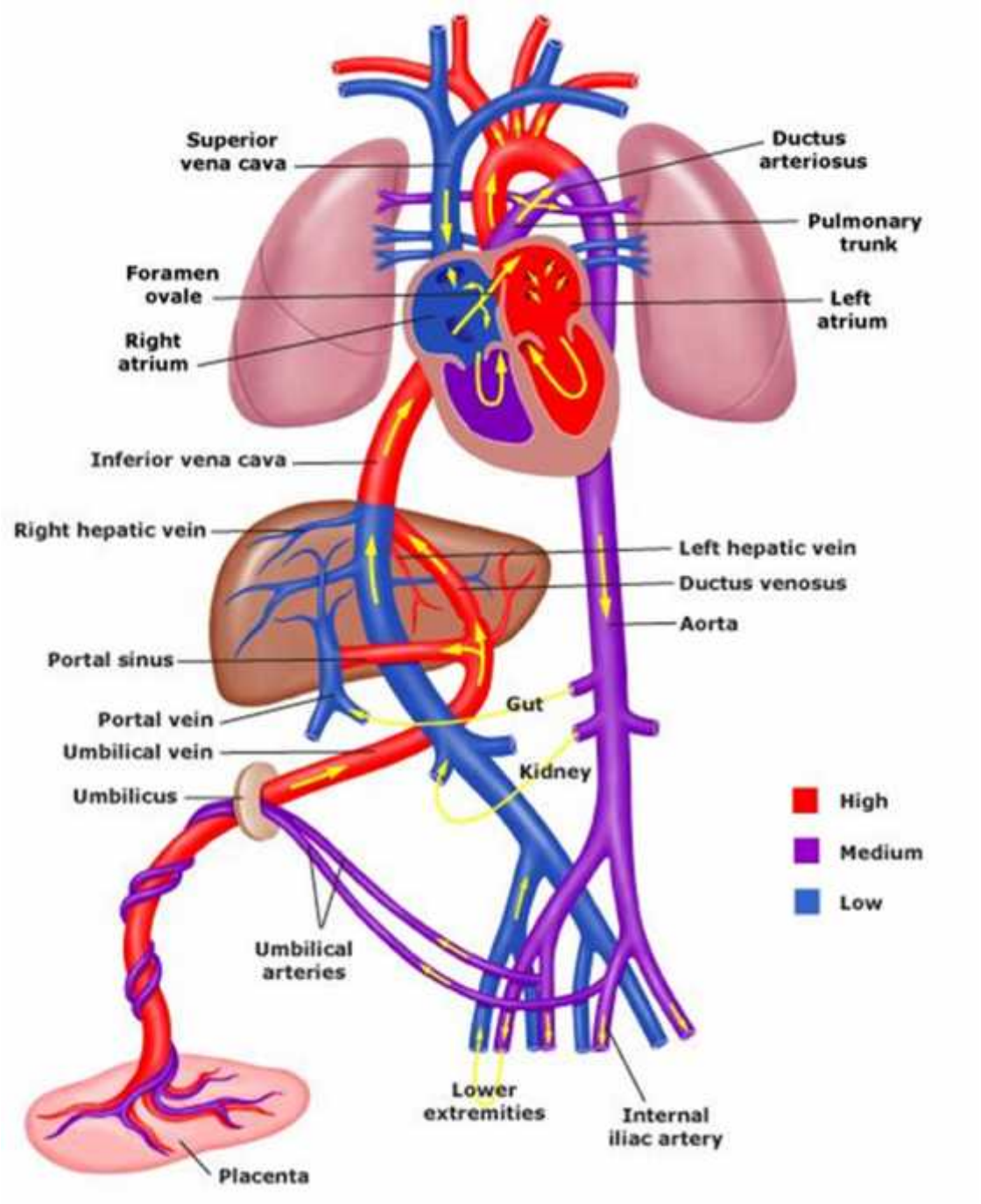


Figure 3: Fetal circulation before birth. Yellow arrows, show direction of the blood flow. Note where oxygenated blood mixes with the deoxygenated blood in the liver, inferior venacava, the right atrium, left atrium and at the entrance of the ductus arteriosus into the descending aorta.

Oxygenated maternal blood is delivered to the placenta through 80-100 end branches of the uterine arteries called spiral arteries. Maternal blood enters the intervillous space near the central part of each placental lobule where it flows around and over the surface of the villi. This process permits exchange of oxygen and nutrients with fetal blood flowing in villous capillaries. Maternal blood then returns through a network of basilar, subchorial, interlobular and marginal veins.[24]

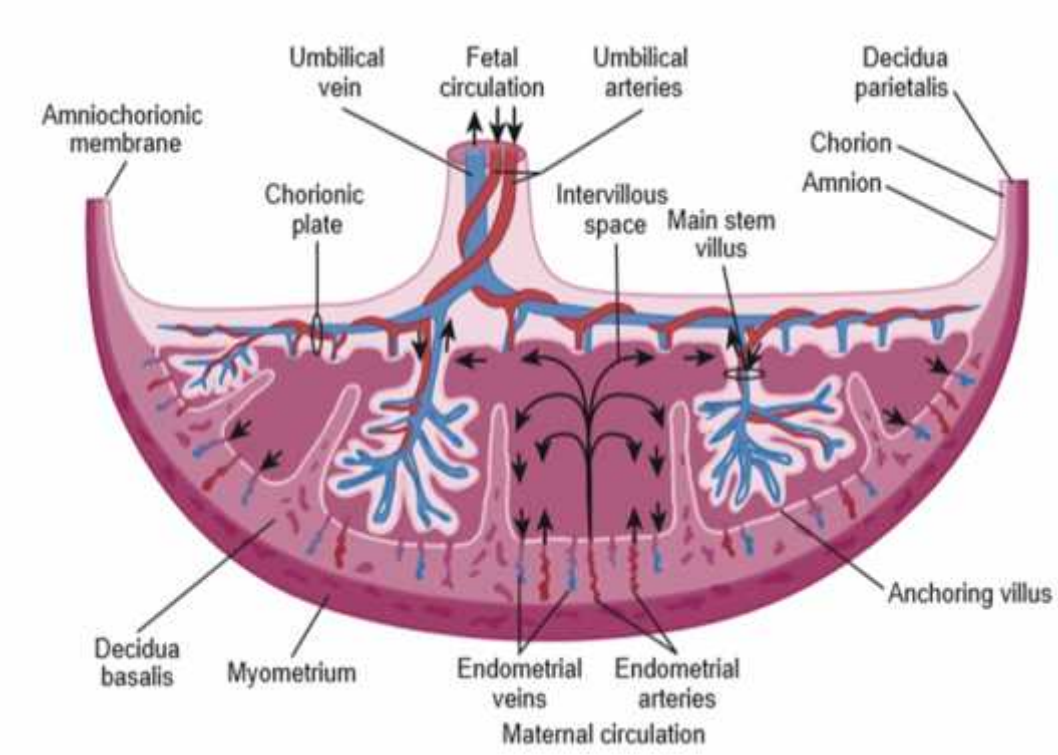


Figure 4: Schematic diagram of transverse section through a full term placenta showing relationship of the chorionic villi (fetal part of the placenta) to deciduas basalis (maternal part of the placenta), fetal placental circulation & maternal placental circulation.[25]

The rate of uteroplacental flow increases from about 50 cc/min at 10 weeks to 500-600 cc/min at term.

The mature placenta appears as a discoid mass, which weighs about 450 grams and has a diameter of 15 to 20 cm.[26] Its uterine surface appears rough & shaggy and

is divided by a series of fissures into lobes.[27] Each lobe is made up of several cotyledons, which is the basic structure of the placenta.[24]

The fetal surface of the placenta is smooth, being closely invested by the thin glistening amnion overlying the chorion. The umbilical cord is inserted on the fetal surface of the placenta at or near its center.

GROWTH OF THE PLACENTA

Growth of the placenta results from multiplication and branching of the chorionic villi.[3] At about the end of the fourth month of pregnancy, it occupies about one half of the uterine cavity, but with increasing gestational age, the relative size of the placenta diminishes rapidly until at term it occupies one quarter to one sixth of the surface of the uterine wall.

PLACENTAL AGEING

As the villi continues to branch and the terminal ramifications become more numerous and smaller, the volume and prominence of cytotrophoblasts decrease. The stroma of the villi also exhibits changes associated with aging. In placentas of early pregnancy, an abundant loose intercellular matrix separates the branching connective tissue cells. Later the stroma becomes denser and the cells more spindle shaped and closely packed.

PLACENTAL FUNCTION[3,23]

The placenta is a multifaceted organ that plays critical role in maintaining and protecting the developing fetus. These roles include nutrient transfer and waste excretion. The placenta is directly responsible for mediating and modulating the maternal environment necessary for normal fetal development. As an active endocrine organ, the placenta is capable of secreting a plethora of hormones, growth factors and

cytokines. It acts as a barrier for the fetus against pathogens and maternal immune system.

Placental function can be summarized as follows:

1. Nutritive function.

2. Excretory function: Fetal metabolic wastes like urea, uric acid and creatinine are transferred to maternal blood by simple diffusion.

3. Respiratory function.

4. Endocrine function: Placenta produces glycoprotein and steroid hormones, which help to maintain homeostasis.

5. Barrier function.

6. Placental transfer of heat: Fetal heat loss is dependent on umbilical blood flow through the placenta.

7. Immunologic function: Placenta plays a fundamental role in the immunological acceptance of the fetal allograft.[28]

SONOGRAPHY OF THE PLACENTA

Ultrasound is the most sensitive, simple, rapid and safe diagnostic tool for placental localization and detecting abnormalities of the placenta.[29,30]

Before the development of prenatal investigation techniques morphological examination of the placenta was limited to retrospective information. Ultrasound placentography has become a standard practice replacing older methods such as soft tissue radiography [31] and radioisotope scanning.[32]

Advances in ultrasound equipment, such as tissue harmonic imaging, computerized sonography and colour Doppler imaging have enhanced the capability of ultrasound for placental evaluation. The development of 3D ultrasound will most

certainly improve the clinical value of comprehensive placental evaluation, especially placental volume measurements.[33]

Placental localization by ultrasound was introduced by Donald in 1958.[18]

Observations made from antenatal sonography have greatly added to our understanding of placenta and feto-placental unit. Sonography can evaluate the intact placenta in-vivo throughout gestation and serial sonograms have helped to show the natural history of certain placental disorders.

NORMAL SONOGRAPHIC ANATOMY

The placenta is first identified by transabdominal sonography at approximately 8 weeks of menstrual age, although the developing placenta can be observed by transvaginal ultrasound from 5 weeks of gestation. At this time a thickening of a portion of the gestational sac, representing the decidua basalis and chorion frondosum is visible.

The placenta consists of chorionic plate on the fetal side, basal plate on the maternal side and placental substance between the plates. The chorionic plate provides a strong acoustic interface with the adjacent amniotic fluid, resulting in a distinct line of echoes.[34] The basal plate does not have a specific echopattern, but is readily distinguishable from the underlying retroplacental myometrium, which appears relatively sonolucent.

The placental substance has a diffuse granular echotexture due to echoes emanating from villus tree, which is bathed in maternal blood in intervillous space. [34]

Between 8 and 20 weeks, placenta appears uniform in echotexture and thickness (as shown in figure 5)**.**

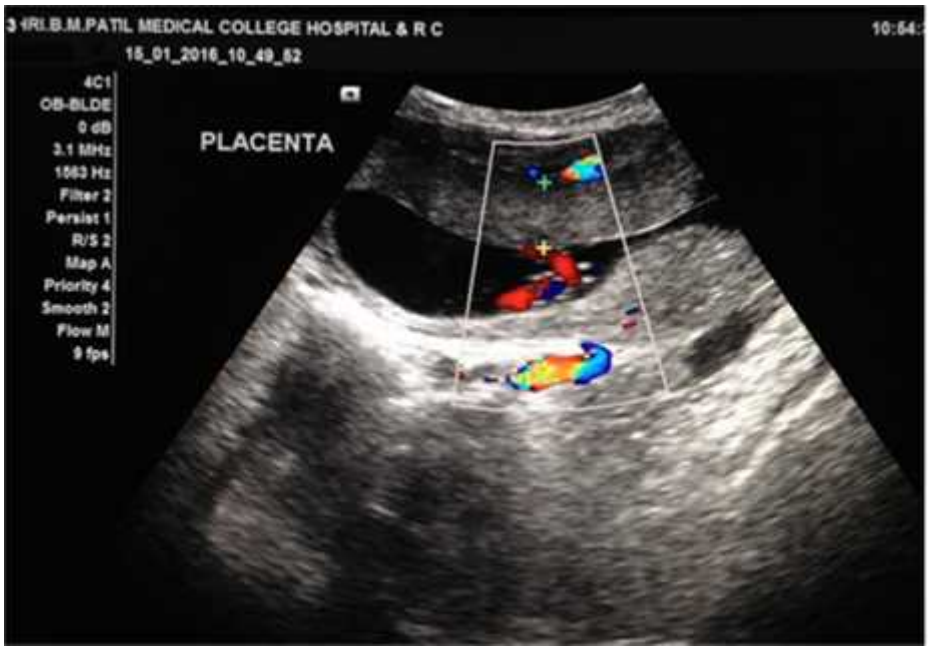


Figure 5: Ultrasonogram showing placenta before 20 weeks of gestation

After 20 weeks, intraplacental sonolucencies (venous lakes or intervillous thrombi) are ubiquitous and are of less significance. Placental calcification may also begin to appear at around 20 weeks [(35)] (as shown in figure 5)**.**

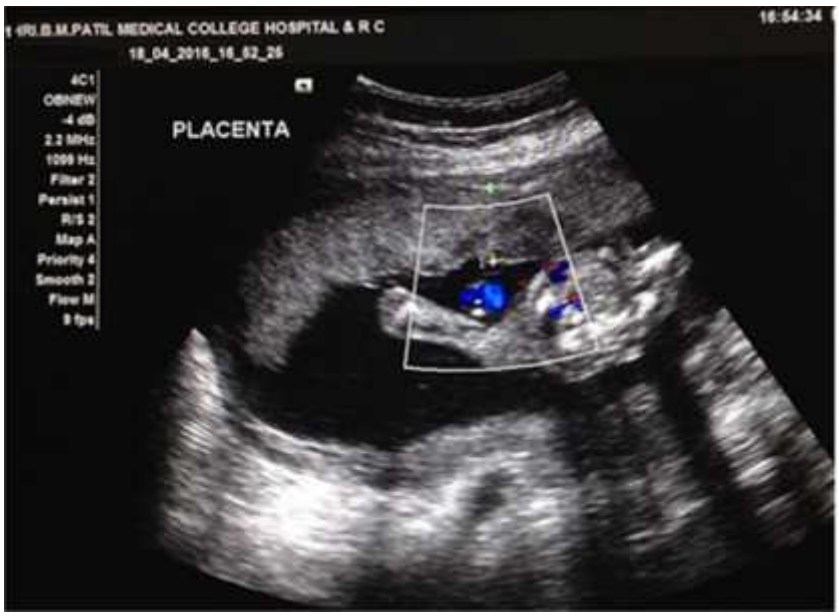


Figure 6: Ultrasonogram showing placenta between 20 and 30 weeks of gestation

After 30 weeks of gestation, a prominent venous plexus separates the basal plate from myometrium.

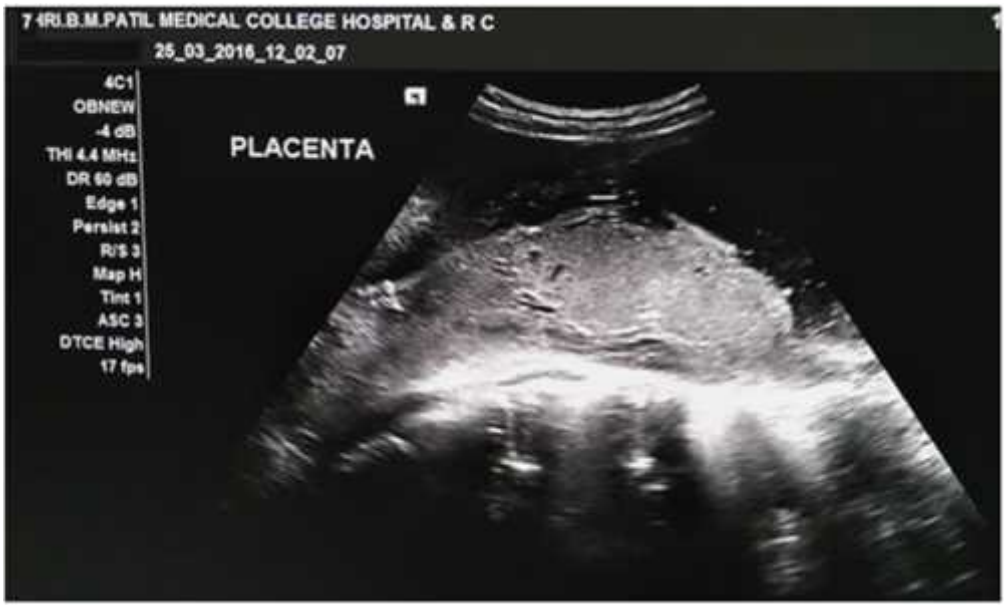


Figure 7: Ultrasonogram showing placenta after 30 weeks of gestation

Retroplacental complex composed of decidua, myometrium and uterine veins appear hypoechoic on ultrasound. The veins associated with the posterior placenta are more dependent and are distended when the patient is supine.

PLACENTAL POSITION

Normal placental insertion covers most of one endometrial surface and usually extends from one endometrial surface to another minimally. Different placental positions are as follows:-

1. **Anterior placenta**: Placenta located anteriorly and extending into lateral walls or fundus minimally.

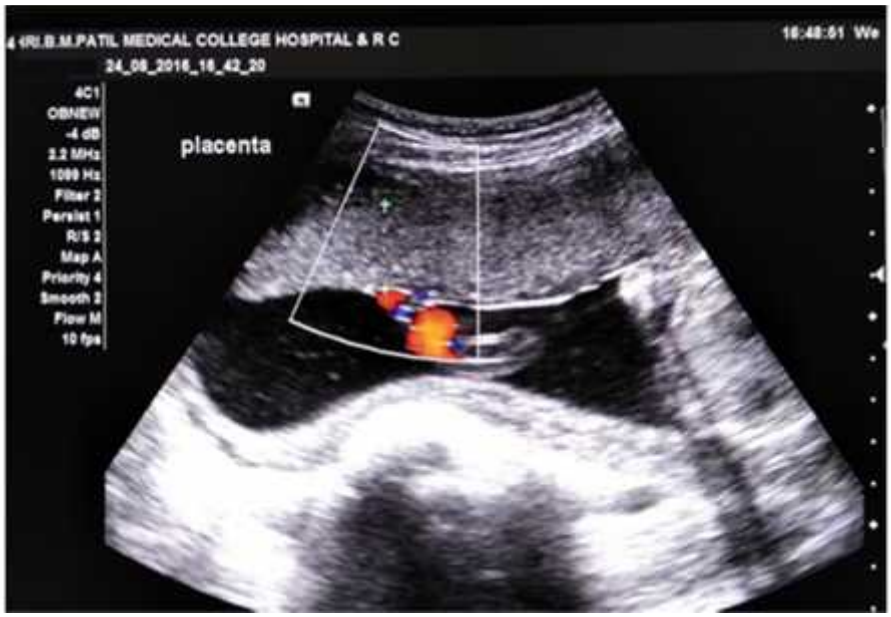


Figure 8: Ultrasonogram showing anterior location of placenta.

2. **Posterior placenta**: Placenta located posteriorly and extending into lateral walls or fundus minimally.

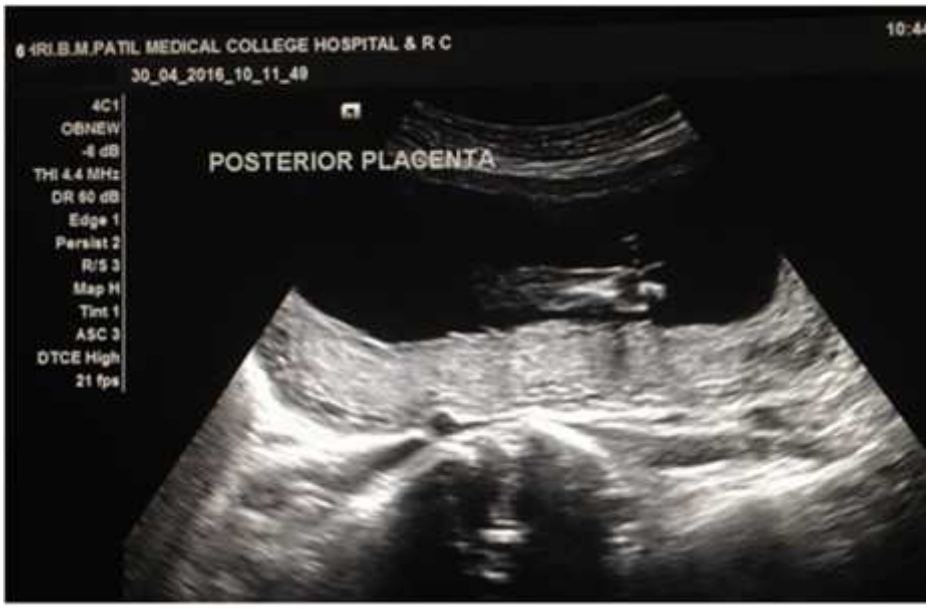


Figure 9: Ultrasonogram showing posterior location of placenta.

3. **Fundal placenta**: Placenta located predominantly in the fundus and extending into anterior or posterior walls minimally.

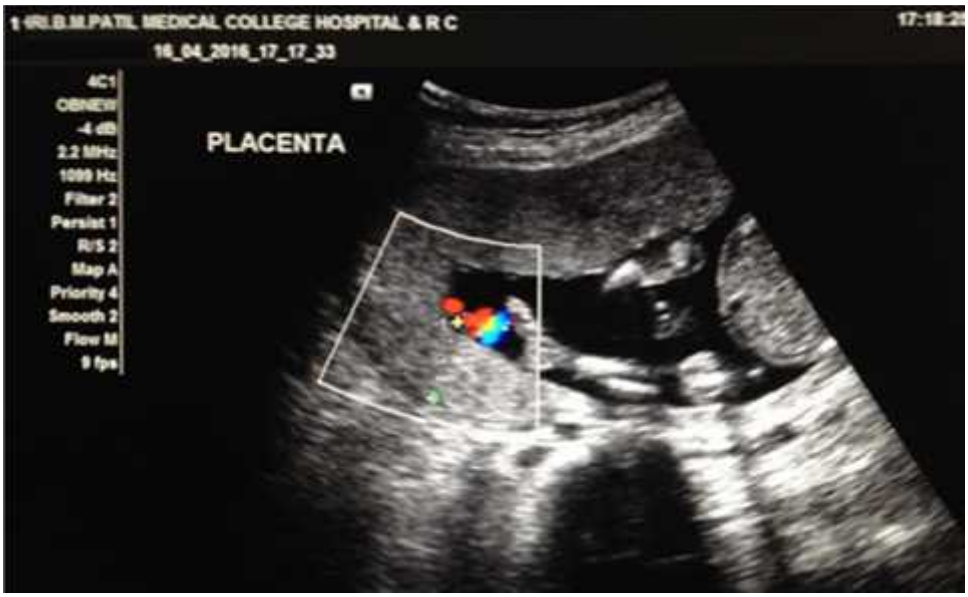


Figure 10: Ultrasonogram showing fundal location of placenta.

4. **Lateral placenta**: Placenta located laterally and extending equally into anterior and posterior walls.

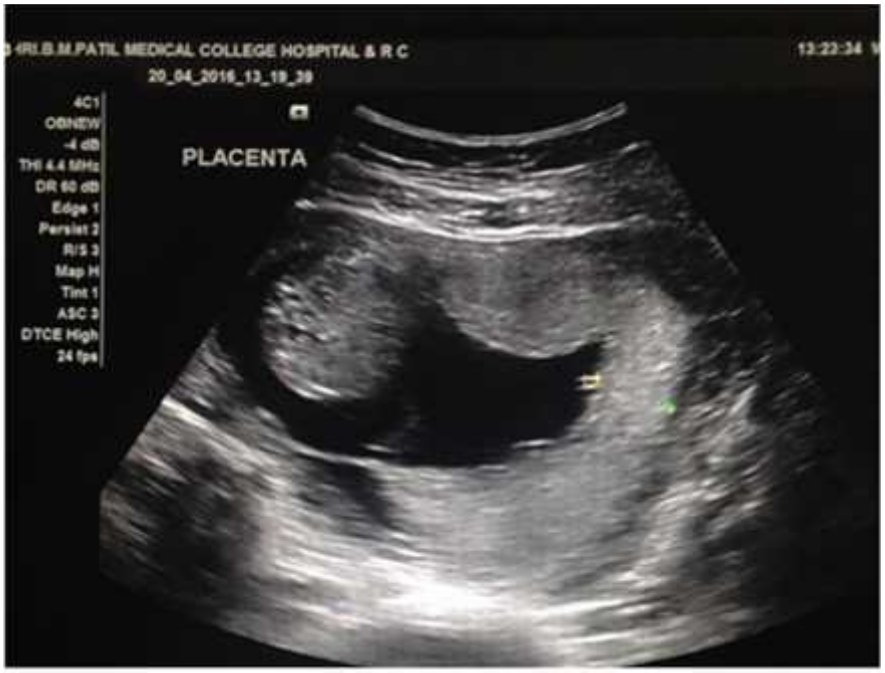


Figure 11: Ultrasonogram showing lateral location of placenta.

PLACENTAL MATURATION

Grannum *et al*,,(1979)[36] studied on 129 patients for a period of four years and devised systemic classification of ultrasonographic morphology of placenta, based on the changes occurring in the chorionic plate, placental substance and the basal layer, the three separate zones of placenta. The placenta was grouped into four grades from zero to three.

Grade 0: The placental tissue and the basal plate are homogeneous without the presence of linear highly reflective foci. The chorionic plate is smooth and well defined.

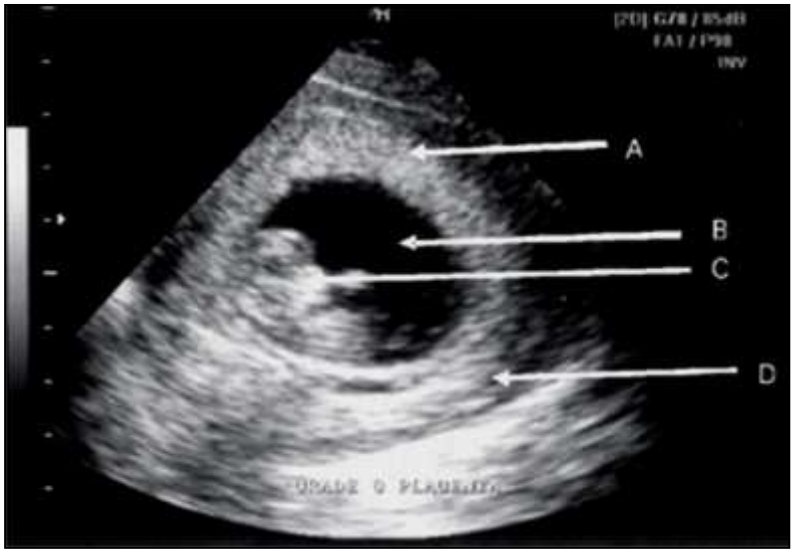


Figure 12: Ultrasonogram showing Grade 0 placenta. **A**= placenta; **B** = liquor amnii; **C** = fetus; **D**= uterine wall.[37]

Grade I: The placental tissue contains a few linear highly reflective foci parallel to the basal plate, which remains unchanged. The chorionic plate presents subtle undulations.

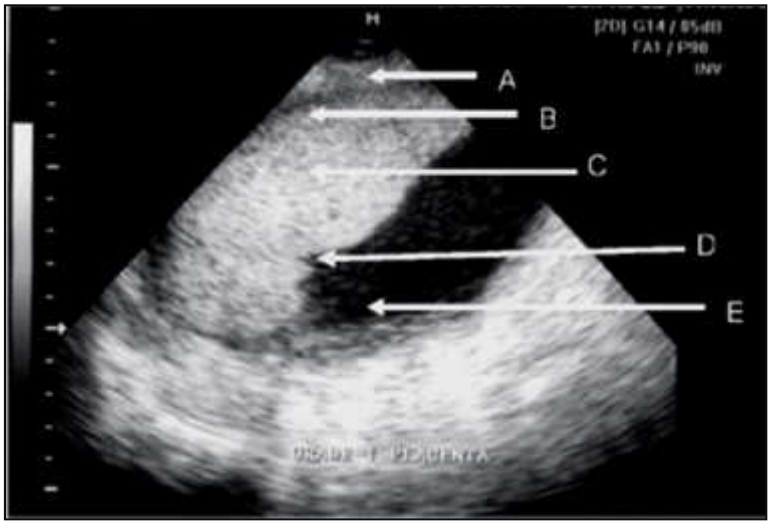


Figure 13: Ultrasonogram showing Grade I placenta. **A**= uterine wall placenta; **B**= basal plate; **C** = placental substance; **D** = indentation in chorionic plate; **E** = liquor amnii.[37]

Grade II: The placental tissue contains randomly dispersed echoes and is divided by comma like reflective structures continuous with the chorionic plate. The marked indentations of the chorionic plate do not reach basal plate, which is well defined by small linear highly reflective areas. According to **Grannum *et al,,*** [36] the basal echoes should be regarded as the hallmark of a grade II placenta.

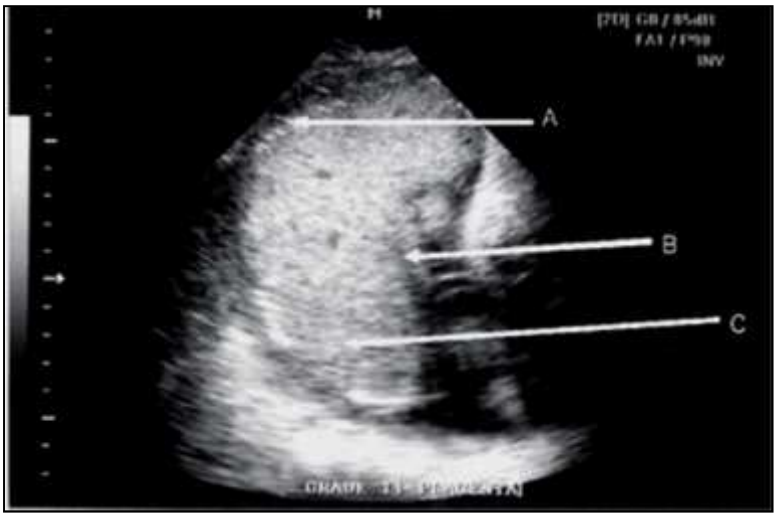


Figure 14: Ultrasonogram showing Grade II placenta. **A**= basal plate echoes; **B**= chorionic plate indentation extending upto placental substance; **C** = placental substance comma like echoes. [37]

Grade III: The placental tissue is divided into compartments containing central echo free areas. The chorionic plate indentations reach the basal plate, which contains almost confluent, very highly reflective areas.

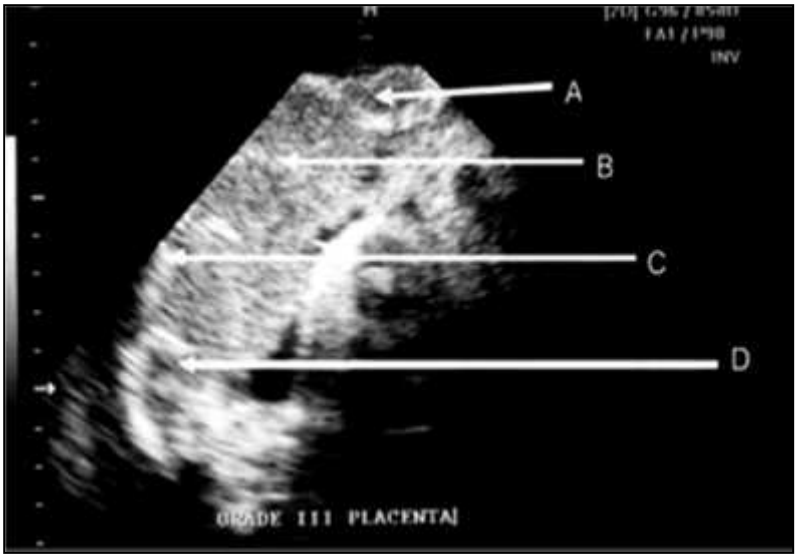


Figure 15: Ultrasonogram showing Grade III placenta. **A**= fall out area of cotelydons; **B** = densities in placental substance; **C** = basal layer echoes; **D** = chorionic plate indentation extending upto basal plate. [37]

Although the placental sonographic grading system is not accurate enough to replace amniocentesis in assessing fetal pulmonary maturity. [38,39]

It may be useful as a predictive indicator of potential perinatal problems.

Many factors are thought to be associated with the maturation of the placenta. Since calcium has been noted in the decidua, fibrin, and the villi of normal term placentas, it is postulated that calcium and fibrous depositions are responsible for the characteristic appearances with aging.

PLACENTAL THICKNESS AND GESTATIONAL AGE

The measurement of placental thickness at the level of umbilical cord insertion site is relatively simple and clinically useful. Few authors have studied the role of placental thickness as an additional parameter for estimating gestational age and also placental thickness nomograms have been published.

Aisha Kiran *et al,,* [40] **2016** Armed Forces Institute of Radiology and Imaging, Military Hospital, Rawalpindi Pakistan did a cross sectional study on 200 antenatal women with singleton pregnancy to determine the correlation of sonographic mean placental thickness in mm with the composite mean 2^{nd} and 3^{rd} trimester gestational age in weeks estimated by ultrasound.

Total of 104 (52%) patients were in 2^{nd} trimester and 96(48%) were in 3^{rd} trimester. A linear relationship was observed between gestational age and placental thickness. There were 104 women with 2^{nd} trimester, correlation between placental thickness and gestational age was positive and significant (r=0.959 and p=0.0005), similarly 96 women with 3^{rd} trimester, correlation between placental thickness and gestational age was positive and significant (r=0.858 and p=0.0005). Strong positive correlation between placental thickness and gestational age was observed (r= 0.985 and p= 0.0005).

They concluded as placental thickness increases, the fetal weight also increases so that the placental growth directly influences the fetal weight.

Dr. B. Venkateswarlu and Dr.S.V.Rao (may 2016)[41] studied on 300 normal antenatal women attending antenatal clinic at the department of Obstetrics and gynecology, AlluriSita Rama Raju Academy of Medical Sciences , Eluru.

They concluded that the relationship between the placental thickness and gestational age is linear and direct. Placental thickness (in mm) increases with

increasing gestational age (in weeks) and almost matching it from 11 to 35 weeks of gestation. The relationship of Placental thickness with gestational age falls marginally and the rate of growth of Placental thickness decreased after 36 weeks of gestation and was lower by 1-3 mm. The thickness of the placenta and growth pattern did not vary relative to the placental location. Normal Placental thickness nomograms have been established in the present study to determine whether a given Placental thickness is normal or abnormal for a particular gestational age. Thoughtful attention to technical detail and correlation of placental thickness with gestational age should facilitate the detection of abnormal placental thickness associated with IUGR, hydrops fetalis and diabetes mellitus in early stages.

Anu Kapoor, Mahesh D. Dudhat 2016[42] conducted a study to evaluate the placental thickness by sonography in normal singleton pregnancies at different stages of gestation in order to develop this as a useful tool for gestational age estimation.

They evaluated 310 normal singleton pregnancies with the age range of 18 to 39 years (mean age 23 years) and calculated the fetal gestational age using sonographic biometric criteria for different periods of gestation. Placental thickness was measured by sonography at the site of umbilical cord insertion using the standardized technique.

Placental localization by sonography revealed fundal placenta in 128 out of 310 cases followed by anterior, posterior and lateral locations in 84, 79 and 19 cases respectively.

The placental thickness gradually increased from an average of 9.9 mm at 10 weeks of gestation to 40 mm at 38 weeks of gestation. There was a fairly linear increase in the placental thickness with increasing gestational age between 10 to 38 weeks at the rate of 0.9 mm per week.

Mean placental thickness (in mm) closely matched with the gestational age (in weeks) between 10 to 30 weeks of gestation.

Beyond 30 weeks of gestation, the mean placental thickness was lower by 1 mm and showed a wider range and variance as evident by increased standard deviation and widened 95% confidence interval. At no stage of pregnancy the placental thickness was greater than 40 mm.

Placental thickness has a linear relationship with gestational age especially during the second trimester of pregnancy. Placental thickness measurements when used along with fetal biometry can increase the accuracy of predicting gestational age during pregnancy.

Lovely Kaushal *et al,,*[43] 2015 evaluated 199 normal antenatal women, the age ranged between 18 yrs to 34 yrs and the mean age was between 20 and 25 yrs of age. Anterior placenta was noted to be the most common location amongst the study sample.

A linear increase in mean placental thickness with gestational age was observed using correlation analysis in study conducted to determine the relationship between placental thickness and gestational age.

Placental thickness measured in millimeters increases with gestational age from 11 weeks to 37 weeks. Placental thickness can be used as a predictor of the gestational age, in women in whom the last menstrual period is unreliable or is not known.

In instances when femoral length was difficult to measure due to excessive foetal movements, Placental thickness was found to be a reliable alternative biometric measurement in calculating gestational age.

The substitution of abnormal foetal parameters like biparietal diameter in hydrocephalus with placental thickness in the gestational age estimation can be looked into.

Dr. P. Pranesh *et al,,* [44] **(april 2015)** conducted prospective cross sectional study on 200 antenatal women of all gestational ages from 11 weeks to 40weeks.

They observed that the placental thickness gradually increased from approximately 11.4 mm at 11 wks to 36.5 mm at 40 wks of gestation. From 11 to 35 wks of gestation, the placental thickness (in mm) almost matched the gestational age in weeks, thereafter from 36 to 40 weeks; the placental thickness was lower by 1-3 mm.

They concluded that the relationship between the placental thickness and gestational age is linear and direct; Placental thickness (in mm) measurement can be used as an important additional parameter for estimating gestational age along with other parameters especially from 11 to 35 weeks of gestation**.**

Natwar Lal Agrawal (December 2015)[45] studied 100 pregnant females, between 13th to 39th weeks gestation with their age ranging from 18 -35 years. They concluded a fairly linear relationship between PT and FL and it provide accurate parameter for estimating fetal gestational age especially in late mid trimester (21st to 25th week) and early 3rd trimester (26th to 30th week) of gestation where the exact duration of pregnancy is not known.

Ridhi Adhikari *et al,,* (Dec 2015)[46] evaluated 150 normal antenatal women, the age ranged between 17 years to 35 years with mean age of 22 yrs.

The minimum gestational age was 11.57 weeks and the maximum gestational age was 40.00 weeks with a mean gestational age of 25.49 weeks.

Anterior placenta was noted in 36%, posterior in 46%, fundal in 11% and lateral in 7% cases.

Grade I placenta was present in 93 subjects, 37 had grade 2 and 20 had grade 3 placenta.

Placental thickness gradually increased from approximately 11 mm at 11 weeks to 38.33 mm at 40 weeks of gestation.

The minimum placental thickness was 11.00 mm; the maximum placental thickness was 38.33 mm with a mean placental thickness of 25.21 mm.

From 11 to 34 weeks of gestation, the placental thickness (in mm) almost matched the gestational age in weeks, thereafter from 35 to 40 weeks; the placental thickness was lower by 1 to 2 mm. At no stage of pregnancy was the normal placenta greater than 39 mm.

Limitations in this study was a cross sectional design, which is made up of observations on different individuals and did not follow the subjects longitudinally. So, it may not provide a clear understanding in individual growth patterns. Accuracy of placental measurements depends on making a perpendicular scan of the placenta and care should be taken in acquisition and interpretation of the images to prevent spurious measurements. Placental thickness measurement using 3D ultrasonography may more accurately assess placental size than placental thickness measurements. However, 3D ultrasonography is expensive, time consuming and not widely available. The parameter of placental thickness may vary among different population groups. Population specific nomograms may be needed derived from large sample sizes. The placental growth curves may be different for different population groups. Short placental insertion site may spuriously suggest placental thickening in a normal

placenta. Moreover, cord insertion site on the placenta was difficult to image in normal term pregnancies, especially in posterior locations.

They concluded that relationship between the placental thickness and gestational age was linear and direct. Placental thickness (in mm) measurement can be an important additional parameter for estimating gestational age along with other parameters especially from 11 to 34 weeks of gestation. It can be an additional indicator of estimating gestational age especially where the duration of pregnancy is unknown or uncertain.

Preeti baghel *et al,,* [47] **2015** carried out a study on 100 pregnant patients at 24 weeks, 32 weeks and 36 weeks.

They concluded that PT on USG seems to be a promising parameter for estimation of GA of the fetus and predicting fetal outcome as placental thickness in mm almost equals GA in weeks. Patient below 10^{th} percentile was found to be associated with LBW & IUGR.

Mean placental thickness of 24.5 mm is the same as the gestational age in weeks i.e. 24 weeks and can be useful in estimation of gestational age. Mean PT at 24 weeks was 24.5 mm, 31.8 mm at 32 weeks and 35.5 mm at 36 weeks. So, there was linear increase of PT at 24, 32 & 36 weeks.

Mumal Nagwani *et al,,* [48] **2014** recruited 100 pregnant women in third trimester to determine Placental thickness and its correlation to estimate the gestational age. The mean placental thickness was 3.90+- 1.1 cm which increased till 38 weeks of gestation, thereafter surprisingly placental thickness decreased.

T Karthikeyan *et al,,* [49] **(July 2012)** carried out a cross-sectional prospective study on 211 pregnant women between 11 to 40 weeks and they were not complicated by

either maternal or foetal diseases .The maximum mean PT in the 1st, 2nd, 3rd and the combined trimesters were 16.5 mm, 23.78 mm, 35.81 mm and 28.49 mm.

There was a strong positive correlation between PT and GA. There was a significant positive correlation between PT and BPD, AC, FL, HC and FW also.

They concluded that PT can be used as a predictor of the GA. Subnormal PT for corresponding GA should be evaluated for any disease condition**.**

Ganjoo S *et al,,* [50]**2014** carried out a prospective study on 300 antenatal patients 100 each in 1st, 2nd& 3rdtrimester, respectively, with GA of more than 10 weeks till term.

They observed that during GA 10- 13 weeks, PT was higher than GA by 1-2 mm. It matched GA almost equally between GA 14-21 weeks, after which it was slightly lower than GA by 1-3 mm till term.

Limitations of study was the variability of PT and potential effects of the contour of the uterine wall, the interpretation may not be accurate.

The study showed a positive correlation between gestational age and placental thickness and can be used in women with unknown duration of pregnancy. Placental thickness in millimeter accurately matched the GA in weeks from 14 to 21 weeks of gestation after which it was seen to be lesser than GA by 1-4mm

Aditi Tiwari, Kavita Chandnani 2013[51] evaluated 754 antenatal cases of all gestational ages (> 10 weeks of gestation) were selected. They concluded up to 21 weeks of gestation the mean placental thickness was slightly higher than the gestational age (1-4 mm). From the 22nd week to the 35th week of gestation the placental thickness almost matched the gestational age in weeks, thereafter the placental thickness was lower by (1-2 mm).

Lee *et al,,* [52] **2011** carried out cross-sectional study placental thickness in second trimester on 114 singleton pregnancies and concluded that placental position and

possibly GA need to considered when determining PT. Anterior placentas are approx 7mm thinner than posterior or fundal placentas.

Anterior placenta greater than 33 mm and posterior placenta greater than 40 mm should be considered abnormally thick.

Ohagwu CC *et al,,*[53] 2009 studied 666 Nigerian women in the second and third trimesters of pregnancies. They concluded that there was a fairly linear increase in placental thickness with GA. This relationship suggests that placental thickness can be used as an indicator of gestational age. Study showed a statistically significant positive correlation between placental thickness and BPD & AC.

Arafa Ahmed *et al,,*[54] (2009-2010) carried out a study on 110 normal singleton pregnant Sudanese women in third trimester and there were significant correlations between Placental thickness, femur length and bi-parietal diameter in which correlation coefficients were 0.85 and 0.80 respectively.

They concluded Placental thickness can be considered as one of the parameters for estimating gestational age in the third trimester.

Khatri *et al,,*[55] march 2005 study showed that the placental thickness increases from 16mm at 12 weeks to 39mm at 40 weeks. He concluded that measurement of PT can be used as an important additional parameter for estimation of GA especially in the cases where the exact duration of pregnancy is not known.

Tongsong *et al,,*[56] 2004 studied on 333 normal pregnant women with singleton pregnancies between 8 and 20 weeks of gestation. All the newborns were normal at birth. Placental thickness was measured perpendicularly through the thickest part of the placenta on transabdominal scans. The placental thickness data were analyzed for mean, standard deviation, 95% confidence interval, and 2.5^{th}, 5^{th}, 50^{th}, 95^{th}, and

97.5thpercentile for each week of gestational age. The best-fit mathematical model was derived by regression analysis.

They have established nomogram of placental thickness for the first half of pregnancy (8 – 20 weeks) and they found a linear relationship between placental thickness and GA.

Celeste Durnwald & Brian Mercer 2004[57] did a prospective cross-sectional study on 167 viable singleton pregnancies at Metro Health Medical Center at CWRU School of Medicine, Obstetrics and Gynaecology, Maternal Fetal Medicine, Cleveland, Ohio.

There were 17 1st, 100 2nd, and 50 3rd trimester scans at mean gestations of 11.8 (1.5), 21.5 (3.6) and 34.1 (3.0) wks, respectively. Placental location was anterior (52%), posterior (38%) and fundal (11%).

PT varies with gestational age and is thinner for anterior placentas in 2nd, 3rd trimester. Placental thickness of 4 cm may not be abnormal, especially in 3rd trimester. PT should be assessed in context of implantation site and gestational age.

Mittal P et al., 2002[16] studied on 600 normal antenatal women of all gestational ages (10 weeks of gestation) attending Antenatal Clinic at the Department of Obstetrics and Gynaecology, S.M.S. Medical College, Jaipur (Rajasthan).

It was observed that the placental thickness gradually increased from 15 mm at 11 weeks of gestation to 37.5 mm at 39 weeks. From the 22nd week to the 35th week of gestation the placental thickness coincide almost exactly with the gestational age in weeks. They concluded that the measurement of the placental thickness is an important parameter for estimation of fetal age along with other parameters especially in the late mid trimester and early third trimester, where the exact duration of

pregnancy is not known. The placental thickness coincides almost exactly with GA in weeks.

Anupama jain *et al,,* [17] **2001** studied antenatal cases of all gestational ages (> 10 weeks of gestation). He observed value of mean placental thickness increases with advancing gestational age almost matching from the 22nd week to the 35th week. They found placental thickness almost matched GA from 27 to 33 weeks.

Nyberg and Finberg (1990) [15] also reported that as a rule of thumb, placental thickness parallels GA in weeks.

Hoddick *et al,,* [6] **(1985**) reviewed 200 randomly selected singleton pregnancies. Placental thickness was measured and correlated with menstrual age. With advancing menstrual age placenta showed increase in thickness. At no stage of pregnancy the normal placenta was greater than 4 cm in thickness. Potential pitfalls in measuring placental thickness are addressed, as well as potential causes of aberrations in placental thickness.

Renato La Torre 1979 [58] opined that at no stage of pregnancy PT exceeded 40 mm.

Tanawattancharoen *et al,,* [59] reported less variation in placental thickness at gestational age between 18 weeks and 41 weeks.

Jauniaux *et al,,* [60] did a prospective, cross-sectional study on 210 women between 16 and 28 weeks of gestation. Ultrasonographic investigations of placenta included measurements of thickness, circumference, volume and morphologic studies. Uterine Doppler and maternal serum alpha-fetoprotein measurements were performed at the same time.

This study shows an association between abnormal placental development, ultrasonographic appearances, and subsequent abnormal fetal growth or hypertensive disorders of pregnancy. The interrelationships demonstrated between the different

techniques suggest that a combination of placental thickness and morphologic characteristics, uterine Doppler analysis, and evaluation of maternal serum alpha-fetoprotein level may allow more efficient screening for these complications than is currently possible using any single method.

O.Tulin and Eva K. Pressman[61] reported that the placental thickness increases with advancing gestational age.

Appiah 2009[62] observed no significant correlation between PT and GA. Instead stated a positive correlation between PT and weight of the baby, indicating that factors affecting the weight will indirectly affect the PT.

ABNORMALITIES OF PLACENTAL SIZE

Great variations are usually observed in placental size. Some of the variation may have genetic origin, because there are some differences in the gene that regulate fetal and placental growth.

Jauniaux *et al,,*[63] have identified association between placental volume and pregnancy outcome.

SMALL AND THIN PLACENTAS

An unusually small placenta often has clinical significance. Low maternal pregravid weight, low pregnancy weight gain, and the absence of hand and facial edema in the gravida were all associated with small placentas. All these factors are associated with low maternal gestational blood volume expansion with resulting low blood flow from the uterus to the placenta. The most important risk factor is fetal growth retardation. Other factors associated with small placentas include accelerated placental maturation and major fetal malformations. Unevenly accelerated placental maturation is the characteristic consequence of pre-eclampsia and chronic maternal hypertension, which reduces blood flow from the uterus to the placenta. Many of the

major autosomal disorders are associated with placental growth retardation. Small placentas are usually associated with increased frequency of stillbirths and mental retardation. The association with stillbirths raises the possibility that small placentas are sometimes functionally inadequate to supply all the needs of the fetus for oxygen and nutrients.

Placentas less than 2.5 cm thick at term are associated with intrauterine growth retardation of the fetus, preeclampsia, prematurity, fetal malformations or trisomy, small for date fetus and neonatal high hemoglobin.[64,65]

Other causes of placentomalacia are chromosomal abnormalities, high maternal hemoglobin during pregnancy, gestational hypertension, low parity, maternal preconceptional diabetes, CMV, HSV or other chronic intrauterine infections.

Hoogland HJ *et al,,* [65] studied placental growth during pregnancy serially by ultrasonographic measurement of placental area in 50 primigravid women. Placental area at a menstrual age of 150 days was compared to infant birth weight. Small placental area at a menstrual age of 150 days was significantly related to low infant birth weight (< tenth percentile of birth weight for gestational age). A "warning limit" of placental area at mid pregnancy was calculated. If placental area was equal to or smaller than this limit of 187 sq cm, six of nine patients (67%) compared to four of 41 subjects with larger placentas ($p < 0.01$) were delivered of a small-for-gestational age baby. Ultrasonographic placental area measurement in mid pregnancy thus appears to be of prognostic value in identifying pregnancies at high risk for the subsequent occurrence of fetal growth.

THIN PLACENTA

An unusually thin placenta increases the risk for both fetal growth retardation, and for neonatal death, raising the possibility that very thin placenta are sometimes functionally insufficient. A thin placenta does not increase the risk for long-term neurological abnormalities.

LARGE AND THICK PLACENTAS

Placentas more than 4 cm thick over their entire extent have an association with maternal diabetes mellitus, fetal hydrops (of both immune and nonimmune etiology) and intrauterine fetal infections. Common causes of unusually large placenta are villous edema, severe maternal anaemia, fetal anaemia, congenital syphilis, large intervillous thrombi and a large blood clot beneath the subchorionic (fetal) plate of the placenta.

Rare causes of unusually large placenta include toxoplasmosis, congenital fetal nephrosis, idiopathic fetal hydrops and multiple placental chorioangiomas. Placental enlargement with diabetes mellitus and chronic fetal & maternal anaemia are usually related to abnormally large villi.

Villous edema is the most frequent cause of a preterm placenta being overweight. Recognizing placental villous edema is important because when it is widespread and severe it makes fetuses hypoxic with resulting low Apgar scores, difficulty in resuscitation at birth, neonatal respiratory distress, a high neonatal mortality, and an increased frequency of long-term neurologic abnormalities. Pathophysiological reasons for placental edema are unknown. The hypotheses proposed have been similar to those for fetal hydrops, involving disturbance of hydrostatic and colloid osmotic pressure.

Increased umbilical venous pressure leads to placental edema and hypoxia, which in turn causes capillary damage and increased capillary permeability leading to thickening.

The incidence of perinatal mortality was significantly higher among gravidae with thick placentae. Sonographically thick placenta is associated with increased perinatal risk with increased mortality related to fetal anomalies and higher rates of both small for gestational age and large for gestational age infants at term.

The rates of abruptio placentae, neonatal intensive care unit admissions and anomalies were also significantly increased among the thick placenta.

Dombrowski *et al,,* [66] studied 18,827 viable singleton pregnancies. Of these, 116 had thick placentas diagnosed by ultrasound examination. Perinatal mortality was markedly increased among pregnancies with thick placentas. The rates of abruptio placentae, neonatal intensive care unit admissions and anomalies were also significantly increased among the thick placenta cohort compared to controls.

The 106 live born neonates with thick placentas had lower Apgar scores, were delivered at an earlier gestational age, and weighed less than controls. Anomalies, hydrops fetalis and abruptio placentae complicated 16 of the 24 cases of perinatal mortalities. Sonographically thick placentas should alert the clinician to the possibility of compromised perinatal outcome.

Live born neonates with thick placentas had lower Apgar scores, were delivered at an earlier gestational age, and weighed less than controls. Sonographically, thick placentas should alert the clinician to the possibility of compromised perinatal outcome.

Ultrasonography remains the cornerstone of fetal imaging in fetuses in whom hydrops fetalis is suspected. Sonograms demonstrate the cardinal signs of the disease,

namely, fetal skin edema (>5 mm), fluid in a serous cavity, polyhydramnios, and a thickened placenta. Hydrops fetalis is associated with polyhydramnios and a thickened placenta (>6 cm) in as many as 30-75% of patients.

Tongsong T *et al,,* [67] screened 17,254 pregnant women for severe thalassaemia, to know the placental thickness, at mid-pregnancy, as a predictor of Hb Bart's disease. Of 345 pregnancies at risk, 70 fetuses with Hb Bart's disease were finally diagnosed. The mean placental thickness (+/-SD) of the normal pregnancies and pregnancies with Hb Bart's fetuses were significantly different, 24.6+/-5.2 mm and 34. 5+/-6.7 mm, respectively. For couples at risk, when sonographic placental thickness is normal, the risk of having an Hb Bart's fetus is markedly decreased.

Placental thickness varied from 4 cm to 17 cm and thickening was an early sonographic change in affected fetuses. Edematous placentas showed ground glass appearance, disappearance of chorionic plate and buckling of chorionic plate on histopathology.

Ghosh *et al,,* [68] used the ultrasound measurement of placental thickness in 231 at risk pregnancies to detect pregnancies affected by homozygous alpha 1 thalassemia.

Heterogenous thick placentas are seen with molar pregnancy, triploidy, placental hematoma and mesenchymal dysplasia.

Potential pitfall is the small area of placental attachment to the uterus, which may cause artifactual thickening of the placenta. This may be avoided by completely scanning the maternal surface (360°), which makes the condition apparent.

PLACENTAL GRADES AND GESTATIONAL AGE

Grannum *et al,,* [64] (1979) devised systemic classification of ultrasonographic morphology of placenta, based on the changes occurring in the chorionic plate,

placental substance and the basal layer, the three separate zones of placenta. The placenta was grouped into four grades from zero to three as explained above.

According to **Petrucha and Piatt (1982)**[69] all placenta start as grade zero. The mean gestational age at which the placenta matures to a Grade I is 31.11 weeks, Grade II, 36.36weeks and Grade III, 38.04 weeks.

Winsberg F (1973)[35] described a ultrasonic appearance of the placenta after 36 weeks of gestation, appearance of rounded transonic areas correspond to the placental tissue and a villous space between the interlobular septa show as white echoes due to their calcium content.

PLACENTAL GRADES AND MEDICAL COMPLICATIONS

Placental maturity may be accelerated or delayed in complicated pregnancy.

Accelerated Maturation

In making the diagnosis one must be certain of the gestational age. Accelerated maturation is identified by finding abnormally small villi and an abnormally thin syncytiotrophoblastic cell layer covering the villi. When present, accelerated maturation can be relatively uniform throughout the placenta, or it can be interspersed with areas that appear normally mature for gestational age.

Uniformly Accelerated Maturation

The antecedents are being of black race, absence of maternal third-trimester peripheral edema, low maternal net pregnancy weight gain and low maternal pregravid weight for height. The only unfavourable outcome was for stillbirths.

Unevenly Accelerated Maturation

Hills D *et al,,* [70] **(1984)** reported that a delayed change from a grade 0 to a grade I configuration, i.e. a grade 0 placenta presented after 32-33 weeks, might be associated with the onset of gestational diabetes and Rh sensitization, whereas hypertension and

intrauterine growth retardation showed a strong correlation with accelerated placental maturation**.**

An uneven acceleration of placental maturation is widely recognized as a manifestation of stenosis and occlusions in the uterine spiral arteries that unevenly reduce blood flow to the intervillous space in the placenta. This uneven blood flow, when present for several weeks or longer, accelerates villous maturation in those areas of the placenta where blood flow into the intervillous space is low, while acceleration is absent in the areas where the blood flow to intervillous space is normal. The cause of uneven acceleration presumed to be a combination of fluctuating vasoconstriction and longstanding stenotic lesions. Placental infarcts are a common associated finding. Risk factors include preeclampsia, chronic hypertension, intrauterine growth retardation and eclampsia.

Others include white race, primigravida, low maternal prepregnancy weight gain, and overweight mother for height before pregnancy.

Stillbirths and neonatal deaths are increased with unevenly accelerated maturation.

Proud J and Grant A (1987)[71] observed in a study of 2000 unselected pregnant women that the development of mature placental appearance (grade 3) on USG by 34-36 weeks gestation in high risk (HT and APH) cases was associated with increased risk of low birth weight and perinatal death .

A grade 3 placenta at 34-36 weeks, observed in 15% of cases, was found to be significantly associated with low maternal age; nulliparity 149 (67%) v 601 (48%); and being white 211 (95%) v 1113 (89%). The association with maternal smoking at booking was confirmed: 83 (37%) women with grade 3 placentas were smokers compared with 287 (23%) women with grades 0-2.

A grade 3 placental appearance at 34-36 weeks was associated with an increased risk of meconium staining of the liquor, fetal distress in labour, low Apgar score, low birth weight, and perinatal death. Secondary analyses showed that the association with low birth weight reflected both increased risk of preterm delivery and increased risk of low birth weight for gestational age.

Hopper KD *et al,,* [72] **(1984)** noted that if the placenta appeared to be grade I prior to 27 weeks, grade II prior to 32 weeks and grade III prior to 34 weeks of gestation, the pregnancy would likely to be complicated with intrauterine growth retardation and preeclampsia.

Kazzi GM *et al,,* (1983), Kumari S *et al,,* (2001) and Dudley NJ *et al,,* (1993) [73–75] also reported the association of grade III placenta with small for gestational age infants.

Zhang LY *et al,,* [76] **(2005)** maintain the grade III placenta maturation before 37 weeks of gestation is associated with oligohydramnios and low birth weight and might help predict placental dysfunction, which needs close monitoring for the benefits of the mother and fetus.

Mckenna D *et al,,* [77] **2004** studied 1802 low risk patients at 36 weeks gestation to determine placental maturity. He found that incidence of grade III placenta at 36 weeks was 3.8% (68/1802). A grade III placenta was associated with young maternal age and cigarette smoking, protenuric pregnancy – induced hypertension and low birth weight babies, with $p<0.001$ which was significant. He concluded ultrasound detection of grade III placenta at 36 weeks helps in identifying “at-risk” pregnancy, to predict development of protenuric pregnancy – induced hypertension and helps in identifying the growth restricted baby.

Delayed maturation of the placenta

Delayed placental maturation is less frequent than accelerated maturation. The antecedents are maternal diabetes mellitus, major fetal malformations, and erythroblastosis fetalis.

Delayed placental maturation is associated with an increased risk of stillbirths, neonatal deaths, and mental retardation in 8.6 percent.

Delayed villous maturation (DVM) is a spectrum of placental disease characterized by decreased tertiary villus formation, reduced vasculo syncytial membrane formation, and, in its more severe forms, increased large bullous villi. In some series it has been associated with an increased risk of stillbirth in the late third trimester, but overall there are few data on its significance. The aim of this study was to assess perinatal factors associated with, and the clinical significance of, the finding of DVM on placental histology. This was a retrospective study investigating all pregnancies with DVM diagnosed on placental histology in a tertiary level unit between December 2001 and August 2006. Over a 6-year period, 2915 placentas were triaged for histopathological assessment, representing 6.1% of all 48,054 deliveries in this time period. One hundred ninety (6.3%) of these selected cases showed DVM. Fifteen placentas from infants with less than 34 completed weeks of gestation were excluded, leaving 175 for further analysis. When compared with controls matched for gestation and delivering within the same time period (n =175), DVM was significantly associated with pregestational diabetes (8% vs 2.8%, $P < .05$; relative risk 2.8 [95% confidence interval 1.03–7.6]), gestational diabetes (8.6% vs 3.4%, $P < 0.05$; relative risk 2.5 [95% confidence interval 0.99–6.3]), and prenatal or intrapartum intrauterine death (8.6% vs 0%, $P < 0.05$). Delayed villous maturation is

associated with both gestational and pregestational diabetes mellitus and with perinatal death.[78]

Deopa D et al., [37] **(2011**) studied on total number of 42 patients coming to antenatal clinic of obstetrics & gynaecology and in the department of Radiodiagnosis, at SardarVallabhBhai Patel Hospital, Meerut, Uttar Pradesh. The placental grading was done according to Grannum's[64] classification. It was observed that between 32 to 37 weeks, grade II placenta were found more common as compared to grade I, whereas with >37 weeks grade III placenta was found in normal pregnancy. Acceleration and deceleration of placental growth were observed in high risk case.

In their study it was observed that HT, APH & IUGR cases showed acceleration in maturity of placenta, i. e. grade II & III were predominant.

However Rhesus negative cases showed delay in maturation of placenta. This study alone does not justify routine scanning in late pregnancy.

FOCAL CYSTIC / HYPOECHOIC LESIONS

Cystic or hypo echoic lesions are ubiquitous in placenta after 25 weeks in 2 to 20 percent. They represent a variety of entities, including intervillous thrombosis, subchorionic fibrin deposition, perivillous fibrin and decidual septal cyst.

Brown DL *et al,,* [79] evaluated the clinical outcome and histologic findings of pregnancies in which placental surface cysts were detected on prenatal sonography.

In 34 cases sonographic features were correlating with the pathological examination, where subchorionic fibrin with central cyst formation was seen. All pregnancies were live births, although few showed intrauterine growth restriction (12%), maternal floor infarction (11%). Only 2 showed significant associations between sonographic features and postnatal findings. In cases intrauterine growth restriction, average cyst size was larger than 4.5 cm. Of 12 cysts larger than 4.5 cm, 4

(33%) had intrauterine growth restriction. Of 22 cysts smaller than 4.5 cm, there were no instances of intrauterine growth restriction (P = 0.01). Of 32 cases with 3 or fewer cysts, only 2 had intrauterine growth restriction, whereas in 2 cases with more than 3 cysts, both had intrauterine growth restriction (P = 0.01). They concluded that most placental surface cysts are associated with a normal pregnancy outcome. Most such cysts are related to cystic change in an area of subchorionic fibrin. Cysts larger than 4.5 cm or more than 3 in number are more frequently associated with intrauterine growth restriction.

LESIONS RESULTING FROM MATERNAL BLOOD FLOW DISTURBANCES[80]

i. **Massive perivillous fibrin deposition:** These are located in the peripheral area or marginal angle of placenta. These deposits occur in nearly all full term pregnancy, but macroscopically visible plaques occur in 20% to 25% of uncomplicated pregnancies.

ii. **Subchorionic fibrin deposition**: These are triangular or rectangular areas of fibrin deposited under the chorion or fetal surface of placenta. They are noted in approximately 20% of placentas and are not associated with any maternal factors. They appear anechoic on ultrasound and do not show flow on colour Doppler.

iii. Intervillous thrombi: These are usually 1 – 2 cm in diameter and consist of coagulated maternal blood in the intervillous space. These are very common and appear hypoechoic on ultrasound. Intervillous thrombi have no effect on placental function or fetal health.

iv. **Placental Infarction:** A placental infarct is defined as an area of ischemic villous necrosis. Infarcts are usually the result of the occlusion of one or more spiral arteries in the uterine wall. Such occlusions are common with disorders that unevenly reduce uteroplacental blood flow. The most common of these are preeclampsia, eclampsia,

and chronic maternal hypertension. One or two small infarcts and even larger infarcts that are at the margin of the placenta are not usually associated with unfavorable pregnancy outcomes in full-term infants. As the number and size of infarcts increase, so do the frequencies of stillbirth and neonatal death. Overall the perinatal mortality rate associated with placental infarction increases with the size of the infarct, with preterm delivery, and with the presence of disorders that reduce placental function such as preeclampsia, eclampsia, chronic maternal hypertension, and lupus erythematosus. One to four grossly visible infarcts and infarcts >3 cm in diameter are associated with increased risk for fetal growth retardation.

v. **Maternal Floor Infarction**: Also called massive basal plate fibrin deposition. The fibrin is deposited in the basal plate from maternal blood in the intervillous space. It is very rare, occurring in 0.1 %-0. 5% of pregnancies. This lesion may interfere with the perfusion of the intervillous space by maternal blood and is associated with a high incidence of fetal death or IUGR. On ultrasound, typical basal location near the decidua is characteristic.

GROWTH PATTERN OF NORMAL PLACENTA[(3)]

Growth of placenta results from multiplication and branching of chorionic villi. Growth can be estimated by measuring the thickness or by an estimation of placental volume. Placenta grows throughout pregnancy, initial growth being much more rapid than that of the fetus. Placental and fetal weights are closely correlated in most circumstances and it follows nearly a linear pattern except during last few weeks of gestation. Placenta having reached sufficient size to meet its transfer function, it adequately grows little nearer term and the ratio of fetal weight to placental weight increases towards term.

Grannum *et al,,* [36] reported that placental thickness would increase linearly until 33 weeks of pregnancy, after which there was gradual thinning.

Bleker *et al,,* postulated that decrease of placental volume towards term might be due to a decrease of blood volume of intervillous space. They also found that human placenta stops growing before the end of pregnancy.

Jauniaux *et al,,* [60] also reported reduced placental volume growth rate after 30 weeks.

Geirsson RT *et al,,* [81] reported that placenta appears to continue to provide nutrition adequately for the fetus till term inspite of little increase in its size.

Bonds DR *et al,,* [82] studied the relationship of placental size to perinatal outcome was investigated in a population of low-risk infants. A trimmed and drained placenta was weighed for each of 417 low-risk infants, and for 108 infants whose intrapartum course was complicated only by compression of the umbilical cord. Tracings from intrapartum electronic fetal heart rate monitoring were analyzed by an investigator who was unaware of the fetal weight/placental weight ratio. The incidence of perinatal problems was increased in those infants whose fetal weight/placental weight ratio was greater than 11: intrapartum fetal distress, 20% ($p = 0.0046$); meconium-stained amniotic fluid, 28.9% ($p = 0.0017$); Apgar score less than 7, 11.1% ($p = 0.04$); and hyperbilirubinemia, 24.4% ($p = 0.0008$). On the basis of these data, the conclusion drawn was that there is a population of presumably low-risk infants who are at increased risk because they have outgrown their placentas.

PATTERN OF CELLULAR GROWTH:

Rate of DNA increase rapidly declines towards term. But weight, RNA, and protein continue to increase linearly until term. Initially cell division predominates, later only increase in cell size occurs.

However Sands *et al,,* found total placental DNA levels continue to rise in a linear fashion until and even beyond 40 weeks of gestation.

ULTRASOUND EVALUATION OF PLACENTAL SIZE

Determination of placental size is part of the overall assessment of intrauterine environment. Total placental volume is probably the most accurate estimation of placental size, but volumetric measurement is too complex for routine use. The development of 3D ultrasound will most certainly improve the clinical value of placental volume measurement.

METHODOLOGY

MATERIAL AND METHODS

- **Source of data:** The source of data for this study is cases referred to the Department of Radio diagnosis from antenatal clinic, Department of Obstetrics and Gynecology, Shri B.M. Patil Medical College Hospital and research center, Bijapur.
- **Period Of Study**: December 2014 – June 2016
- **Study Design**: Prospective cross sectional study

SAMPLE SIZE:

With 95% confidence interval and Pearson correlation coefficient between placental thickness and gestational age as 0.98. The minimal sample size is 200.

The sample size is calculated by plotting the sample size against estimated lower bound confidence interval.

INCLUSION CRITERIA:

Normal singleton pregnancies from 12 to 24 weeks of gestation.

EXCLUSION CRITERIA:

1. Maternal Disease

a. Gestational Diabetes.

b. Hypertension (Systemic hypertension and Pregnancy induced hypertension)

c. Anemia

2. Fetal anomalies.

3. Placenta previa, posterior placenta, placental anomalies and poor visualization of the placenta.

4. Twin pregnancy.

5. Last menstrual period (LMP) not known or irregular.

6. Intrauterine growth restriction

SCANNERS AND TRANSDUCERS USED:

The grey scale real time ultrasonographic examinations were performed using PHILIPS HD 11XE and SEIMENS ACCUSON X 700.

Philip's transducer: C5-2 Hz convex array and L12-3 Hz linear array transducers were used.

Seimen's transducer: 4C1 Hz convex probe and VF12-4 Hz linear transducers were used.

Detailed history, consent, general physical and obstetrical examinations were done before the USG.

SCANNING TECHNIQUE[48]

- Patient was made to lie in the supine position.
- Fetus will be examined for viability, fetal congenital abnormalities and various growth parameters.
- To rule out oligohydramnios and polyhydramnios, amniotic fluid volume is measured by taking Amniotic Fluid Index (AFI).
- Adnexa were looked for the presence of any mass.
- The fetus was observed for gestational age estimation using bi-parietal diameter (BPD), head circumference (HC), abdominal circumference (AC) and femur length (FL) in the second trimester. The composite average of the gestational age estimated by the various growth parameters were taken for each fetus and was computed by the ultrasound machine based on Hadlock tables by using regression equations from combination of measurements (computation software package).[6]
- Fetal parameters were taken to rule out intrauterine growth restriction.
- Fetal weight was calculated using the Shepard formula.[83]

- The placenta was identified as a hyperechoic area separated from fetus by a hypo echoic area of amniotic fluid.
- At the level of umbilical cord insertion, straight line was drawn up to the maternal surface of the placenta and thus maximum thickness was measured.
- Umbilical artery color Doppler was used for further reconfirmation of the site of insertion.
- Each placenta was measured to a 1 mm precision, at its greatest thickness, which was perpendicular to the uterine wall.
- The uterine myometrium and the retroplacental veins were excluded.
- Placental grading according to Grannum's scale [36] was done.

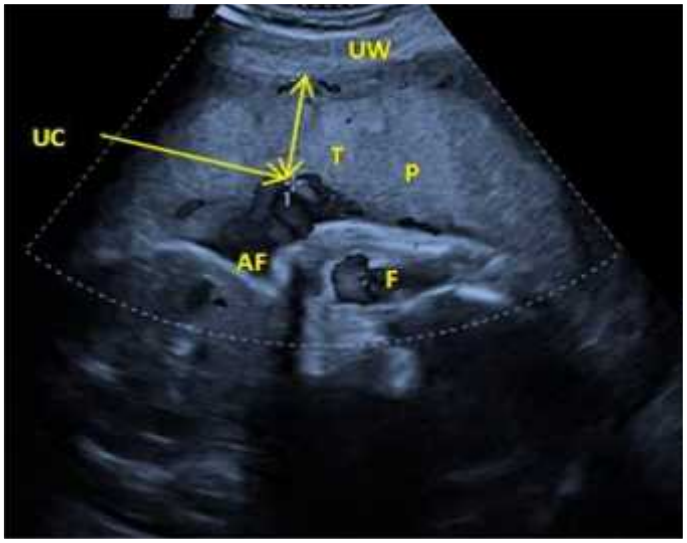


Figure 16: Ultrasonogram showing landmarks for measuring thickness of placenta (P = placenta, UW = uterine wall, T = thickness of placenta, UC = umbilical cord, AF = amniotic fluid, F = fetus)[48]

STATISTICAL ANALYSIS

Study design:

A Prospective cross sectional study.

Statistical Methods:

All characteristics were summarized descriptively. For continuous variables, the summary statistics of N, mean, standard deviation (SD) were used. For categorical data, the number and percentage were used in the data summaries.

Bivariate correlation analysis using Pearson's correlation coefficient (r) was used to test the strength and direction of relationships between the interval levels of variables. For continuous data, the differences of the analysis variables were tested with the t-test. If the p-value is > 0.05, then the results will be considered to be not significant.

The mean values of placental thickness (mm), Biparietal Diameter (mm), Head Circumference (mm), Head Circumference (mm), Abdominal Circumference (mm) and Femur Length (mm) along with respective standard deviation (SD) were computed for each Gestational age from 12 weeks to 24 weeks. The Correlation analysis has been carried out to quantify the relationship between the gestational age in weeks and Placental thickness in mm.

Statistical software:

Data were analysed using SPSS software v 20.0 and Microsoft word & Excel have been used for DTP work.

RESULTS

TABLE & FIGURE OF CORRELATION AND COMPARISON OF MEAN BIPARIETAL DIAMETER AND PLACENTAL THICKNESS BY PLACENTAL LOCATION

Placental Location	Biparietal Diameter		Placental Thickness		t test p value	Correlation	p value
	Mean	SD	Mean	SD			
Anterior	18.35	3.30	18.48	3.46	0.075	0.99	<0.001*
Posterior	18.43	3.29	18.60	3.46	0.074	0.97	<0.001*
Fundal	17.93	3.42	18.02	3.84	0.453	0.98	<0.001*
Lateral	15.14	3.02	14.96	2.85	0.286	1.00	<0.001*

*Note: *Significant at 5% level of significance*

Table 1: Shows significant strong positive correlation of Biparietal Diameter (in weeks) with Placental Thickness (in mm) by location of Placenta.

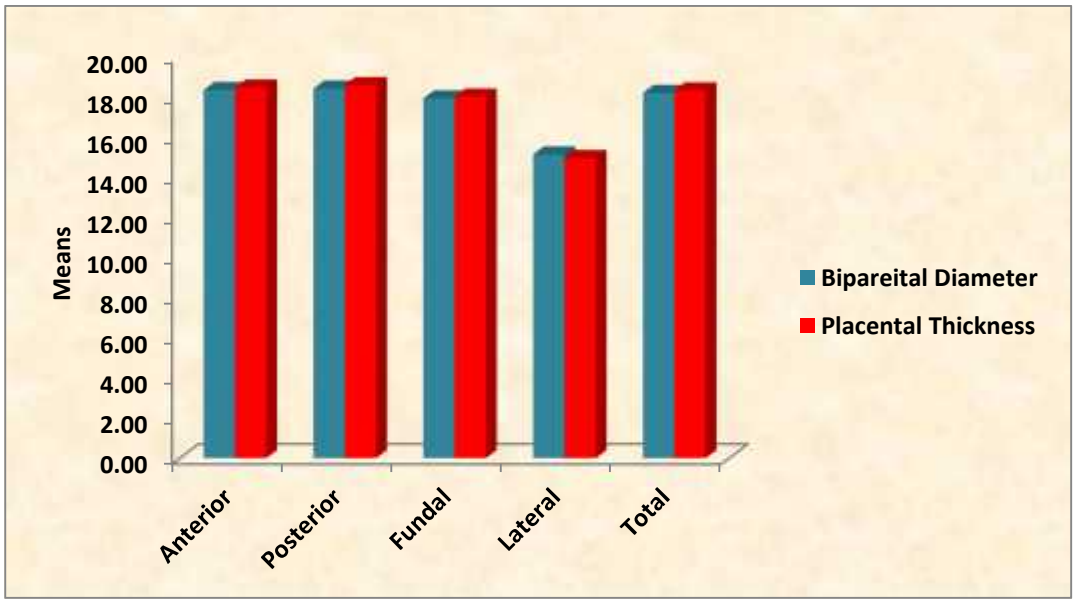


Figure 17: Illustrates the mean of Biparietal Diameter (in weeks) with Placental Thickness (in mm) in different locations of placenta.

TABLE & FIGURE OF CORRELATION AND COMPARISON OF MEAN HEAD CIRCUMFERENCE AND PLACENTAL THICKNESS BY PLACENTAL LOCATION

Placental Location	Head Circumference		Placental Thickness		t test p value	Correlation	p value
	Mean	SD	Mean	SD			
Anterior	18.32	3.37	18.48	3.46	0.019	0.99	<0.001*
Posterior	18.34	3.31	18.60	3.46	0.004*	0.98	<0.001*
Fundal	17.92	3.52	18.02	3.84	0.387	0.98	<0.001*
Lateral	14.92	2.31	14.96	2.85	0.888	1.00	<0.001*

*Note: *Significant at 5% level of significance*

Table 2: Shows significant strong positive correlation of Head Circumference (in weeks) with Placental Thickness (in mm) by location of Placenta.

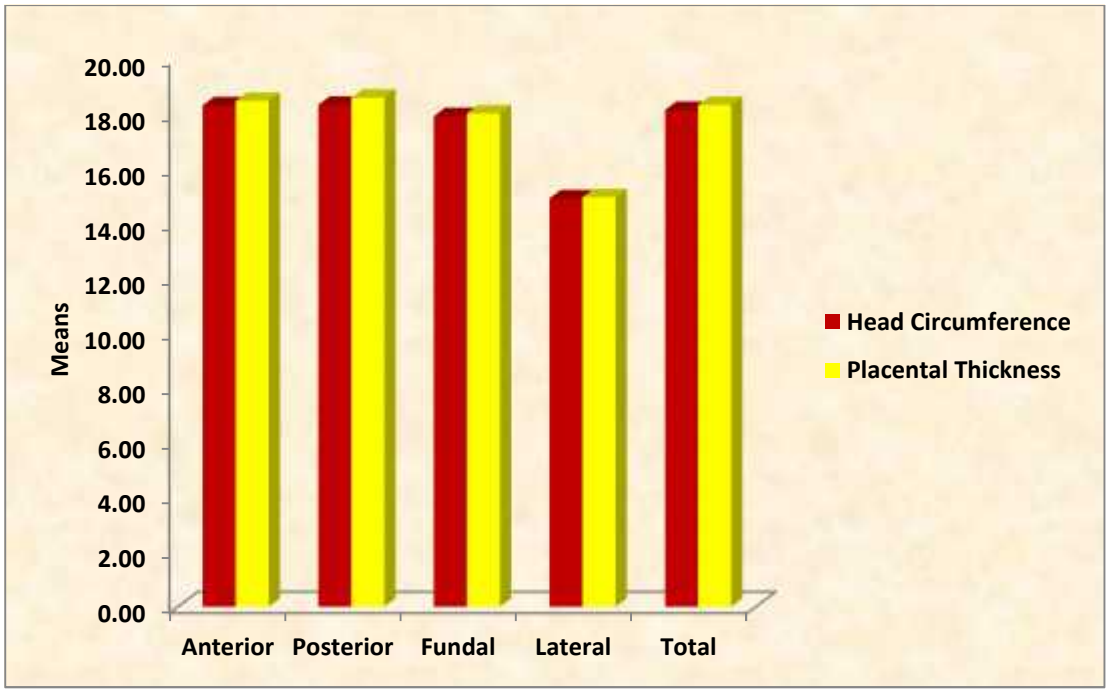


Figure 18: Illustrates the mean of Head Circumference (in weeks) with Placental Thickness (in mm) in different locations of placenta.

TABLE & FIGURE OF CORRELATION AND COMPARISON OF MEAN ABDOMINAL CIRCUMFERENCE AND PLACENTAL THICKNESS BY PLACENTAL LOCATION

Placental Location	Abdominal Circumference		Placental Thickness		t test p value	Correlation	p value
	Mean	SD	Mean	SD			
Anterior	18.39	3.37	18.48	3.46	0.221	0.98	<0.001*
Posterior	18.38	3.27	18.60	3.46	0.015	0.98	<0.001*
Fundal	17.69	3.56	18.02	3.84	0.003*	0.98	<0.001*
Lateral	14.58	1.96	14.96	2.85	0.418	0.99	0.001*

*Note: *Significant at 5% level of significance*

Table 3: Shows significant strong positive correlation of Abdominal Circumference (in weeks) with Placental Thickness (in mm) by location of Placenta.

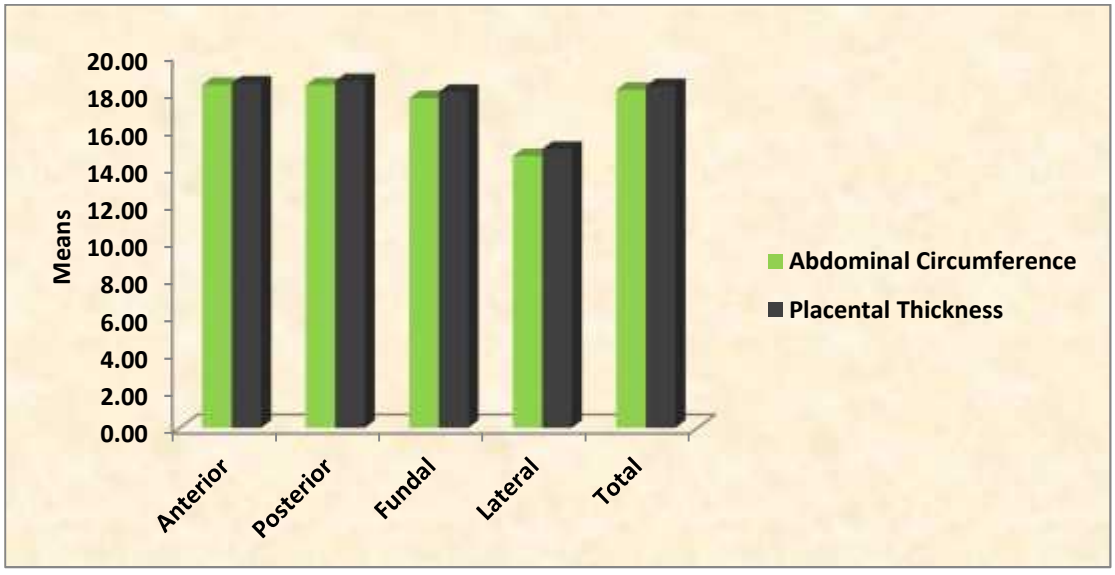


Figure 19: Illustrates the mean of Abdominal Circumference (in weeks) with Placental Thickness (in mm) in different locations of placenta.

TABLE & FIGURE OF CORRELATION AND COMPARISON OF MEAN FEMUR LENGTH AND PLACENTAL THICKNESS BY PLACENTAL LOCATION

Placental Location	Femur Length		Placental Thickness		t test p value	Correlation	p value
	Mean	SD	Mean	SD			
Anterior	18.26	3.40	18.48	3.46	0.001*	0.99	<0.001*
Posterior	18.22	3.41	18.60	3.46	0.001*	0.98	<0.001*
Fundal	17.76	3.81	18.02	3.84	0.016*	0.98	<0.001*
Lateral	15.00	2.86	14.96	2.85	0.740	1.00	<0.001*

*Note: *Significant at 5% level of significance*

Table 4: Shows significant strong positive correlation of Femur Length (in weeks) with Placental Thickness (in mm) by location of Placenta.

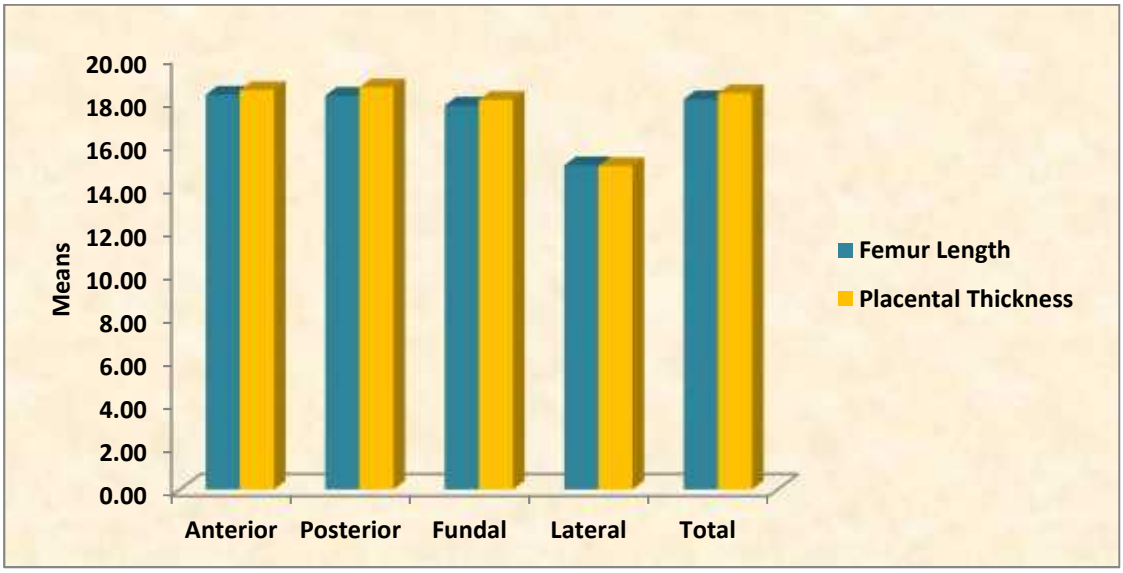


Figure 20: Illustrates the mean of Femur Length (in weeks) with Placental Thickness (in mm) in different locations of placenta.

TABLE & FIGURE OF CORRELATION AND COMPARISON OF MEAN GESTATIONAL AGE AND PLACENTAL THICKNESS BY PLACENTAL LOCATION

Placental Location	Gestational Age (Wks)		Placental Thickness		t test p value	Correlation	p value
	Mean	SD	Mean	SD			
Anterior	18.37	3.35	18.48	3.46	0.055	0.99	<0.001*
Posterior	18.34	3.32	18.60	3.46	0.003*	0.98	<0.001*
Fundal	17.88	3.72	18.02	3.84	0.078	0.99	<0.001*
Lateral	14.94	2.46	14.96	2.85	0.920	1.00	<0.001*

*Note: *Significant at 5% level of significance*

Table 5: Shows significant strong positive correlation of Gestational age (in weeks) with Placental Thickness (in mm) by location of Placenta.

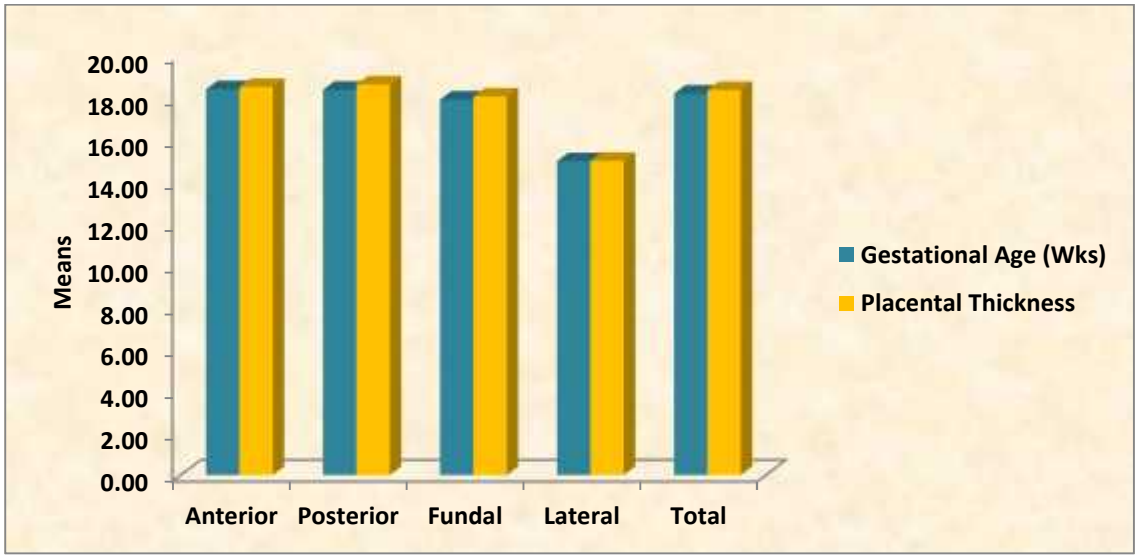


Figure 21: Illustrates the mean of Gestational age (in weeks) with Placental Thickness (in mm) in different locations of placenta.

TABLE AND FIGURE OF PLACENTAL LOCATION IN CASES

Placental Position	N	Percent
Anterior	77	38.3%
Posterior	74	36.8%
Fundal	45	22.4%
Lateral	5	2.5%
Total	201	100%

Table 6: Among the study group of 201 normal antenatal women, anterior placenta was noted in 77 cases (38.3%), posterior in 74 cases (36.8%), fundal in 45 cases (22.4%) and lateral in 5 cases (2.5%).

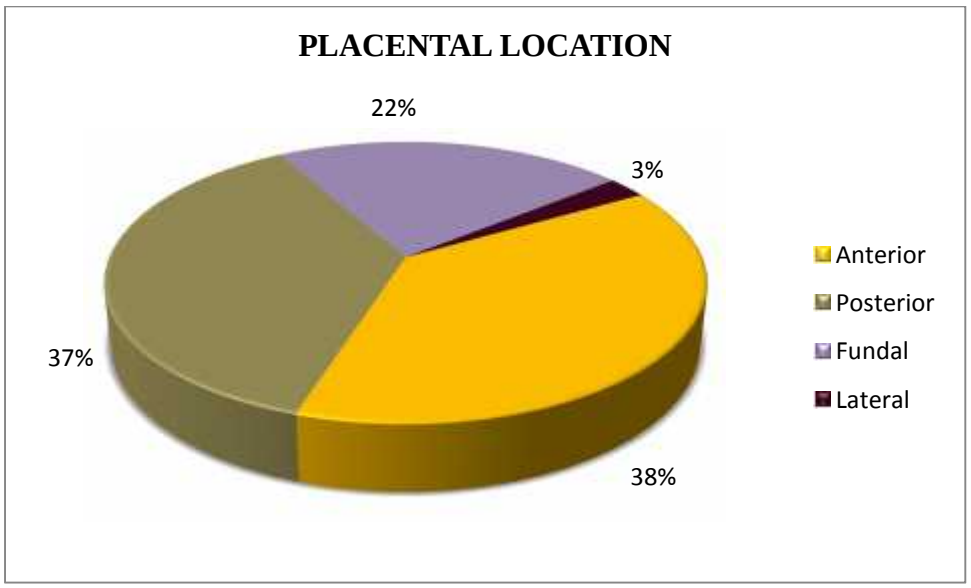


Figure 22: Shows anterior placental location in 38% cases, posterior in 37% cases, fundal in 22% cases and lateral in 3% cases.

TABLE AND FIGURE OF PLACENTAL LOCATION IN DIFFERENT AGE GROUPS

Age (Yrs)	Placental Position							
	Anterior		Posterior		Fundal		Lateral	
	N	%	N	%	N	%	N	%
<20	7	41.2%	5	29.4%	5	29.4%	0	0.0%
21-25	56	37.8%	61	41.2%	28	18.9%	3	2.0%
26-30	14	42.4%	7	21.2%	11	33.3%	1	3.0%
>30	0	0.0%	1	33.3%	1	33.3%	1	33.3%
Total	77	38.3%	74	36.8%	45	22.4%	5	2.5%

Table 7: Shows anterior location (42.4%) of the placenta is most common in 26 – 30 yrs age group, followed by posterior (41.2%) in 21 – 25 yrs age group, fundal (33.3%) in 26 – 30yrs & also in >30 yrs age group and lateral (33.3%) in more than 30 yrs age group.

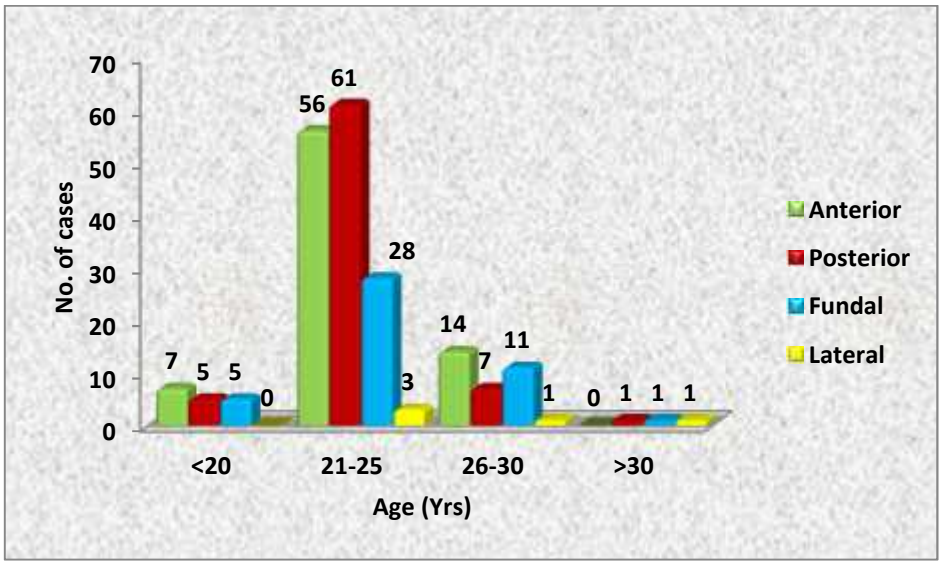


Figure 23: Shows anterior location (42.4%) of the placenta is most common in 26 – 30 yrs age group, followed by posterior (41.2%) in 21 – 25 yrs age group, fundal (33.3%) in 26 – 30yrs & also in >30 yrs age group and lateral (33.3%) in more than 30 yrs age group.

TABLE AND FIGURE OF AGE WISE DISTRIBUTION OF CASES

Age group (Yrs)	No	Percent
<20	17	8.5%
21-25	148	73.6%
26-30	33	16.4%
>30	3	1.5%
Total	201	100%

Table 8: Among the study group of 201 normal antenatal women, majority patients were in the age group of 21 – 25 yrs (73.6%), followed by 26-30 yrs (16.4%), less than 20 yrs (8.5%) and the subjects aged more than 30 were less in number i.e. 3 (1.5%).

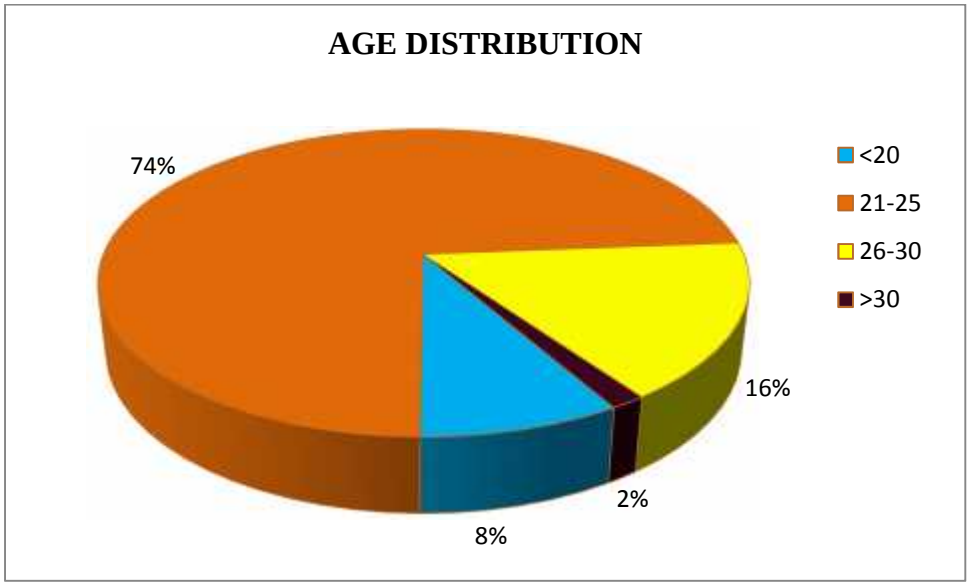


Figure 24: Shows age distribution of cases among 201 antenatal women with majority in 21-25 yrs age group (74 %).

TABLE AND FIGURE OF GESTATIONAL AGE (WKS) WISE DISTRIBUTION OF CASES

Gestational Age (Wks)	No	Percent
12	9	4.5%
13	15	7.5%
14	20	10%
15	21	10.4%
16	11	5.5%
17	17	8.5%
18	14	7%
19	18	9%
20	20	10%
21	21	10.4%
22	13	6.5%
23	15	7.5%
24	7	3.5%
Total	201	100%

Table 9: Among the study group of 201 normal antenatal women. 21 women were in the 15 & 21 weeks of gestation, 20 were in 14 & 20 weeks, 18 were in 19 weeks, 17 were in 17 weeks, 15 were in 13 & 23 weeks, 14 were in 18 weeks, 13 were in 22 weeks, 11 were in 16 weeks, 9 were in 12 weeks and 7 were in 24 weeks.

Percent Distribution of Gestational Age (Wks)

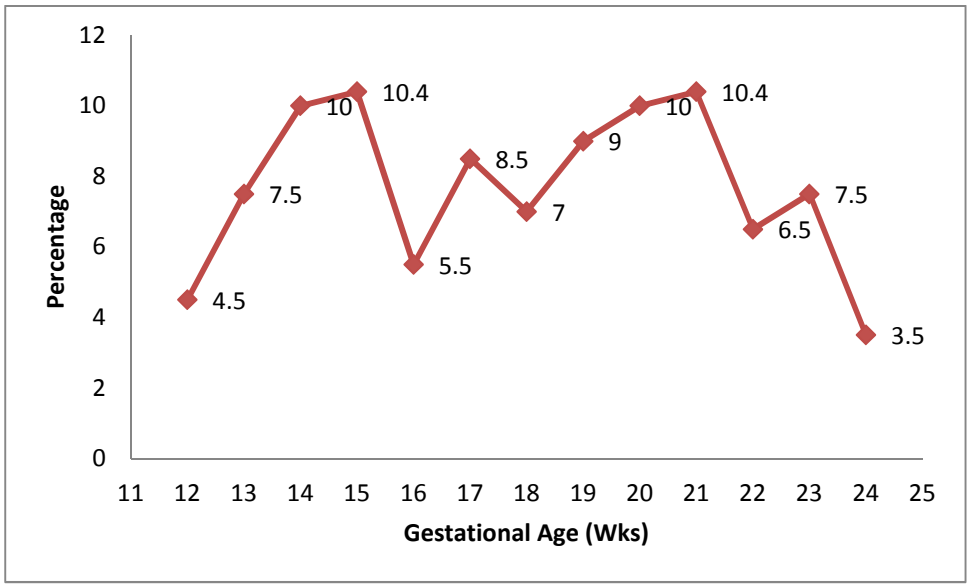


Figure 25: Among the study subjects of 201 singleton pregnant women from 12 to 24 weeks, majority of cases were in 14, 15 and 21 weeks of gestation.

TABLES & FIGURES OF CORRELATION AND COMPARISON OF MEAN PARAMETERS (BPD, HC, AC, FL & GA) WITH MEAN PLACENTAL THICKNESS

Parameters	Mean	SD	t test p value	Correlation	p value
Biparietal Diameter	18.21	3.33	0.014	0.98	<0.001*
Head Circumference	18.15	3.39	<0.001*	0.98	<0.001*
Abdominal Circumference	18.13	3.39	<0.001*	0.98	<0.001*
Femur Length	18.05	3.50	<0.001*	0.98	<0.001*
Gestational Age (Wks)	18.16	3.43	<0.001*	0.99	<0.001*
Placental Thickness	18.33	3.56			

Table 10: Shows that means of Biparietal Diameter, Head Circumference, Abdominal Circumference, Femur Length and Gestational Age (in weeks) were significantly different with the mean of Placental Thickness (in mm). These parameters also show significant positive correlation with Placental Thickness (in mm).

Figures (graph) interpret the same results.

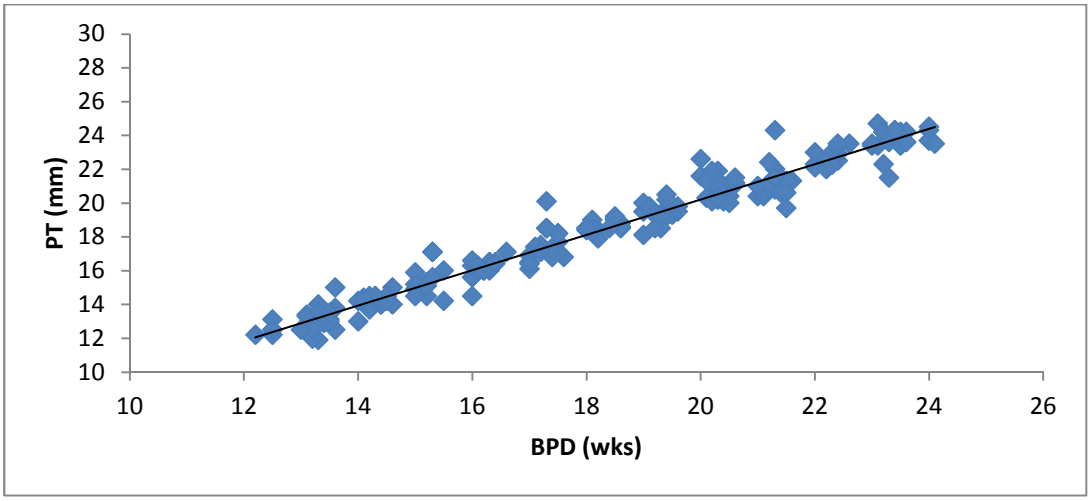


Figure 26: Shows that mean of Biparietal Diameter (in weeks) was significantly different with the mean of Placental Thickness (in mm) and showing significant positive correlation with Placental Thickness (in mm).

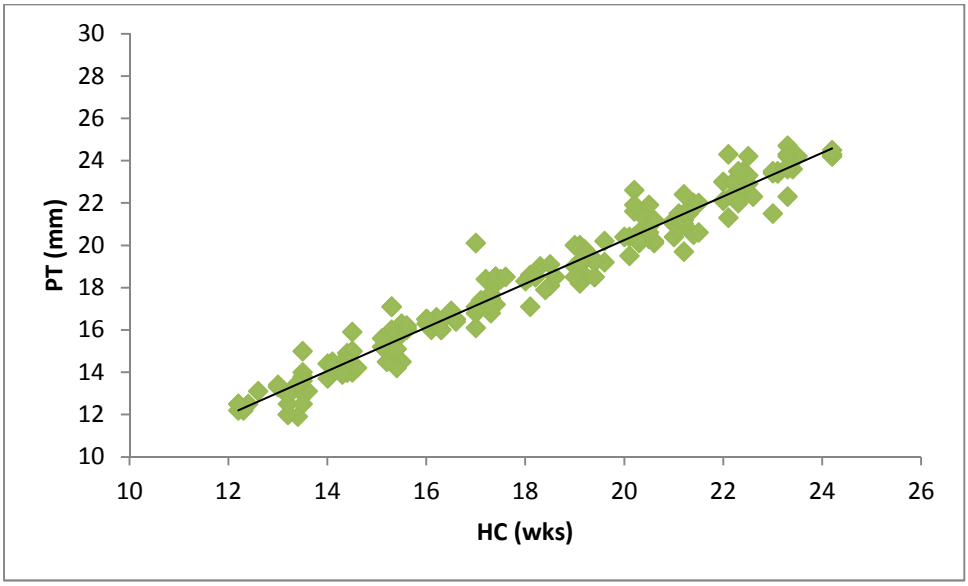


Figure 27: Shows that mean of Head Circumference (in weeks) was significantly different with the mean of Placental Thickness (in mm) and showing significant positive correlation with Placental Thickness (in mm).

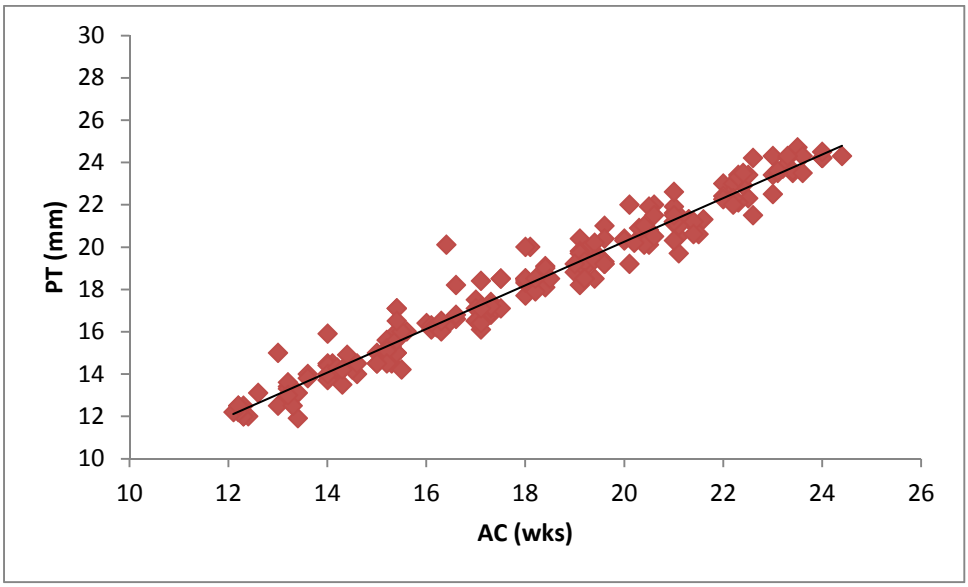


Figure 28: Shows that mean of Abdominal Circumference (in weeks) was significantly different with the mean of Placental Thickness (in mm) and showing significant positive correlation with Placental Thickness (in mm).

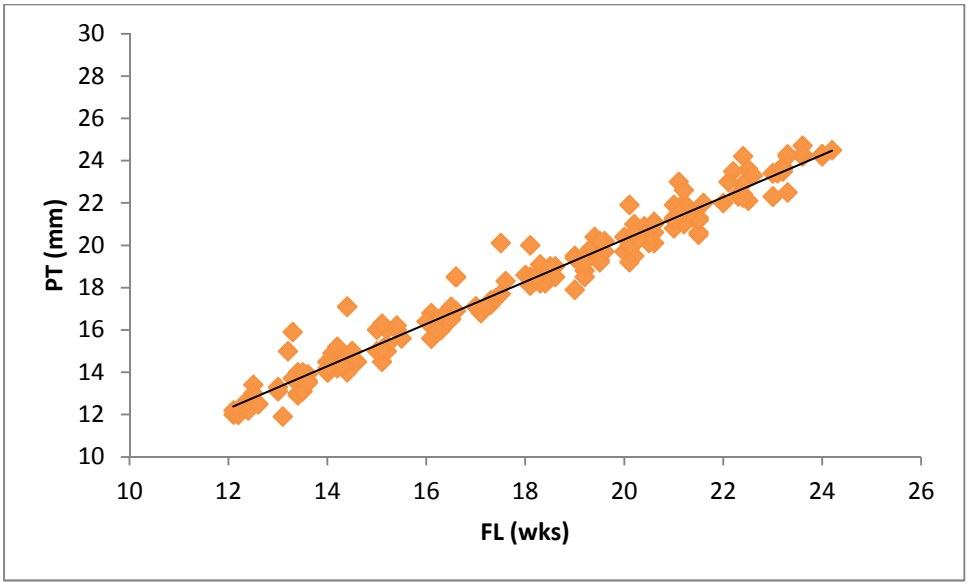


Figure 29: Shows that mean of Femur Length (in weeks) was significantly different with the mean of Placental Thickness (in mm) and showing significant positive correlation with Placental Thickness (in mm).

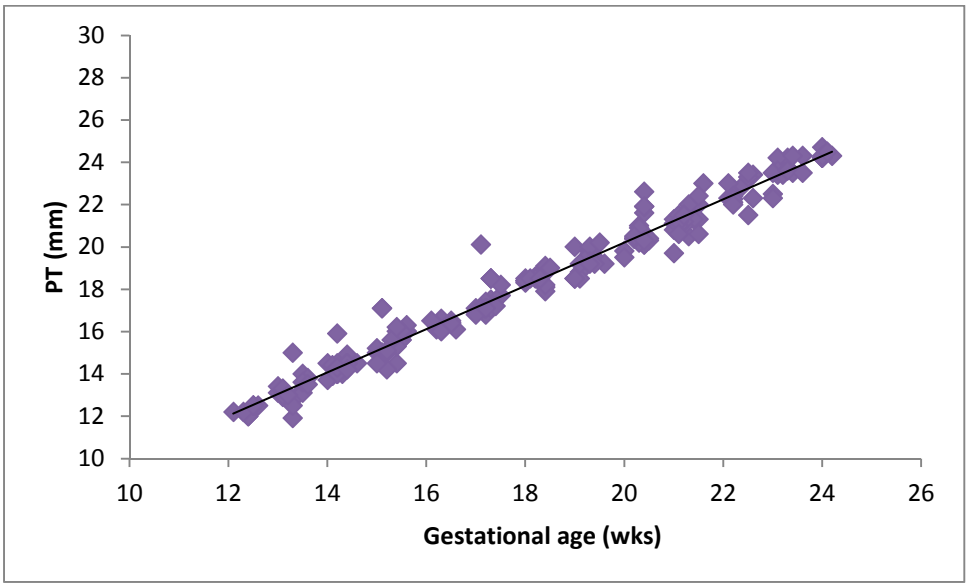


Figure 30: Shows that mean of Gestational age (in weeks) was significantly different with the mean of Placental Thickness (in mm) and showing significant positive correlation with Placental Thickness (in mm).

TABLE & FIGURE OF CORRELATION AND COMPARISON OF MEAN BIPARIETAL DIAMETER AND PLACENTAL THICKNESS BY GESTATIONAL AGE (IN WKS)

Gestational Age (Wks)	Biparietal Diameter		Placental Thickness		t test p value	Correlation	p value
	Mean	SD	Mean	SD			
12	12.83	0.40	12.27	0.23	0.013*	-0.34	0.365
13	13.38	0.33	13.27	0.70	0.591	0.08	0.783
14	14.40	0.33	14.32	0.47	0.361	0.59	0.006*
15	15.53	0.51	15.54	0.78	0.955	0.35	0.118
16	16.45	0.37	16.35	0.20	0.462	-0.07	0.836
17	17.30	0.24	17.62	0.88	0.155	0.06	0.829
18	18.29	0.46	18.50	0.34	0.173	0.12	0.677
19	19.12	0.55	19.27	0.55	0.179	0.68	0.002*
20	20.21	0.46	20.67	0.78	0.027*	0.10	0.668
21	21.26	0.51	21.27	0.70	0.930	0.29	0.210
22	22.35	0.39	22.57	0.60	0.314	-0.03	0.930
23	23.28	0.75	23.58	0.58	0.215	0.11	0.698
24	23.36	0.30	24.34	0.19	0.001*	0.21	0.652

*Note: *Significant at 5% level of significance*

Table 11: Majority of the women in GA of 13^{th}, 14^{th}, 15^{th}, 17^{th}, 18^{th}, 19^{th}, 20^{th}, 21^{st}, 23^{rd} & 24^{th} weeks had positive correlation of BPD (in weeks) with PT (in mm). Gestational age of 14^{th} & 19^{th} weeks showed statistically significant positive correlation. Except in GA of 12^{th}, 16^{th} & 22^{nd} weeks which showed negative correlation of less than 1mm w.r.t GA (in weeks).

It was found that the mean difference between the BPD and PT during the GA of 12^{th}, 20^{th} & 24^{th} weeks was statistically significant.

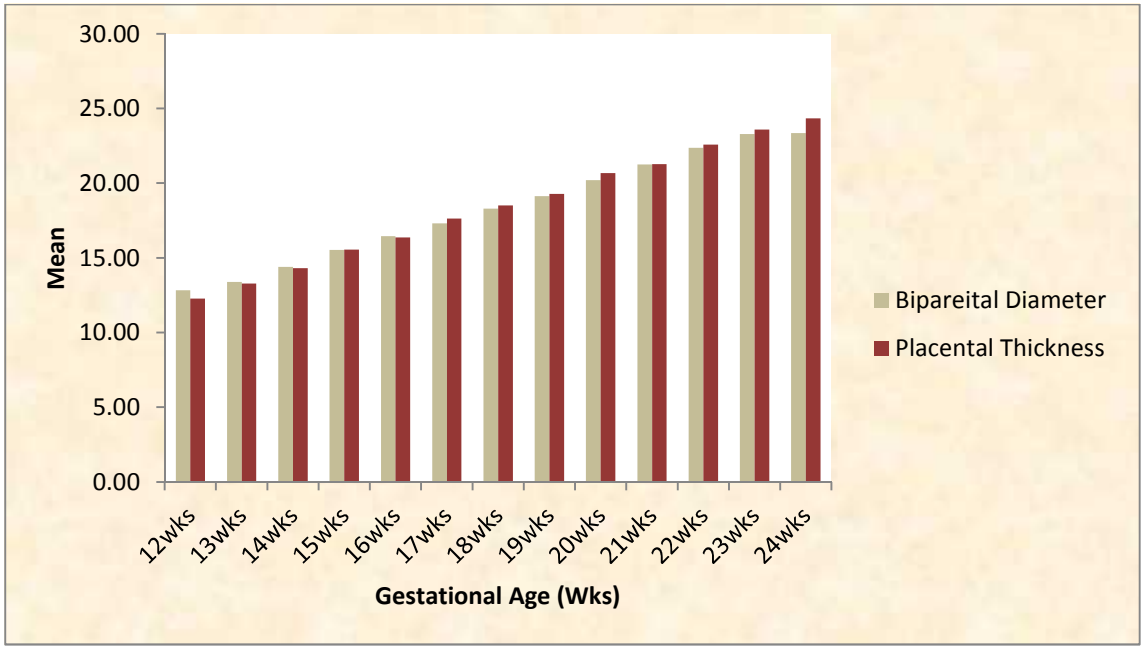


Figure 31: Illustrates the mean of Biparietal Diameter (in weeks) with Placental Thickness (in mm) by gestational age (weeks).

TABLE & FIGURE OF CORRELATION AND COMPARISON OF MEAN HEAD CIRCUMFERENCE AND PLACENTAL THICKNESS BY GESTATIONAL AGE (IN WKS)

Gestational Age (Wks)	Head Circumference		Placental Thickness		t test p value	Correlation	p value
	Mean	SD	Mean	SD			
12	12.68	0.50	12.27	0.23	0.099	-0.56	0.115
13	13.31	0.27	13.27	0.70	0.858	0.17	0.548
14	14.34	0.26	14.32	0.47	0.818	0.24	0.314
15	15.27	0.49	15.54	0.78	0.107	0.43	0.053
16	16.24	0.39	16.35	0.20	0.408	-0.11	0.758
17	17.25	0.32	17.62	0.88	0.115	0.06	0.833
18	18.19	0.53	18.50	0.34	0.072	0.14	0.643
19	19.22	0.24	19.27	0.55	0.701	0.23	0.358
20	20.32	0.39	20.67	0.78	0.072	0.17	0.488
21	21.20	0.41	21.27	0.70	0.634	0.35	0.120
22	22.40	0.31	22.57	0.60	0.384	0.07	0.818
23	22.99	0.42	23.58	0.58	0.008*	-0.06	0.835
24	23.86	0.43	24.34	0.19	0.053	-0.38	0.400

*Note: *Significant at 5% level of significance*

Table 12: Majority of the women in GA of 13^{th}, 14^{th}, 15^{th}, 17^{th}, 18^{th}, 19^{th}, 20^{th}, 21^{st} & 22^{nd} weeks had positive correlation of HC (in weeks) with PT (in mm). Except in GA of 12^{th}, $16^{th,}$ 23^{rd} & 24^{th} weeks which showed negative correlation of less than 1mm w.r.t GA (in weeks).

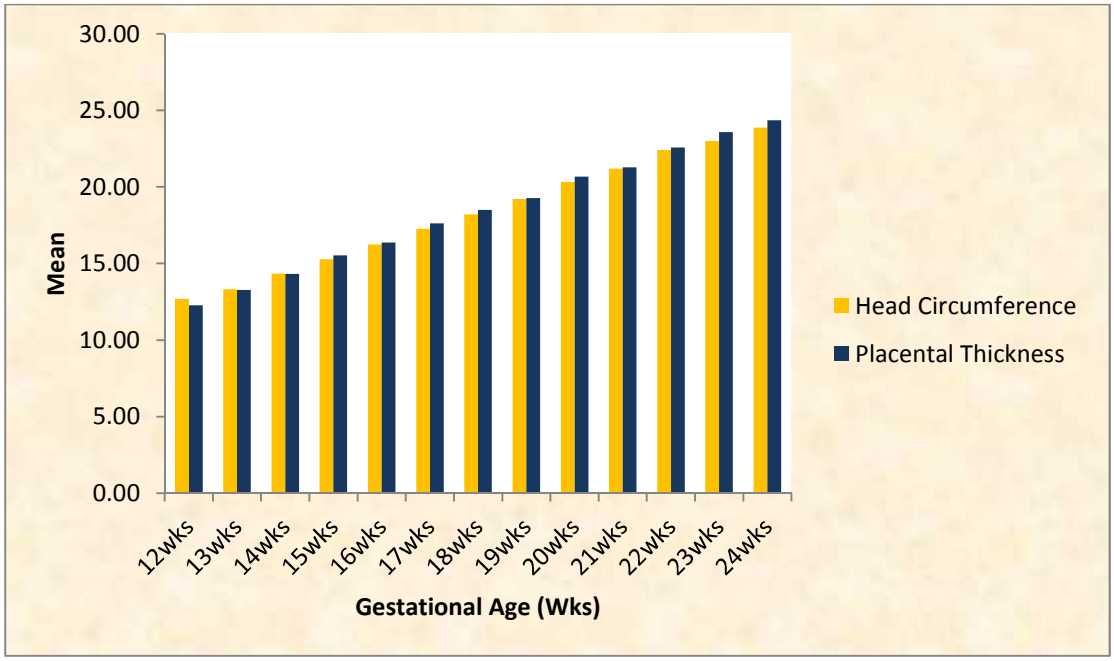


Figure 32: Illustrates the mean of Head Circumference (in weeks) with Placental Thickness (in mm) by gestational age (weeks).

TABLE & FIGURE OF CORRELATION AND COMPARISON OF MEAN ABDOMINAL CIRCUMFERENCE AND PLACENTAL THICKNESS BY GESTATIONAL AGE (IN WKS)

Gestational Age (Wks)	Abdominal Circumference		Placental Thickness		t test p value	Correlation	p value
	Mean	SD	Mean	SD			
12	12.33	0.26	12.27	0.23	0.540	0.22	0.567
13	13.31	0.36	13.27	0.70	0.845	0.03	0.924
14	14.27	0.32	14.32	0.47	0.713	0.12	0.631
15	15.41	0.28	15.54	0.78	0.416	0.43	0.053
16	16.48	0.54	16.35	0.20	0.481	0.01	0.977
17	17.30	0.50	17.62	0.88	0.205	0.00	0.991
18	18.16	0.57	18.50	0.34	0.056	0.22	0.459
19	19.17	0.53	19.27	0.55	0.620	-0.23	0.366
20	20.24	0.59	20.67	0.78	0.008*	0.58	0.008*
21	21.10	0.48	21.27	0.70	0.318	0.20	0.377
22	22.27	0.18	22.57	0.60	0.117	-0.02	0.962
23	23.15	0.46	23.58	0.58	0.005*	0.56	0.029*
24	23.74	0.49	24.34	0.19	0.026	-0.10	0.840

*Note: *Significant at 5% level of significance*

Table 13: Majority of the women in GA of 12^{th}, 13^{th}, 14^{th}, 15^{th}, 16^{th}, 17^{th}, 18^{th}, 20^{th}, 21^{st} & 23^{rd} weeks had positive correlation of AC (in weeks) with PT (in mm). Gestational age of 20^{th} & 23^{rd} weeks showed statistically significant positive correlation.

Except in GA of 19^{th}, 22^{nd} & 24^{th} weeks which showed negative correlation of less than 1mm w.r.t GA (in weeks).

It was found that the mean difference between the AC and PT during the GA of 20^{th} & 23^{rd} weeks was statistically significant.

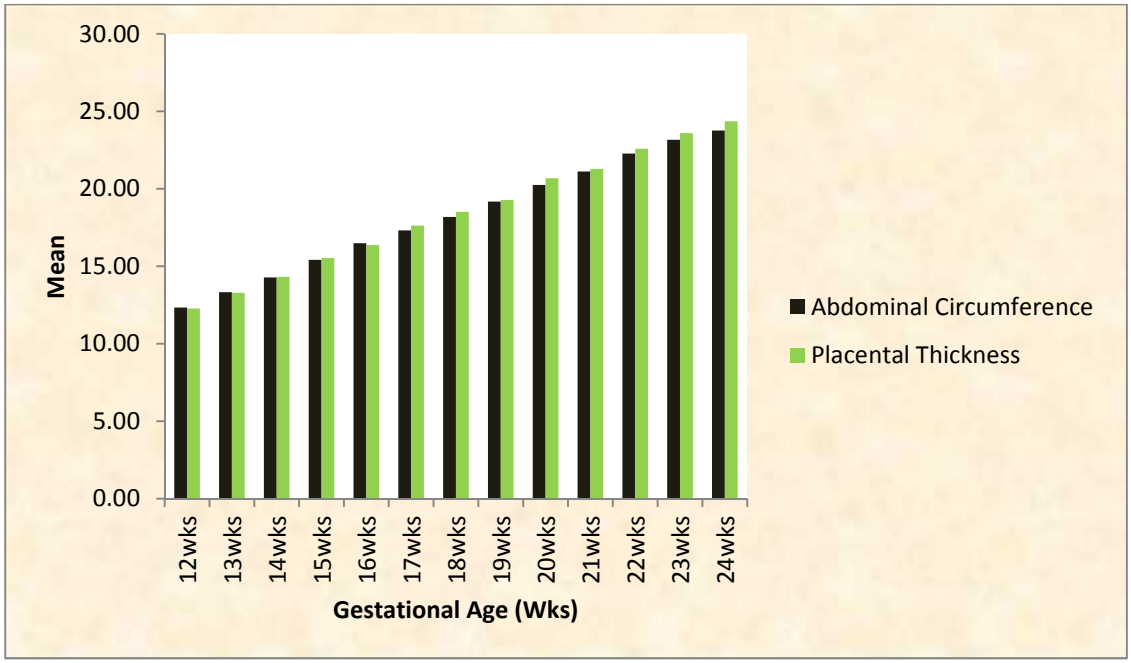


Figure 33: Illustrates the mean of Abdominal Circumference (in weeks) with Placental Thickness (in mm) by gestational age (weeks).

TABLE & FIGURE OF CORRELATION AND COMPARISON OF MEAN FEMUR LENGTH AND PLACENTAL THICKNESS BY GESTATIONAL AGE (IN WKS)

Gestational Age (Wks)	Femur Length		Placental Thickness		t test p value	Correlation	p value
	Mean	SD	Mean	SD			
12	12.33	0.20	12.27	0.23	0.195	0.80	0.010*
13	13.18	0.39	13.27	0.70	0.615	0.27	0.330
14	13.96	0.35	14.32	0.47	0.015*	-0.04	0.884
15	15.07	0.61	15.54	0.78	0.029*	0.16	0.494
16	16.26	0.14	16.35	0.20	0.194	0.25	0.462
17	17.04	0.52	17.62	0.88	0.016*	0.25	0.325
18	18.28	0.34	18.50	0.34	0.107	0.01	0.982
19	19.14	0.58	19.27	0.55	0.385	0.42	0.080
20	20.35	0.45	20.67	0.78	0.036*	0.58	0.008*
21	21.19	0.54	21.27	0.70	0.521	0.56	0.009*
22	22.40	0.52	22.57	0.60	0.192	0.72	0.006*
23	23.08	0.45	23.58	0.58	0.011*	0.20	0.482
24	23.76	0.32	24.34	0.19	0.005*	0.09	0.846

*Note: *Significant at 5% level of significance*

Table 14: Majority of the women in GA of 12^{th}, 13^{th}, 15^{th}, 16^{th}, 17^{th}, 18^{th}, 19^{th}, 20^{th}, 21^{st} , 22^{nd} , 23^{rd} & 24^{th} weeks had positive correlation of FL (in weeks) with PT (in mm). Gestational age of 12^{th}, 20^{th}, 21^{st} & 22^{nd} weeks showed statistically significant positive correlation.

Except in GA of 14^{th} week which showed negative correlation of less than 1mm w.r.t GA (in weeks).

It was found that the mean difference between the FL and PT during the GA of 14^{th}, 15th, 17^{th}, 20^{th}, 23^{rd} & 24^{th} weeks was statistically significant.

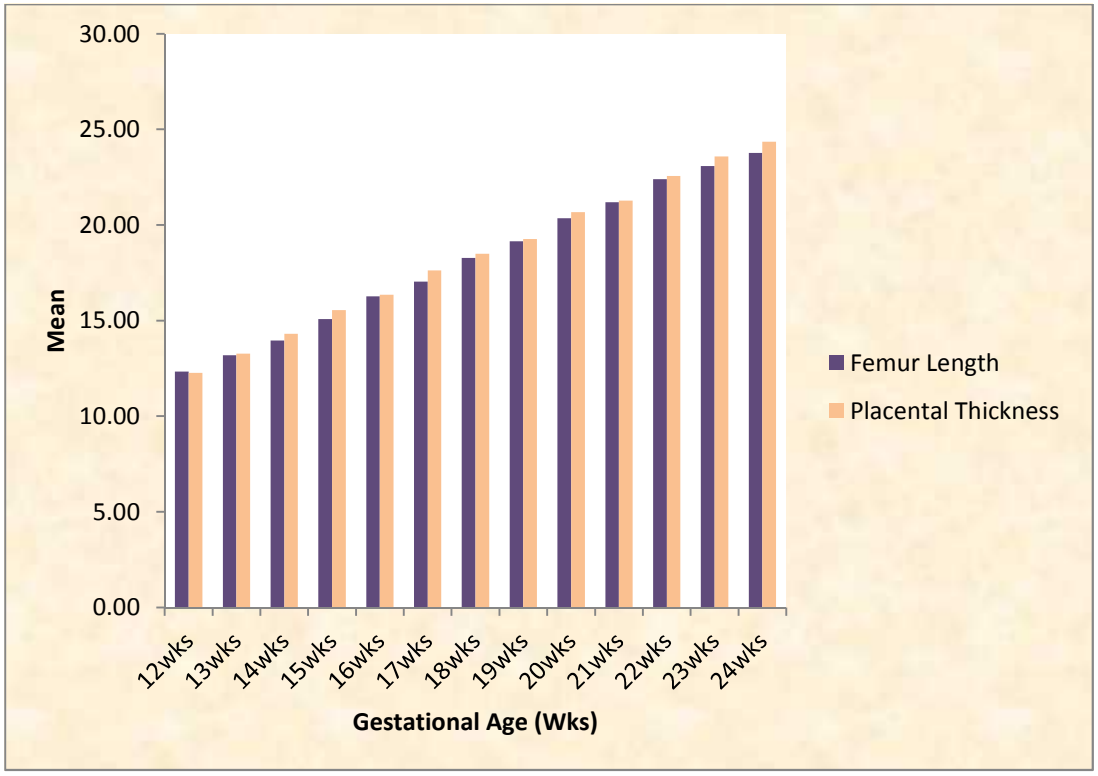


Figure 34: Illustrates the mean of Femur Length (in weeks) with Placental Thickness (in mm) by gestational age (weeks).

REPRESENTIVE CASES

CASE 1

1) NAME :

2) **AGE :**

3) BP : 130 / 80 mm Hg

4) **Hb% :** 13.8 gm/dl

5) BAD OBSTETRIC HISTORY IF ANY : nil

6) CALCULATION OF GESTATIONAL AGE

a) BPD

18 wk 1 day **Average: 18 wk 4 days**

18 wk 5 day

19 wk 0 day

b) HC

18 wk 4 days **Average: 18 wk 5 days**

18 wk 5 days

19 wk 2 days

c) AC

19 wk 0 days **Average: 19 wk 0 days**

18 wk 5 days

19 wk 2 days

d) **FL** 19 wk 0 days **Average: 19 wk 2 days**

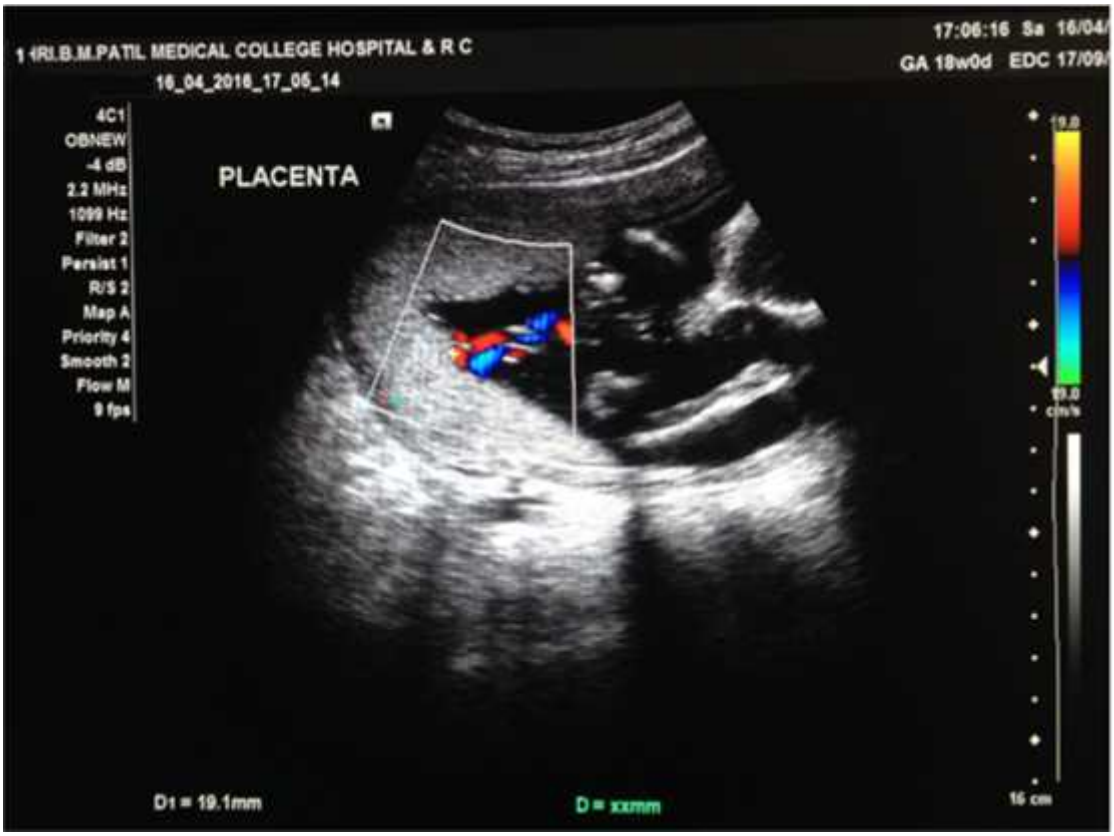
19 wk 2 days

19 wk 3 days

7) PLACENTAL LOCATION : Fundal

8) AVERAGE GESTATIONAL AGE : 19 week 0 days

9) AVERAGE PLACENTAL THICKNESS : 19.1 mm


1 (R)L.B.M.PATIL MEDICAL COLLEGE HOSPITAL & R C
16_04_2016_17_05_14
17:06:16 Sa 16/04/
GA 18w0d EDC 17/09/
4C1
OBNEW
-4 dB
2.2 MHz
1099 Hz
Filter 2
Persist 1
R/S 2
Map A
Priority 4
Smooth 2
Flow M
9 fps
PLACENTA
19.0
19.0
cm/s
D1 = 19.1mm
D = xxmm
16 cm

CASE 2

1) NAME :

2) AGE :

3) **BP :** 110 / 78 mm Hg

4) **Hb% :** 14.1 gm/dl

5) BAD OBSTETRIC HISTORY IF ANY : nil

6) CALCULATION OF GESTATIONAL AGE

e) BPD

17 wk 4 day **Average: 17 wk 5 days**

17 wk 5 day

17 wk 6 day

f) HC

17 wk 5 day **Average: 17 wk 4 days**

17 wk 4 day

17 wk 3 day

g) AC

17 wk 6 day **Average: 17 wk 5 days**

17 wk 5 day

17 wk 5 day

h) FL

18 wk 1 day **Average: 18 wk 0 days**

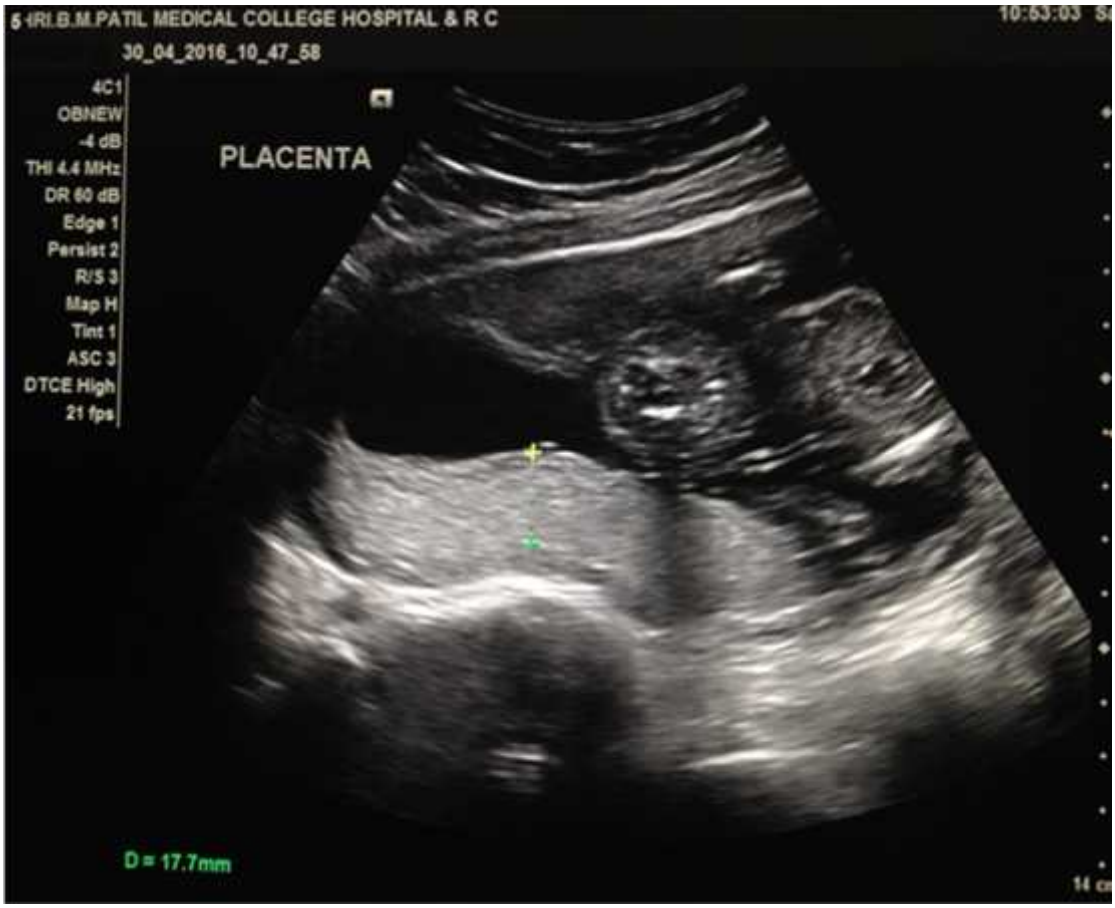
17 wk 6 day

18 wk 1 day

7) PLACENTAL LOCATION : Posterior

8) AVERAGE GESTATIONAL AGE : 17 week 6 days

9) AVERAGE PLACENTAL THICKNESS : 17.7 mm


RI.B.M.PATIL MEDICAL COLLEGE HOSPITAL & R C
30_04_2016_10_47_58
4C1
OBNEW
-4 dB
THI 4.4 MHz
DR 60 dB
Edge 1
Persist 2
R/S 3
Map H
Tint 1
ASC 3
DTCE High
21 fps
PLACENTA
D = 17.7mm

CASE 3

1) **NAME :**
2) **AGE :**
3) **BP :** 120 / 80 mm Hg
4) **Hb% :** 14 gm/dl
5) **BAD OBSTETRIC HISTORY IF ANY :** nil
6) **CALCULATION OF GESTATIONAL AGE**

i. **BPD**

18 wk 1 day — **Average: 18 wk 0 days**

17 wk 5 day

17 wk 6 day

ii. **HC**

18 wk 1 day — **Average: 18 wk 2 days**

18 wk 3 day

18 wk 0 day

iii. **AC**

17 wk 4 day — **Average: 17 wk 5 days**

18 wk 2 day

17 wk 6 day

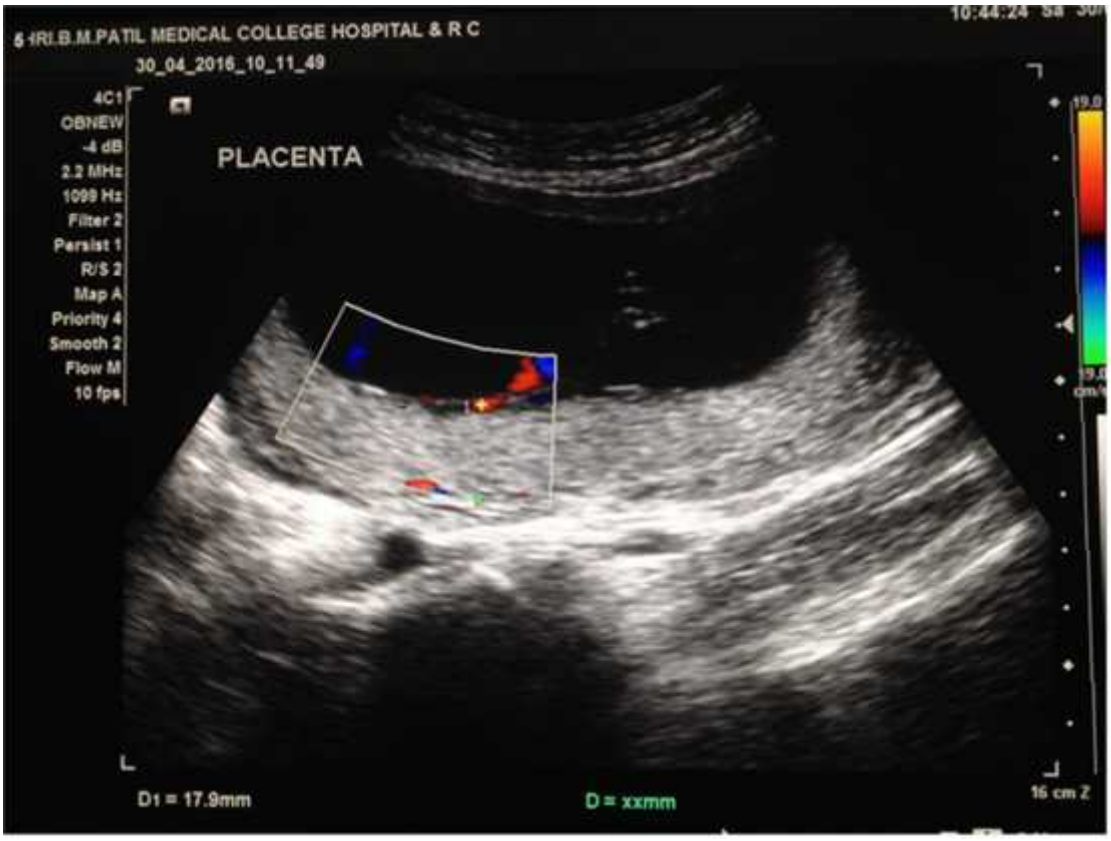
iv. **FL**

18 wk 1 day — **Average: 18 wk 0 days**

17 wk 5 day

18 wk 0 day

7) **PLACENTAL LOCATION : Posterior**
8) **AVERAGE GESTATIONAL AGE : 18 week 1 day**
9) **AVERAGE PLACENTAL THICKNESS : 17.9 mm**


IRLB.M.PATIL MEDICAL COLLEGE HOSPITAL & R C
30_04_2016_10_11_49
4C1
OBNEW
-4 dB
2.2 MHz
1099 Hz
Filter 2
Persist 1
R/S 2
Map A
Priority 4
Smooth 2
Flow M
10 fps
PLACENTA
D1 = 17.9mm
D = xxmm
16 cm 2

CASE 4

1) **NAME :**
2) **AGE :**
3) **BP :** 110 / 80 mm Hg
4) **Hb% :** 14.5 gm/dl
5) **BAD OBSTETRIC HISTORY IF ANY :** nil
6) **CALCULATION OF GESTATIONAL AGE**

i. **BPD**

20 wk 4 day — **Average: 20 wk 5 days**

20 wk 5 day

20 wk 5 day

ii. **HC**

20 wk 2 day — **Average: 20 wk 2 days**

20 wk 3 day

20 wk 0 day

iii. **AC**

20 wk 0 day — **Average: 20 wk 3 days**

20 wk 2 day

20 wk 3 day

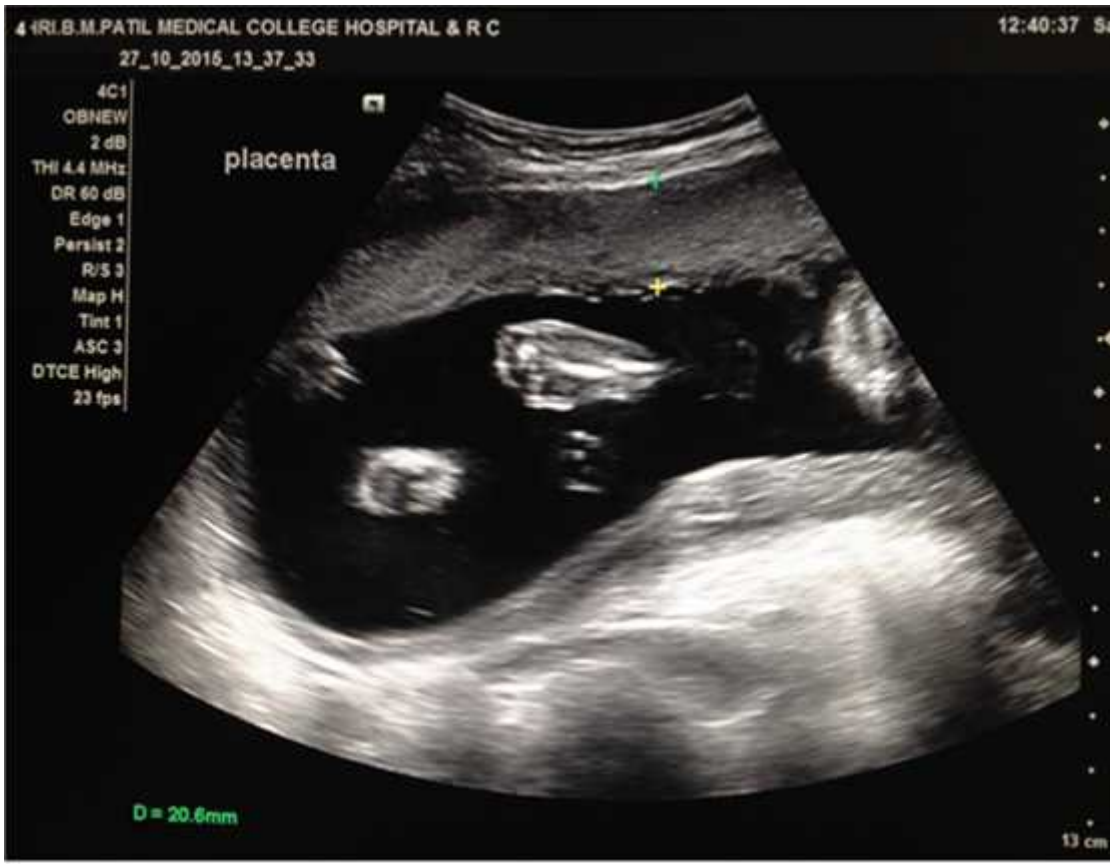
iv. **FL**

20 wk 5 day — **Average: 20 wk 5 days**

20 wk 5 day

20 wk 4 day

7) **PLACENTAL LOCATION : Anterior**
8) **AVERAGE GESTATIONAL AGE : 20 week 5 days**
9) **AVERAGE PLACENTAL THICKNESS : 20.6 mm**


4 IRI.B.M.PATIL MEDICAL COLLEGE HOSPITAL & R C
12:40:37
27_10_2015_13_37_33
4C1
OBNEW
2 dB
THI 4.4 MHz
DR 60 dB
Edge 1
Persist 2
R/S 3
Map H
Tint 1
ASC 3
DTCE High
23 fps
placenta
D = 20.6mm
13 cm

CASE 5

1) **NAME :**
2) **AGE :**
3) **BP : 120 / 80 mm Hg**
4) **Hb% : 13.7 gm/dl**
5) **BAD OBSTETRIC HISTORY IF ANY : nil**
6) **CALCULATION OF GESTATIONAL AGE**

i. **BPD**

22 wk 4 day — **Average: 22 wk 5 days**

23 wk 0 day

22 wk 5 day

ii. **HC**

23 wk 1 day — **Average: 23 wk 0 days**

23 wk 3 day

22 wk 4 day

iii. **AC**

23 wk 4 day — **Average: 23 wk 3 days**

23 wk 3 day

23 wk 3 day

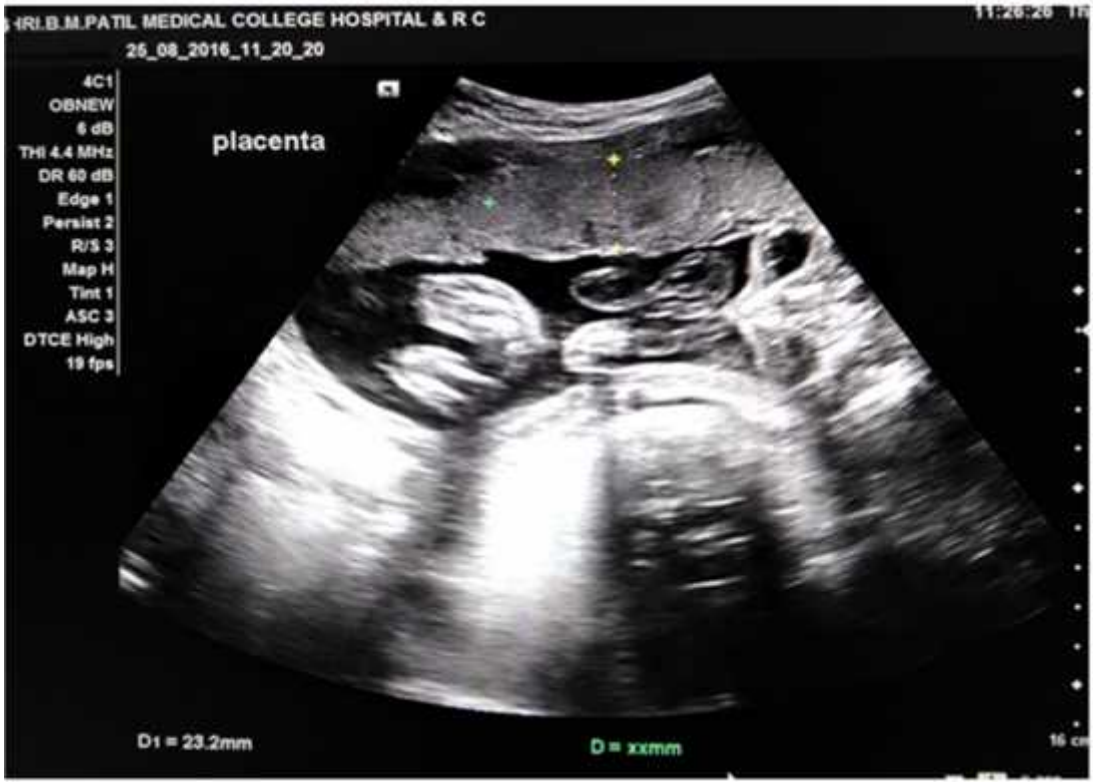
iv. **FL**

23 wk 4 day — **Average: 23 wk 4 days**

23 wk 5 day

23 wk 4 day

7) **PLACENTAL LOCATION : Anterior**
8) **AVERAGE GESTATIONAL AGE : 23 week 4 days**
9) **AVERAGE PLACENTAL THICKNESS : 23.2 mm**


4RI.B.M.PATIL MEDICAL COLLEGE HOSPITAL & R C
25_08_2016_11_20_20
4C1
OBNEW
6 dB
THI 4.4 MHz
DR 60 dB
Edge 1
Persist 2
R/S 3
Map H
Tint 1
ASC 3
DTCE High
19 fps
placenta
D1 = 23.2mm
D = xxmm

DISCUSSION

In our study we adopted a prospective cross sectional design and did not follow the patients longitudinally.

PLACENTAL THICKNESS & ITS CORRELATION WITH BIPARIETAL DIAMETER (BPD), HEAD CIRCUMFERENCE (HC), ABDOMINAL CIRCUMFERENCE (AC), FEMUR LENGTH (FL) & GESTATIONAL AGE (GA) IN DIFFERENT LOCATIONS OF PLACENTA.

Placenta was first identifiable at 8 – 9 menstrual weeks as a focal thickening of the chorio-decidual reaction.

Correct identification of the placental – myometrial interface should also preclude the illusion of placental thickening induced by focal myometrial thickening. Since the placenta is passive structure lacking the capacity to expand focally, measurement of the placental thickness at any point, except near its edge yields the same results.

Placental thickness appears focally increased over uterine contractions. The myometrium and subplacental veins were excluded in the study.[6]

Anterior location: In our study, the majority of the placenta was anterior in location. Anterior located placenta was reliable in measurement as the placental – myometrial surface was clearly delinated. Length of the placental insertion is also one of the factors for placental thickness to be thick and thin in nature. If the length of the placental insertion is long then the placenta is usually extended from one endometrial surface to another (antero-fundal, antero-lateral) while the short placental thickness were limited to one endometrial surface (anterior).[6]

Anterior placenta showed significant correlation with the placental thickness from 12 – 24 weeks of gestation with the p value of <0.001.

Posterior location: In our study, next common location of the placenta was posterior. Care was taken at the time of the measurement to reduce the reverberation artefact from the fetal spine, changing the fetal position and taking the measurements, proper technique of visualization was done.[6]

Posterior placenta also showed significant correlation with the placental thickness from 12 – 24 weeks of gestation with the p value of <0.001.

Fundal location: Fundal placenta also showed significant correlation with the placental thickness from 12 – 24 weeks of gestation with the p value of <0.001.

Lateral location: We found that lateral location of the placenta was more accurate in determining the placental thickness compared to other location and had a strong correlation of PT with GA, BPD, HC, AC & FL. However the sample size included less no of cases (2.5%) in lateral location of the placenta which should be confirmed by larger no of sample size in this location.

Lateral placenta also showed significant correlation with the placental thickness from 12 – 24 weeks of gestation with the p value of <0.001.

Hoddick *et al,,*[6] study showed that the placental location was irrelevant for estimating the GA.

In a similar study conducted by **Dr. P. Pranesh *et al,,***[44] they found that placental thickness did not vary with location of the placenta.

In our observational study placental location did not show any significant variation in the placental thickness (PT).

PLACENTAL LOCATION:

In the study conducted by **Dr. P. Pranesh *et al,,*** [44] in 200 antenatal women of all gestational ages from 11 weeks to 40 weeks of gestation in Department of Radiodiagnosis, Rajah Muthiah Medical College & Hospital, Annamalai University, Annamalainagar. They observed 36% anterior location of the placenta, 24% in fundal position, 22.5% in posterior & 17.5% of the cases lateral position and showed no significant variation in placental thickness with respect to location of the placenta.

Lovely Kaushal *et al,,* [43] studied 199 normal antenatal women in Department of Radiodiagnosis, Gandhi medical college and Hamidia hospital, Bhopal. This cross-sectional study showed 30% anterior placenta, 29% posterior placenta, 23% fundal placenta and 18% lateral placenta.

Hoddick *et al,,* [6] studied 200 normal singleton pregnancies in Department of radiology, University of California school of medicine, San Francisco, California. This retrospective study showed 46% cases of posterior placenta and showed no significant variation in placental thickness with respect to location of the placenta.

Ridhi Adhikari *et al,,* [46] studied 150 normal antenatal women in Department of Obstetrics and Gyaenocology, College of Medical Sciences & Teaching Hospital, Bharatpur, Nepal. In this prospective cross sectional study majority of placenta were posterior in location (46%), followed by anterior (36%), fundal (11%), and 7% cases in lateral positions.

Anu Kapoor *et al,,* [42] studied 310 normal singleton pregnancies in Department of Radiodiagnosis, Nizam's Institute of Medical Sciences, Hyderabad , Telangana. This prospective study showed majority of placenta were fundal in location (41.3%), followed by anterior (27%), posterior (25.5%) and lateral locations (6.2%).

In the present study, it was found that majority of the placenta were anterior in location (38.3%) followed by posterior (36.8%), fundal (22.4%) and lateral (2.5%) locations. however thickness of the placenta did not vary relative to the placental location.

AGE WISE DISTRIBUTION OF CASES:

Dr. P. Pranesh *et al,,* [44] studied 200 antenatal women of all gestational ages from 11 weeks to 40 weeks of gestation in Department of Radio diagnosis, Rajah Muthiah Medical College & Hospital, Annamalai University, Annamalainagar. Their prospective cross sectional study showed mean age group of 20 -25 yrs (46.5%).

Lovely Kaushal *et al,,* [43] studied 199 normal antenatal women in Department of Radiodiagnosis, Gandhi medical college and Hamidia hospital, Bhopal. Their cross-sectional study showed mean age of 20 to 25 yrs.

Anu Kapoor *et al,,* [42] studied 310 normal singleton pregnancies in Department of Radiodiagnosis, Nizam's Institute of Medical Sciences, Hyderabad , Telangana. Their prospective study showed majority of cases from 21 years to 25 years with mean age of 23 years.

Ridhi Adhikari *et al,,* [46] studied 150 normal antenatal women in Department of Obstetrics and Gynaecology, College of Medical Sciences & Teaching Hospital, Bharatpur, Nepal. In this prospective cross sectional study majority of antenatal women were in the age group between 20 and 30 years with mean age of 22.64 years.

Ganjoo S *et al,,* [50] studied 300 antenatal patients, 100 each in first, second, and third trimester, in the Department of Obstetrics and Gynecology, SMGS Hospital, Government Medical College, Jammu. It was observed that the majority of the age group was from 23 – 27 yrs.

Aisha Kiran *et al,,* [40] studied 200 antenatal women in 2nd and 3rd trimester in Department of Radio diagnosis, Military hospital, AFIRI Rawalpindi. Mean age of the antenatal women included in the study was 25.43±2.63 years.

In the present study group of 201 normal antenatal women, the age ranged between 18 yrs to 37 years. It was found that majority of the antenatal women belonged to 21 – 25 yrs (73.6%) which is similar to study conducted by **Dr. B. Venkateswarlu *et al,,*** [41] which showed majority where between the age group of 20 – 25 yrs (48%).

As in our hospital setup and the place we studied, most of the antenatal women were from rural background with early marriages. Hence in our study the majority of the antenatal women belonged to 21 – 25 yrs of age.

GESTATIONAL AGE (IN WKS) WISE DISTRIBUTION OF CASES:

In our study of 201 antenatal women we observed majority of cases in 14^{th} (10%), 15^{th} (10.4%) and 21^{st} (10.4%) weeks of gestation. Least cases were seen in 24 weeks of gestation.

PLACENTAL LOCATION IN DIFFERENT AGE GROUPS:

In our study we observed that anterior location (42.4%) of the placenta is most common in 26 – 30 yrs age gp, followed by posterior (41.2%) in 21 – 25 yrs age gp, fundal (33.3%) in 26 – 30yrs & also in >30 yrs age group and lateral (33.3%) in more than 30 yrs age group.

PLACENTAL THICKNESS AND ITS CORRELATION WITH GESTATIONAL AGE (GA), BIPARITAL DIAMETER (BPD), HEAD CIRCUMFERENCE (HC), ABDOMINAL CIRCUMFERENCE (AC) & FEMUR LENGTH (FL) IN 12 – 24 WEEKS OF GESTATION:

In the study conducted by **Ridhi Adhikari *et al,,*** [46] on 150 normal antenatal women in Department of Obstetrics and Gyaenocology, College of Medical Sciences & Teaching Hospital, Bharatpur, Nepal. They observed significant positive correlation between placental thickness and FL, BPD and AC in the second & third trimesters; with all parameters having identical relationships with placental thickness.

Aisha Kiran *et al,,* [40] studied 200 antenatal women in 2nd and 3rd trimester in Department of Radiodiagnosis, Military hospital, AFIRI Rawalpindi. Study showed strong positive correlation between placental thickness and gestational age in second trimester ($r = 0.985$ and $p = 0.0005$).

Anna J. Lee *et al,,* [52] studied 114 normal antenatal women in second trimester between 18 weeks 1 day and 22 weeks 6 days in Victoria, Australia. This pilot study showed mean placental thickness to be 24.6 (SD, 7.29) mm.

Ohagwu CC *et al,,* [53] studied 666 antenatal women in the Department of Radiology and Department of Obstetrics and Gynaecology, Federal Medical Centre, Makurdi Benue State, Nigeria in the second and third trimesters of pregnancies. The cross sectional prospective study showed statistical significance of placental thickness with biparietal diameter & abdominal circumference with Pearson's value of < 0.01 between the variables.

Mital P *et al,,* [16] studied 600 normal antenatal women of all gestational ages in Department of Obstetrics and Gynecology, S.M.S. Medical College, Jaipur (Rajasthan). They observed linear increase of placental thickness which was found to

correlate with gestational age throughout the pregnancy where exact duration of pregnancy was not known (especially between the 22ndweek and 35th week). The correlation co-efficent and p-value were similar to our study.

Tsonge *et al,,* [49] studied on 333 normal pregnant women with singleton pregnancies between 8 and 20 weeks of gestation, found that the mean placental thickness between 18-21 weeks in normal pregnant women and in pregnancies with Hb barts disease were 24.6 + 5.2mm and 34.5 + 6.7mm respectively.

Baghel P *et al,,* [47] conducted a prospective observational longitudinal study on 100 pregnant antenatal women starting from 24 weeks and were followed up at 32 weeks, 36 weeks in the Department of Obstetrics and Gyanecology in collaboration with the Departments of Radio diagnosis and Pediatrics in Kasturba Hospital, BHEL Bhopal. They observed at 24 weeks of gestation the mean placental thickness was 24.5 mm which is closely correlating with the gestational age. It also showed correlation of placental thickness with BPD, FL and AC. They concluded as linear direct relationship of the placental thickness with gestational age in 24 weeks.

In the prospective cross sectional study conducted by **T Karthikeyan *et al,,*** [49] on 211 antenatal women in Sree Balaji Medical College and Hospital, Bharat University, Chennai showed placental thickness increased > 4 mm from 15^{th} to 20^{th} week, increased by > 5mm from 20^{th} to 25^{th} week. Placental thickness was decreased by 0.85 mm between 19^{th} to 20^{th} week and decreased by 0.97mm between 22^{nd} to 23^{rd} weeks.

Khatri *et al,,* [55] studied 100 pregnant females in P.N.S. Shifa Hospital, Karachi 2004. They observed that the placental thickness measured 16mm at 12 weeks of gestation to 25 mm at 24 weeks of gestation.

Tanawattancharoen *et al,,* [59] reported less variation in placental thickness at gestational age between 18 and 41 weeks.

In the prospective study conducted by **Natwar Lal Agrawal** [45] on 100 antenatal singleton pregnancies of >15 weeks of gestation, observed significant correlation between placental thickness and Femur Length with gestational age from 21st to 25th week & early 3rd trimester. Their study showed fairly linear relationship between placental thickness and Femur Length with gestational age and provides an accurate parameter for estimating fetal gestational age especially from 21st to 25th week. It also showed linear growth pattern between placental thickness and biparietal diameter in from 21st to 25th week and early 3rd trimester. They concluded as PT is a reliable parameter in assessment of gestational age in cases of unknown LMP.

PLACENTAL THICKNESS NOT CORRELATING WITH GESTATIONAL AGE (IN WEEKS):

Mital P *et al,,* [16] observed that from 10 to 21 weeks of gestation, PT was slightly higher than GA by 1-4 mm, from 22 to 35 weeks almost matched GA in weeks, thereafter up to term PT was lower than GA by 1-2 mm.

Jain *et al,,* [17] observed that from 10 to 25 weeks, the PT was higher than GA by 1-5 mm, they matched almost equally between GA of 27 and 33 weeks, after which they were slightly lower than GA by 1-3 mm up to term

Tongsong and Boonyanurak [56] in their study showed an increase in PT from 8.4 ± 2.5 mm at 8 weeks to 21.8 ± 3.3 mm at 20 weeks of gestation.

Ohagwu CC *et al,,* [53] showed an increase in PT from 10 ± 1.2 mm at 10 weeks to 43 ± 5.3 mm at 40 weeks of gestation.

Biparietal diameter (BPD) correlated well with GA from 12 – 24 weeks except for 12th, 16th & 22nd week which showed negative correlation with decrease in thickness which was less than 1mm w.r.t gestational age (in wks).

Head circumference (HC) correlated well with GA from 12 – 24 weeks except for 12th, 16th, 23rd & 24th week which showed negative correlation with decrease in thickness which was less than 1mm w.r.t gestational age (in wks).

Abdominal circumference (AC) correlated well with GA from 12 – 24 weeks except for 19th, 22nd & 24th week which showed negative correlation with decrease in thickness which was less than 1mm w.r.t gestational age (in wks).

Femur length (FL) correlated well with GA from 12 – 24 weeks except for 14th week which showed negative correlation with decrease in thickness which was less than 1mm w.r.t gestational age (in wks) w.r.t gestational age (in wks).

In the second trimester, the measurements obtained by **Ohagwu CC *et al,,*** [53] were about 5-7 mm higher and observed that PT in millimeters equaled GA only at 10 and 11 weeks of gestation and observed no trend thereafter.

Mital P *et al,,* [16], **Jain *et al,,*** [17] and **Tongsong and Boonyanurak** [56] studies all showed increase in the placental thickness by 1 – 5 mm in second trimester.

In the study conducted by **Aditi tiwari *et al,,*** [51] which showed placental thickness was higher by 1-4 mm than the GA upto 21 weeks, later from 22 weeks it was lower by 1- 2 mm.

In our series also we have come across similar situation and observed placental thickness (PT) was directly matching the gestational age (GA), biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC) & femur length (FL) with variation of less than 1 mm except in few weeks of gestation which was correlating with **Aditi tiwari *et al,,*** [51] from 22 to 24 weeks of gestation.

It was evident that placental thickness (PT) is in a linear relationship with gestational age (GA).

We observed that there was strong positive correlation between biparietal diameter, femur length and gestational age with placental thickness ($p = < 0.001$) with mean placental thickness of 18.33 mm (SD: 3.56) in second trimester.

We also observed biparietal diameter (BPD) and femur length (FL) correlated well with GA from 12 – 24 weeks except for few weeks as explained above.

In our study, we concluded that the placental thickness was correlating well with the GA, BPD, AC, HC & FL, with the placental thickness almost matching the gestational weeks with variation of less than 1 mm in diameter w.r.t gestational age (in wks).

The present study assessed the ultrasonographic measurement of placental thickness (in mm) and its correlation with gestational age (in weeks) in second trimester (12 to 24 weeks). The study showed that the placental thickness (in mm) correlated with increasing gestational age (in weeks) in a linear & direct fashion, almost matching the gestational age from 12 to 24 weeks of gestation.

CONCLUSIONS

- In our study placental thickness correlated well with the gestational age, BPD & FL in second trimester (12 to 24 weeks) which was linear and direct.
- Placental thickness (in mm) is correlating well with estimated gestational age (in weeks) from 12 to 24 weeks of gestation.
- The relationship of Placental thickness with biparietal diameter (BPD) is matching from 12 to 24 weeks of gestation.
- The relationship of Placental thickness with femur length (FL) is matching from 12 to 24 weeks of gestation.
- The thickness of the placenta and its growth pattern did not vary relative to the placental location.

LIMITATIONS

- A cross-sectional study design was used with relatively smaller sample size. So we need to correlate placental thickness with the gestational age from 12 to 14 weeks in a large group.
- In the present study we measured placental thickness only once in each subject from 12 to 24 weeks of gestation.
- The study does not depict the placental growth as we are not taking the serial measurements of the same patient throughout the second trimester. So, it may not provide a clear understanding in individual growth patterns.
- Different population groups may show different placental thickness. So a population specific reference data may be required for accurate correlation.
- Since ultrasonography was used for measurement, an intra-observer variability, instrumental bias, etc. which are inherent limitations of USG could not be overcome.

SUMMARY

In our study we intended to find out the correlation of placental thickness (PT) with gestational age (GA) in normal antenatal women from 12-24 weeks of gestation. We included 201 patients and conducted a cross-sectional study from December 2014 – June 2016. We found a significant correlation of placental thickness (PT) with the gestational age (GA), biparietal diameter (BPD) and femur length (FL) in 12 – 24 weeks of gestation. Hence we conclude that placental thickness (PT) is one of the significant parameter to assess the gestational age in second trimester.

BIBLIOGRAPHY

1. DC Dutta. Textbook of Obstetrics. 8th editio. Konar H, editor. New Delhi: Jaypee Brothers Medical Publishers Private Ltd; 2015. 106 p.
2. Mary E. Norton, Scoutt L, Feldstein VA. Ultrasonography in Obstetrics and Gynaecology. 5th ed. Callen P W, editor. Philadelphia, PA: Elsevier, a division of Reed Elsevier India Limited; 2002. 225–65 p.
3. Daftary SN, Chakravathi S. Holland and Brews- Manual of obstetrics. 16th ed. New Delhi: B.I Churchill Livingstone Pvt Ltd; 1998. 23-32 p.
4. Elsayes KM, Trout AT, Friedkin AM, Liu PS, Bude RO, Platt JF, et al. Imaging of the placenta: a multimodality pictorial review. Radiographics. 2009;29(5):1371–91.
5. Cunningham FG, Leveno KJ, Bloom SL, Hauth JC. Williams obstetrics. 22nd ed. New York, NY: McGraw Hill; 2005. 36-38 p.
6. Hoddick, William; Mahony, Barry; Callen, Peter; Filly R, Hoddick WK, Mahony BS, Callen PW, Filly RA. Placental thickness. J Ultrasound Med. 1985;4(9):479–82.
7. Elchalal U, Ezra Y, Levi Y, Bar-Oz B, Yanai N, Intrator O, et al. Sonographically thick placenta: a marker for increased perinatal risk--a prospective cross-sectional study. Placenta. 2000;21(2–3):268–72.
8. Chen M, Leung KY, Lee CP, Tang MHY, Ho PC. Placental volume measured by three-dimensional ultrasound in the prediction of fetal alpha(0)-thalassemia: a preliminary report. Ultrasound Obstet Gynecol. 2006 Aug;28(2):166–72.
9. Clapp JF 3rd, Rizk KH, Appleby-Wineberg SK, Crass JR. Second-trimester placental volumes predict birth weight at term. J Soc Gynecol Investig.

1995;2(1):19–22.

10. Hafner E, Metzenbauer M, Hofinger D, Munkel M, Gassner R, Schuchter K, et al. Placental growth from the first to the second trimester of pregnancy in SGA-foetuses and pre-eclamptic pregnancies compared to normal foetuses. Placenta. 2003 Apr;24(4):336–42.
11. Kinare AS, Natekar AS, Chinchwadkar MC, Yajnik CS, Coyaji KJ, Fall CH, et al. Low midpregnancy placental volume in rural Indian women: A cause for low birth weight? Am J Obstet Gynecol. 2000 Feb;182(2):443–8.
12. Suri S, Muttukrishna S, Jauniaux E. 2D-Ultrasound and endocrinologic evaluation of placentation in early pregnancy and its relationship to fetal birthweight in normal pregnancies and pre-eclampsia. Placenta. 2013 Sep;34(9):745–50.
13. Malhotra N, Kumar P. Ultrasound in Obstetrics and Gynaecology. 3rd editio. Mumbai: Jaypee Brothers Medical Publishers Private Ltd; 1999. 92-98-200-388 p.
14. Wolfson RN, Zador IE, Halvorsen P, Andrews B, Sokol RJ. Biparietal diameter in premature rupture of membranes: errors in estimating gestational age. J Clin Ultrasound. 1983 Sep;11(7):371–4.
15. Nyberg D, Finberg H. The placenta, placental membranes and umbilical cord. J Diagnostic Ultrasound Fetal Anomalies. 1990;21(4):623–627.
16. Mital P, Hooja N, Mehndiratta K. Placental thickness: a sonographic parameter for estimating gestational age of the fetus. Indian J Radiol Imaging. 2002;12(4):553.
17. Jain A, Kumar G, Agarwal U, Kharakwal S. Placental thickness–a sonographic indicator of gestational age. J Obs Gyne India. 2001;51(3):48–9.

18. Donald I. On launching a new diagnostic science. Am J Obstet Gynecol. 2016 Oct 5;103(5):609–28.

19. Moore KL. The developing human 4th Ed. Philadelphia, WB Saunders Co. 1988;

20. Zernlyn S. The placenta. 2nd editio. Diagnostic ultrasound. Chicago: Year book medical publishers; 1987. 839-856 p.

21. Crawford JM. A study of human placental growth with observations on the placenta in erythroblastosisfaetalis. BJOG An Int J Obstet Gynaecol. 1959 Dec 1;66(6):885–94.

22. Sadler TW. Langman's medical embryology. 12 th edit. Philadelphia, PA: Wolters Kluwer Health; 2012. 103-105 p.

23. Dutta DC. Textbook of Obstetrics. 8th editio. Konar H, editor. New Delhi: Jaypee Brothers Medical Publishers Private Ltd; 2015. 33-42 p.

24. Crawford JM. Vascular anatomy of the human placenta. Am J Obstet Gynecol. 2016 Oct 5;84(11):1543–67.

25. Rumack CM. DIAGNOSTIC ULTRASOUND. FOURTH EDI. Philadelphia, PA: Mosby, Inc., an affiliate of Elsevier Inc.; 2011. 1502 p.

26. Hamilton WJ, Boyd JD. Trophoblast in Human Utero-Placental Arteries. Nature. 1966 Nov 26;212(5065):906–8.

27. Benirschke K, Burton GJ, Baergen RN. Pathology of the Human Placenta. 6th ed. Verlag Berlin Heidelberg: Springer; 2012. 136-140 p.

28. Fox H. The placenta, membranes and umbilical cord. Turnbull s Obstet. 1995;2:45–60.

29. Gottesfeld KR, Thompson HE, Holmes JH, Taylor ES. Ultrasonic placentography--a new method for placental localization. Am J Obstet

Gynecol. 1966 Oct;96(4):538–47.

30. Kobayashi M, Hellman LM, Fillisti L. Placental localization by ultrasound. Am J Obstet Gynecol. 2016 Oct 5;106(2):279–85.

31. Dippel AL, Brown WH. Roentgen Visualization of the Placenta by Soft Tissue Technique. Am J Obstet Gynecol. 2016 Oct 5;40(6):986–94.

32. Kohorn EI, Walker RH, Morrison J, Campbell S. Placental localization. A comparison between ultrasonic compound B scanning and radioisotope scanning. Am J Obstet Gynecol. 1969 Mar;103(6):868–77.

33. Metzenbauer M, Hafner E, Hoefinger D, Schuchter K, Stangl G, Ogris E, et al. Three-dimensional ultrasound measurement of the placental volume in early pregnancy: method and correlation with biochemical placenta parameters. Placenta. 2001 Jul;22(6):602–5.

34. Spirit BA, Gordon LP, Kagan EH. The principles and practice of ultrasonography in obstetrics and gynaecology. 3rd editio. Connecticut: Applenton-century-crofts; 1985. 333-354 p.

35. Winsberg F. Echographic changes with placental ageing. J Clin Ultrasound. 1973 Mar 1;1(1):52–5.

36. Grannum PA, Berkowitz RL, Hobbins JC. The ultrasonic changes in the maturing placenta and their relation to fetal pulmonic maturity. Am J Obstet Gynecol. 1979 Apr;133(8):915–22.

37. Deopa D, Babu CSR, Dubey K, Aneja S. “ Comparison of Placental Grading By Ultrasonographic Study in Normal and High Risk Pregnancy in North Indian Population .” 2011;60(1):31–6.

38. Quinlan RW, Cruz AC. Ultrasonic placental grading and fetal pulmonary maturity. Am J Obstet Gynecol. 1982 Jan;142(1):110–1.

39. Gast MJ, Ott W. Failure of ultrasonic placental grading to predict severe respiratory distress in a neonate. Am J Obstet Gynecol. 2016 Oct 5;146(4):464–5.

40. Kiran A, Nafees M, Abbas G. Correlation Of Sonographic Placental Thickness With Gestational Age In Normal Singleton Pregnancies. 2016;66:104–8.

41. Venkateswarlu DB, S.V.Rao D. Placental Thickness as an Ultrasonographic indicator for estimating gestational Age of the Fetus. Indian J Appl Res. 2016;VI(V):452–5.

42. Kapoor A, Dudhat MD . Sonographic evaluation of placenta thickness- an indicator of gestational age. JEvidBased MedHealthc. 2016;3(11):305–10.

43. Kaushal L, Patil A, Kocherla K. Evaluation of placental thickness as a sonological indicator for estimation of gestational age of foetus in normal singleton pregnancy. Int J Res Med Sci. 2015;3(5):1213.

44. Modn IJ, Revs R. Placental thickness as a sonological parameter for estimating gestational age. 2015;653–6.

45. Natwar Lar Agrawal . Comparative study between placental thickness and Femur Length for estimation of gestational age of fetus by real time ultrasonographic measurement . Indian J Appl Res. 2015;5(12):299–300.

46. Adhikari R, Deka PK, Tayal A, Chettri PK. Ultrasonographic Evaluation of Placental Thickness in Normal Singleton Pregnancies for Estimation of Gestation Age. Int J Med Imaging. 2015;3(6):143–7.

47. preeti baghel. Correlation of Placental Thickness Estimated by – Ultrasonography with Gestational Age and Fetal Outcome. Indian J Neonatal Med Res. 2014;3(3):19–24.

48. Mumal N, K SP, Urmila S, Anita R, MehrotraSeema. Ultrasonographic

measurement of placental thickness and its correlation with gestational age – a cross-sectional ultrasonographic study . Int J Adv Res. 2014;2(6):354–60.

49. Karthikeyan T, Subramaniam RK, Johnson WMS, Prabhu K. Placental thickness & its correlation to gestational age & foetal growth parameters- a cross sectional ultrasonographic study. J Clin Diagnostic Res. 2012;6(10):1732–5.

50. Raina S, Koul D, Dev G, Ganjoo S, Sharma A, Kaul V. Development of a nomogram to evaluate the usefulness of sonographic measurement of placental thickness for the estimation of fetal gestational age. J Basic Clin Reprod Sci. 2014;3(2):111.

51. Tiwari A, Chandnani K. A study to evaluate gestational age with the help of placental thickness. Int J Reprod Contraception, Obstet Gynecol. 2013;2(4):503.

52. Lee AJ, Bethune M, Hiscock RJ. Placental Thickness in the Second Trimester. J Ultrasound Med. 2012;31:213–8.

53. Ohagwu CC, Abu PO, Ezeokeke U O, Ugwu. Relationship between placental thickness and growth parameters in normal Nigerian foetuses. African J Biotechnol. 2009;8(2):133–8.

54. Ahmed A, Rahim A, Osman H, Elgyoum AA, Elzaki A. The Correlation between Placental Thickness and Fetal Age among the Pregnants in Sudan. Sch J Appl Med Sci. 2014;2:395–8.

55. Khatri MH, Ghaffar A, Rashid M. Estimation of gestational age of the fetus by measuring placental thickness. J Surg Pakistan. 2005;10(1):5–7.

56. Tongsong T, Boonyanurak P. Placental thickness in the first half of pregnancy. J Clin Ultrasound. 2004 Jun;32(5):231–4.

57. Durnwald C, Mercer B. Ultrasonographic estimation of placental thickness with advancing gestational age. Am J Obstet Gynecol. 2004;191(6):S178.

58. La Torre R, Nigro G, Manuela Mazzocco M, Best SP. The ultrasonic changes in the maturing placenta. Am J Obs Gynecol. 1979;42:915.

59. Tanawattancharoen S, Manotaya S, Uerpairojkit B, Prechawat S. Ultrasound measurement of placental thickness in normal singleton pregnancy. Thai J Obs Gynecol. 2000;10:73.

60. Jauniaux E, Ramsay B, Campbell S. Ultrasonographic investigation of placental morphologic characteristics and size during the second trimester of pregnancy. Am J Obstet Gynecol. 1994;170(1):130–7.

61. Ozcan T, Pressman EK. Imaging of the Placenta. Ultrasound Clin. 2008;3(1):13–22.

62. Appiah PK. Relationship between placenta, umbilical cord and perinatal outcome. Available from knust edu gh. 2009;

63. Jauniaux E. Placental ultrasonographic measurement: what can we learn and is it worth doing routinely? Ultrasound Obstet Gynecol. 1992;2(4):241–2.

64. Grannum PA, Hobbins JC. The placenta. Radiol Clin North Am. 1982 Jun;20(2):353–65.

65. Hoogland HJ, de Haan J, Martin CB. Placental size during early pregnancy and fetal outcome: a preliminary report of a sequential ultrasonographic study. Am J Obstet Gynecol. 1980;138(4):441–3.

66. Dombrowski MP, Wolfe HM, Saleh A, Evans MI, O'Brien J. The sonographically thick placenta: a predictor of increased perinatal morbidity and mortality. Ultrasound Obstet Gynecol. 1992;2(4):252–5.

67. Tongsong T, Wanapirak C, Sirichotiyakul S. Placental thickness at mid-

pregnancy as a predictor of Hb Bart's disease. Prenat Diagn. 1999;19(11):1027–30.

68. Ghosh A, Tang MHY, Lam YH, Fung E, Chan V. Ultrasound measurement of placental thickness to detect pregnancies affected by homozygous α-thalassaemia-1. Lancet. 1994;344(8928):988–9.

69. Petrucha RA, Platt LD. Relationship of placental grade to gestational age. Am J Obstet Gynecol. 1982;144(6):733–5.

70. Hills D, Irwin GA, Tuck S, Baim R. Distribution of placental grade in high-risk gravidas. Am J Roentgenol. 1984;143(5):1011–3.

71. Proud J, Grant a M. Third trimester placental grading by ultrasonography as a test of fetal wellbeing. Br Med J (Clin Res Ed). 1987;294(6588):1641–4.

72. Hopper KD, Komppa GH, Bice P, Williams MD, Cotterill RW, Ghaed N. A reevaluation of placental grading and its clinical significance. J Ultrasound Med. 1984 Jun;3(6):261–6.

73. Dudley N, Fagan D, Lamb M. Ultrasonographic placental grade and thickness: associated with early delivery and low birth weight. BJR. 1993;66:175–7.

74. Kumari S, Sawhney H, Visishta K, Narang A. Evalution of placental grade and its correlation with perinatal outcome, in intrauterine growth retardation. J Obs Gynecol, India. 2001;51(1):51–3.

75. Kazzi GM, Gross TL, Sokol RJ, Kazzi NJ. Detection of intrauterine growth retardation: a new use for sonographic placental grading. Am J Obstet Gynecol. 1983 Mar;145(6):733–7.

76. Zhang LY, Yh Y, ML. H. Association between ultrasonographic signs of placental premature aging and pregnancy outcome. Di yi Jan Yi Da Xue Bao. 2005;25(3):318–20.

77. Mckenna D, Tharmaratnam S, Mahsud S, Dornan J. Ultrasound detection of a grade III placenta at 36 weeks gestation in a low risk population help to identify the “at risk” pregnancy. Acta Obs Gynecol Scand. 2005;84(1):7–10.

78. Higgins M, McAuliffe FM, Mooney EE. Clinical associations with a placental diagnosis of delayed villous maturation: a retrospective study. Pediatr Dev Pathol. 2011;14(4):273–9.

79. Brown DL, DiSalvo DN, Frates MC, Davidson KM, Genest DR. Placental surface cysts detected on sonography: histologic and clinical correlation. J Ultrasound Med. 2002;21(6):641–8.

80. Faye-Petersen OM, Heller DS, Joshi V V. Handbook of Placental Pathology. second edi. Abingdon, Ox, UK: CRC press; 2005. 33 p.

81. Geirsson RT, Ogston SA, Patel NB CA. Growth of total intrauterine, intra-amniotic and placental volume in normal singleton pregnancy measured by ultrasound. Br J Obs Gynaecol. 1985;92(1):46–53.

82. Bonds DR, Gabbe SG, Kumar S TT. Fetal weight/placental weight ratio and perinatal outcome. Am J Obs Gynecol. 1984;149(2):195–200.

83. Shepard M, Richard V, Berkowitz R, Warsof S, Hobbins J. An evaluation of two equations for predicting foetal weight by ultrasound. Am J Obs Gynecol. 1987;156:80–5.

ETHICAL CLEARANCE CERTIFICATE

B.L.D.E.UNIVERSITY'S

SHRI.B.M.PATIL MEDICAL COLLEGE, BIJAPUR-586 103

INSTITUTIONAL ETHICAL COMMITTEE

INSTITUTIONAL ETHICAL CLEARANCE CERTIFICATE

The Ethical Committee of this college met on 22-11-2014 *at* 3-30pm *to scrutinize the Synopsis of Postgraduate Students of this college from Ethical Clearance point of view. After scrutiny the following original/corrected & revised version synopsis of the Thesis has been accorded Ethical Clearance.*

Title Ultrasonographic measurement of placental thickness and its correlation with gestational age in normal pregnancy.

Name of P.G. student Dr. Suresh. K. K.
Dept of Radiology

Name of Guide/Co-investigator Dr Ajay. R. Bhagwat
Associate professor of Radiology

for
DR.TEJASWINI VALLABHA
CHAIRMAN
INSTITUTIONAL ETHICAL COMMITTEE
BLDEU'S, SHRI.B.M.PATIL
MEDICAL COLLEGE, BIJAPUR.

Following documents were placed before E.C. for Scrutinization
1) Copy of Synopsis/Research project.
2) Copy of informed consent form
3) Any other relevant documents.

BLDE UNIVERSITY

[Declared as Deemed-to-be-University u/s 3 of UGC Act, 1956, vide Government of India Notification No. F.9-37/2007-U.3 (A)]

The Constituent College

SHRI B. M. PATIL MEDICAL COLLEGE, HOSPITAL AND RESEARCH CENTRE, VIJAYAPUR

BLDEU/REG/PG/2015-16/1199 October 14, 2015

To,
The Professor and HOD
Department of Radiology,
BLDEU's Shri B. M. Patil Medical College,
Hospital and Research Centre,
Vijayapur – 586 103.

Sir,

Subject: Regarding change of PG Guide.
Reference: Your letter no. 462/2015 dated 5th October, 2015.

With reference to the subject and letter cited above, on approval of the Hon'ble Vice Chancellor for change of PG Guide is permitted in respect of PG Students of your department:

Sl. No.	Name of the Student	Previous Guide	New Guide
1.	Dr. Masudi Sheetal	Dr. Ajey R. Bhagwat	Dr. B. N. Lakhkar
2.	Dr. Suresh K. K.		

This is for your information.

REGISTRAR
REGISTRAR
BLDE University, Vijayapur.

Copy to:

- The Dean, Faculty of Medicine and Principal
- PS to the Hon'ble Vice Chancellor

Smt. Bangaramma Sajjan Campus, Sholapur Road, Vijayapur – 586103, Karnataka, India.
University: Phone: +918352-262770, Fax: +918352- 263303, Email: office@bldeuniversity.ac.in
College: Phone: +918352-262770, Fax: +918352-263019, Website: www.bldeuniversity.ac.in, E-mail: bmpmc.principal@bldeuniversity.ac.in

CONSENT FORM

B.L.D.E.U'S SHRI B.M.PATIL MEDICAL COLLEGE HOSPITAL AND RESEARCH CENTER, BIJAPUR-586103

RESEARCH INFORMED CONSENT FORM

TITLE OF THE PROJECT: **"ULTRASONOGRAPHIC MEASUREMENT OF PLACENTAL THICKNESS AND ITS CORRELATION WITH GESTATIONAL AGE IN NORMAL PREGNANCY"**

PRINCIPAL INVESTIGATOR: **Dr. SURESH K. K.** **MBBS**

POST GRADUATE

DEPARTMENT OF RADIO DIAGNOSIS

Email: devakiram.radio@gmail.com.

P.G.GUIDE: **Dr. BHUSHAN. N. LAKHKAR** **M.D.**

PROFESSOR AND HEAD

DEPARTMENT OF RADIO DIAGNOSIS

PURPOSE OF RESEARCH:

I have been informed that this study is **"ULTRASONOGRAPHIC MEASUREMENT OF PLACENTAL THICKNESS AND ITS CORRELATION WITH GESTATIONAL AGE IN NORMAL PREGNANCY".**

I have been explained about the reason for doing this study and selecting me/my ward as a subject for this study. I have also been given free choice for either being included or not in the study.

PROCEDURE:

I/my ward have been explained that, I/my ward will be subjected to ultrasound (USG) abdomen and pelvis for evaluation of the placenta.

RISKS AND DISCOMFORTS:

I/my ward understand that necessary measures will be taken to reduce these complications as and when they arise.

BENEFITS:

I/my ward understand that my participation in this study will help to evaluate gestational age on basis of placental thickness measurement sonographically.

CONFIDENTIALITY:

I/my ward understand that medical information produced by this study will become a part of this Hospital records and will be subjected to the confidentiality and privacy regulation of this hospital. Information of a sensitive, personal nature will not be a part of the medical records, but will be stored in the investigator's research file and identified only by a code number. The code key connecting name to numbers will be kept in a separate secure location.

If the data are used for publication in the medical literature or for teaching purpose, no names will be used and other identifiers such as photographs and audio or video tapes will be used only with my special written permission. I understand that I may see the photograph and videotapes and hear audiotapes before giving this permission.

REQUEST FOR MORE INFORMATION:

I understand that I may ask more questions about the study at any time. Dr. Suresh K.K is available to answer my questions or concerns. I/my ward understand that I will be informed of any significant new findings discovered during the course of this study, which might influence my continued participation.

If during this study, or later, I wish to discuss my participation in or concerns regarding this study with a person not directly involved, I am aware that the social

worker of the hospital is available to talk with me and that a copy of this consent form will be given to me for careful reading.

REFUSAL OR WITHDRAWAL OF PARTICIPATION:

I/my ward understand that my participation is voluntary and I may refuse to participate or may withdraw consent and discontinue participation in the study at any time without prejudice to my present or future care at this hospital.

I/my ward also understand that Dr. Suresh. K.K will terminate my participation in this study at any time after he has explained the reasons for doing so and has helped arrange for my continued care by my own physician or therapist, if this is appropriate.

INJURY STATEMENT:

I understand that in the unlikely event of injury to me/my ward, resulting directly to my participation in this study, if such injury were reported promptly, then medical treatment would be available to me, but no further compensation will be provided.

I understand that by my agreement to participate in this study, I am not waiving any of my legal rights.

I have explained to _____ the purpose of this research, the procedures required and the possible risks and benefits, to the best of my ability in patient's own language.

Date: Dr.Bhushan. N. Lakhkar (Guide) Dr. Suresh .K.K (Investigator)

STUDY SUBJECT CONSENT STATEMENT:

I/my ward confirm that Dr. Suresh K.K. has explained to me the purpose of this research, the study procedure that I will undergo and the possible discomforts and benefits that I may experience, in my own language.

I/my ward have been explained all the above in detail in my own language and I understand the same. Therefore I agree to give my consent to participate as a subject in this research project.

_____

_____

(Participant)

Date

_____

_____

(Witness to above signature)

Date

PROFORMA

A. NAME

B. AGE

C. BP: mm Hg

D. Hb%: gm/dl

E. BAD OBSTETRIC HISTORY IF ANY

F. CALCULATION OF GESTATIONAL AGE

BPD

1. _____ weeks ____ days Average : _____ weeks ____ days

   _____ weeks ____ days

   _____ weeks ____ days

HC

2. _____ weeks ____ days Average : _____ weeks ____ days

   _____ weeks ____ days

   _____ weeks ____ days

AC

3. _____ weeks ____ days Average : _____ weeks ____ days

   _____ weeks ____ days

   _____ weeks ____ days

FL

4. _____ weeks ____ days Average : _____ weeks ____ days

   _____ weeks ____ days

   _____ weeks ____ days

G. PLACENTAL LOCATION

H. AVERAGE GESTATIONAL AGE : _____WEEKS _____DAYS

I. AVERAGE PLACENTAL THICKNESS : _____ MM

MASTER CHART

SLNO	AGE	BP	Hb%	OBST H	BPD	HC	AC	FL	Avg GA	PT	PL
1	24	110/80	11	0	16	15.4	15.2	16.1	15.5	15.6	1
2	22	100/84	11.4	0	19.2	19.4	19.6	19.5	19.4	19.3	1
3	25	106/84	11	0	19	19.3	19.5	19	19.4	19.5	1
4	25	110/78	13.6	0	22.4	22.4	23	23.3	23	22.5	1
5	25	120/80	11.3	0	17.3	17.4	18	16.6	17.3	18.5	2
6	24	110/70	12.9	0	17.2	17.3	17	17.4	17.3	17.5	2
7	24	114/86	11.9	0	13.6	13.5	13	13.2	13.3	15	3
8	26	110/80	12.1	0	14.2	14.5	14.6	14.4	14.3	14	3
9	22	100/90	12.3	0	21	20.2	20	20.2	20.2	20.4	2
10	23	110/90	11.6	0	20.4	20.3	20.5	20.6	20.4	20.6	2
11	19	110/80	11.8	0	14.2	14.3	14.1	14	14	14.5	2
12	18	110/84	11.4	0	22.3	22	22	21.1	21.6	23	2
13	21	110/86	11	0	13.3	13.5	13.6	13.4	13.5	14	1
14	25	114/86	12.5	0	21.3	21.4	20.6	22	21.5	22	3
15	28	120/80	12	0	22.2	22.2	22.1	22.3	22.1	22.3	1
16	30	110/86	12.4	0	22	22.6	22.5	23	22.6	22.3	1
17	23	120/80	11.9	0	17	17	17.1	16.3	16.6	16.1	3
18	20	110/78	12	0	20.2	20.1	19.1	19.4	20.2	20.4	1
19	28	120/84	11	0	23.1	23.3	23.5	23.6	24	24.7	3
20	24	116/86	10.7	0	17.6	17	17.3	17.1	17.2	16.8	1
21	21	100/90	11.5	0	20.1	20.5	20	20.2	20.5	20.3	2
22	22	110/88	11.3	0	19	19.1	18.1	18.1	19	20	1
23	22	110/90	11.4	0	23.4	23.4	23	24	24.2	24.3	3
24	22	110/90	11	0	23.2	23.5	23.3	24	24	24.2	3
25	22	110/90	10.8	0	16	15.5	15.3	15.1	15.4	14.5	1
26	22	114/82	11.9	0	14.2	14.3	14	13.4	14.1	13.9	1
27	19	100/80	12.4	0	20.4	21	19.6	20.2	20.3	21	3
28	19	110/78	11.4	0	21.1	21	20.3	20.5	20.5	20.4	2
29	21	130/80	12.6	0	14.4	14.4	14.1	14	14.2	14	3
30	23	134/78	13	0	24	23.3	23.2	23.2	23.3	23.7	2
31	20	120/80	13.8	0	23.2	24.2	24	23.6	24	24.2	2
32	20	120/88	13.5	0	15.3	15.3	15.4	14.4	15.1	17.1	2
33	25	110/90	13	0	18.6	19.1	19	19.2	19.1	18.8	1
34	20	120/78	12.7	0	21.5	21.2	21.1	20	21	19.7	1
35	22	120/78	13.9	0	20.3	20	20.4	20.3	20.2	20.4	2
36	25	110/84	14	0	13.2	13.2	12.3	12.2	12.4	12	3
37	35	130/80	14.5	0	14.2	14.3	14	13.6	14.1	13.9	4
38	21	120/80	14.4	0	14.4	14.4	14.1	14	14.2	14	3
39	20	120/80	11.8	0	13.2	13.2	12.4	12.1	12.4	12	3
40	32	132/88	13.8	0	16	15.4	15.2	16.1	15.5	15.6	3
41	23	120/82	12.4	0	24	23.3	23.2	23.2	23.3	23.7	2

42	20	120/84	12.9	0	23.2	24.2	24	23.6	24	24.2	2
43	20	110/90	13.6	0	15.3	15.3	15.4	14.4	15.1	17.1	2
44	30	110/90	14.6	0	17.3	17.4	18	16.6	17.3	18.5	2
45	21	120/80	14	0	22.2	21.5	20.1	21.2	21.3	22	3
46	20	110/82	15	0	20	20.2	21	21.2	20.4	21.6	2
47	19	120/80	13.5	0	24	23.3	23.6	24	23.6	24.3	1
48	26	120/86	13.5	0	17.5	17.3	18	17.5	17.5	17.7	3
49	20	110/84	14	0	22.2	22.2	22.1	22.3	22.2	22.4	1
50	27	130/86	11.9	0	22.6	23.1	23.4	23.2	23.4	23.5	2
51	25	120/86	12.7	0	16.3	16	17	16.4	16.3	16.5	1
52	30	124/86	13.7	0	18.1	18.3	19.2	18.6	18.4	19	1
53	20	120/80	14.4	0	14.6	14.5	15.4	15.2	15.1	15	2
54	22	110/80	13.2	0	18	18.2	17.5	18.1	18	18.5	2
55	25	120/80	12.3	0	17.1	17.1	17.3	17.3	17.2	17.4	1
56	23	110/84	13	0	12.5	12.6	12.6	13	13	13.1	1
57	23	120/78	12.8	0	20.4	20.3	20.5	20.6	20.4	20.1	2
58	24	114/88	11.7	0	23	23	22.3	23.1	22.6	23.4	1
59	28	130/80	13.8	0	18.5	18.5	18.4	18.3	18.4	19.1	3
60	20	120/80	14	0	21.1	21.4	21.1	21.5	21.3	20.5	2
61	19	110/80	12.1	0	16.6	17.3	17	16.5	17	17.1	2
62	24	120/80	12.5	0	13.4	13.2	13.2	13.4	13.1	12.9	2
63	22	110/84	13	0	18.6	18.1	18.3	18	18.2	18.6	1
64	24	124/84	12.9	0	18.1	19.4	19.4	18.5	19	18.5	1
65	26	126/90	13.7	0	21.6	22.1	21.6	21	21.5	21.3	1
66	20	120/78	14.4	0	23.1	23.1	23	23	23.1	23.4	1
67	22	110/80	13.9	0	20.6	21	21	20.6	21	21.1	1
68	20	110/84	15	0	22	22	22.3	22.5	22.2	22.1	2
69	27	120/82	14.7	0	22.4	22.5	22.4	22.4	22.4	22.9	2
70	23	116/80	12.7	0	16.2	16.1	15.5	15.2	15.6	16	3
71	30	130/82	12.2	0	17	16.5	17.3	16.6	17	16.9	1
72	21	118/90	13.9	0	13.6	13.5	13.6	13.5	13.6	13.8	1
73	24	120/80	15.5	0	13.1	13	13.2	12.5	13	13.4	1
74	25	120/80	13.6	0	20.3	20.5	20.3	20.4	20.3	20.9	2
75	20	116/84	13.8	0	23.5	23.3	24	22.4	23.3	24.2	3
76	20	108/78	14	0	22	22.2	22.2	22.1	22.1	23	2
77	21	110/80	15.2	0	13.4	13.2	13.2	13.4	13.1	13	2
78	21	110/90	13.9	0	13.3	13.4	13.4	13.1	13.3	11.9	1
79	25	120/76	14.1	0	20.2	20.6	20.4	20.5	20.4	20.1	2
80	25	120/80	14.9	0	16.3	16	17	16.4	16.3	16.5	1
81	21	110/86	12.3	0	19	18.5	18.4	18.1	18.4	18.1	1
82	25	120/80	13.4	0	15.5	15.4	15.5	14.2	15.2	14.2	2
83	29	130/80	13.9	0	13.1	13	13.2	13	13.1	13.3	2
84	20	120/84	14.6	0	18.5	19	18.4	18.5	18.5	19	1
85	28	126/84	13.6	0	19.1	19.1	19.2	20.1	20	19.8	1

86	23	134/88	12.9	0	21.4	21.3	21.1	21.3	21.2	21.5	1
87	20	108/76	11.9	0	23.6	22.5	22.6	23.3	23.1	24.2	2
88	30	124/85	15.2	0	20.3	20.6	20.2	19.6	20.3	20.2	1
89	22	120/80	13.7	0	16.4	16.3	16	16.2	16.5	16.4	3
90	23	120/80	12.8	0	20.3	20.5	21	20.1	20.4	21.9	1
91	27	126/86	13.6	0	15.2	15.2	15	14	14.6	14.5	3
92	28	110/80	14.2	0	13.2	13.2	12.3	12.2	12.4	12	3
93	25	120/78	13.7	0	14.2	14.2	14.3	14.2	14.3	14.2	4
94	22	110/78	14.5	0	23.3	23.4	23.4	22.5	23.1	23.6	1
95	24	120/76	14.2	0	15	14.4	14.4	14.1	14.4	14.9	3
96	22	110/80	13.2	0	17.4	18.1	17.3	17	17.1	17.1	2
97	29	110/80	12.6	0	15.2	15.2	15.3	15.2	15.4	15.3	3
98	22	120/82	12.8	0	13.2	13.2	12.3	12.5	12.6	12.5	1
99	22	110/80	13.6	0	20.1	20.4	21.3	21.4	21	21.3	3
100	25	120/80	14	0	16.1	16.3	15.6	15	15.6	16	2
101	20	110/80	14.3	0	22.2	22.2	22.1	22.3	22.2	22.4	1
102	22	120/78	13.8	0	20	20.2	21	21.2	20.4	22.6	2
103	25	116/82	13.7	0	20.5	20.4	19.6	20	20.2	20.4	3
104	20	110/86	13.9	0	17.5	17	17.4	17	17.2	17.1	2
105	30	120/76	14.9	0	19.6	20.1	19.5	20.2	20	19.5	3
106	20	116/90	15	0	21.5	21	21	21.5	21.2	21.2	1
107	23	110/80	14.6	0	21.5	21.1	21.3	21.5	21.4	21.3	1
108	21	110/78	13	0	14.5	14.3	14	14	14.2	14.5	2
109	24	120/78	12.6	0	15	14.5	14	13.3	14.2	15.9	3
110	25	110/90	13.8	0	23.2	23.3	22.2	23	23	22.3	3
111	20	110/78	14.6	0	23.3	23	22.6	21.4	22.5	21.5	2
112	22	110/82	13.9	0	15.1	14.5	15	15	15.1	15	2
113	25	116/88	14.5	0	14.2	14	14	13.3	14	13.7	2
114	21	114/82	15	0	21.3	21.1	20.5	21	21	20.8	2
115	23	110/80	15.4	0	21.2	21.2	20.4	21.2	21.2	21	2
116	23	114/78	14.7	0	14	13.5	13.3	13.4	13.4	13	2
117	22	120/80	15	0	18.2	17.2	17.1	18.3	18	18.4	1
118	26	110/86	13.6	0	23.5	23.1	22.5	23	23.2	23.4	3
119	20	110/80	13	0	18.2	18.4	18.2	19	18.4	17.9	3
120	21	120/80	12.9	0	16.3	15.3	15.4	16.3	15.4	16	3
121	30	120/76	14.2	0	21.4	21.5	21.5	21.5	21.5	20.6	1
122	22	110/78	14	0	16	15.5	16.1	15.1	15.6	16.3	2
123	24	120/80	12.5	0	17.3	17	16.4	17.5	17.1	20.1	2
124	20	110/80	13.9	0	13.5	13.6	13.4	13.5	13.5	13.1	4
125	26	120/84	14.6	0	20.2	20.2	20.5	21	20.4	21.9	1
126	22	110/80	14.3	0	13	12.4	13	12.3	12.5	12.5	2
127	30	110/80	12.8	0	16.3	15.6	16.1	16.3	16.2	16.1	2
128	19	110/78	13.6	0	15.1	14.5	15.2	14.5	15	15	1
129	22	110/82	14.6	0	17.5	17.4	16.6	18.3	17.5	18.2	2

130	19	110/76	15	0	14.1	14	14	14.2	14.1	14.4	1
131	26	116/78	14.8	0	21.2	21.2	22	22.4	21.5	22.4	1
132	20	120/82	14.5	0	18.1	18.1	18	18.6	18.2	18.5	1
133	21	110/80	14.1	0	18.1	18	18	17.6	18	18.3	3
134	22	116/74	13.5	0	19.6	19.2	19.1	19.3	19.3	19.8	2
135	21	110/80	14	0	15.1	15.3	15.4	14.5	15.2	15	2
136	25	120/80	14.8	0	22.4	22.5	22.3	22.6	22.5	23.3	1
137	22	120/80	13	0	21.3	22.1	23.3	23.6	23.4	24.3	3
138	18	110/70	14.3	0	15	15.1	15.2	14.2	15	15.2	1
139	22	120/80	14	0	17.5	17.1	17.5	17	17.3	17.1	1
140	25	118/78	12.9	0	13.6	13.5	13.3	12.6	13.3	12.5	2
141	25	110/80	14.4	0	19.4	19.2	19.1	19.6	19.3	19.7	2
142	22	110/80	13.9	0	20.5	19	18	20.1	19.3	20	4
143	26	116/82	14	0	15.3	15.1	15.4	15.5	15.3	15.6	1
144	25	120/80	14.2	0	15.5	15.6	15.5	15.4	15.5	16	1
145	30	120/78	14	0	13.3	13.5	13.2	13.6	13.5	13.6	4
146	22	110/80	13.8	0	17.5	19.1	19.1	18.4	18.4	18.2	1
147	25	110/80	14.5	0	14.3	14.2	14.5	14.2	14.3	14.2	1
148	23	120/80	14.6	0	18	17.5	18	18.1	18	18.4	1
149	22	118/80	13.9	0	16	16.2	16.6	16.3	16.3	16.6	1
150	25	124/80	12.9	0	19.4	19.6	19.4	19.5	19.5	20.2	1
151	19	110/80	13.7	0	16.1	16	16.4	16.1	16.2	16.3	1
152	25	120/80	11.3	0	17.3	17.4	18	16.6	17.3	18.5	2
153	20	110/80	12.8	0	12.5	12.2	12.2	12.6	12.5	12.5	1
154	20	108/74	13.2	0	19.5	19.2	19.2	19.2	19.3	19.3	2
155	22	120/80	12.7	0	20.6	20.6	21.4	21.5	21.2	21.2	2
156	20	110/80	13.5	0	19.4	19.6	19.6	20.1	19.6	19.2	2
157	25	110/76	12.4	0	19.2	19.2	19.4	19	19.2	19.4	2
158	25	110/80	14	0	20.6	21.1	20.6	21.3	21.1	21.5	1
159	20	120/80	13.5	0	23.4	24.2	24.4	23.3	24	24.3	1
160	20	110/80	13.4	0	16.3	15.6	16.2	15.4	15.4	16.2	1
161	24	110/70	12.8	0	19.4	20.3	20.6	20.3	20.2	20.5	2
162	24	116/80	13.7	0	21	21.2	21.1	20.6	21.1	21	1
163	20	120/78	12.3	0	18.6	19.4	18.5	18.2	19.1	18.5	3
164	25	118/78	12.6	0	15.2	15.4	15.2	15.1	15.2	15.1	2
165	19	110/80	13.6	0	22.3	22.2	22	22.4	22.2	22.25	3
166	28	120/80	14	0	17.4	17.3	16.6	16.1	17	16.8	3
167	19	110/80	13.8	0	19.3	19.4	20.1	19.1	19.4	19.2	1
168	25	110/80	12.9	0	18	17.6	18.2	18.1	18.1	18.5	2
169	19	108/82	13.4	0	19.3	18.2	17.5	18.2	18.3	18.5	2
170	25	110/80	14.2	0	16.4	16	15.4	16.2	16.1	16.5	3
171	24	120/80	13.4	0	17.4	17.4	17.3	17.3	17.4	17.2	1
172	20	110/80	13.9	0	14	14.3	14.2	14.1	14.2	14.2	2
173	30	114/84	12.8	0	18.5	19.1	19	19.5	19.1	19.2	3

174	25	110/80	12.9	0	15	14.4	15.2	14.6	15	14.5	2
175	25	120/80	13.5	0	16.2	16.3	16.3	16.2	16.3	16	3
176	26	118/86	14.1	0	21.2	21.2	21	21	21.1	21.2	2
177	24	110/80	13.4	0	19.2	18.6	19.2	18.2	19	18.5	2
178	22	110/84	12.7	0	18.4	19	19.2	19.2	19	18.5	3
179	20	110/78	13.8	0	23	22.4	23.1	23.1	23	23.5	1
180	30	120/78	14	0	22.2	22.3	22.2	21.6	22.2	22	1
181	21	110/80	13.4	0	17	16.6	16.3	16.5	16.5	16.5	3
182	25	110/84	12.8	0	19.3	19.1	19.6	19.2	19.3	19.2	2
183	27	110/80	13.8	0	12.5	12.2	12.2	12.1	12.1	12.2	1
184	19	110/78	13	0	13.5	13.2	13.2	12.5	13.2	13	3
185	23	120/80	14.5	0	22.4	22.3	22.4	23.2	22.5	23.5	2
186	19	108/78	14.1	0	14.3	14.1	15	14.3	14.4	14.5	3
187	20	110/80	13.4	0	20.3	20.3	21	20.3	20.4	20.3	1
188	17	110/80	13.8	0	14.3	14.4	14.6	14.3	14.4	14.5	3
189	19	110/80	13.4	0	21.3	21.2	21	21.1	21.2	21.5	1
190	27	120/80	12.7	0	23.6	23.3	23.1	23.2	23.3	23.6	2
191	23	114/84	12.9	0	12.2	12.3	12.1	12.4	12.3	12.2	1
192	24	118/78	13.4	0	24.1	23	23.6	22.2	23.6	23.5	2
193	27	120/80	13.5	0	14.6	14.3	14	13.5	14.2	14	1
194	20	110/80	14	0	12.5	12.2	12.2	12.6	12.5	12.5	1
195	25	110/884	14.2	0	13.5	13.4	14.3	13.6	13.6	13.5	2
196	37	120/80	13.8	0	17	16.6	17.1	16	16.5	16.4	2
197	23	110/78	14	0	21.5	20.5	21.4	20.2	21.1	20.6	1
198	24	114/84	13.2	0	24	24.2	24	24.2	24.1	24.5	3
199	21	110/84	13.9	0	14.1	14.1	14.2	14.3	14.2	14.3	2
200	22	110/82	12.9	0	14.5	14.6	14.3	14	14.4	14.2	2
201	20	112/82	13.5	0	17.2	17.3	17.1	17.2	17.2	17.1	1

KEY TO MASTER CHART

BPD	Biparietal diameter
HC	Head circumference
AC	Abdominal circumference
FL	Femur length
OBST H	Obstetric history if any
Avg GA	Average gestational age
PT	Placental thickness
PL	Placental location
1	Anterior
2	Posterior
3	Fundal
4	Lateral